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GUIDELINES ON LANDSCAPING AND TREE PLANTATION

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GUIDELINES ON LANDSCAPING AND TREE PLANTATION

INTRODUCTION

The Manual on Landscaping of Roads was published by the Indian Road Congress as an IRC Special Publication: 21, in December 1979. The Manual provides comprehensive guidelines on both the hard and soft landscaping of roads with respect to the physiographical, environmental, climatic and operational factors. However, with the changing scenario of rapid development and diversification of road infrastructure in the country, especially the highways, a need was felt to revise the Manual in line with the changing specifications for roads.

The draft for the revised manual was prepared by S/Shri V.K. Sharma, Member Secretary and S.P. Sharma, Member of the Environment Committee (G-3). The revised Manual essentially retains the structure of the present Manual with desired modifications in the specifications. Major modifications have been done in the Appendix on roadside arboriculture; since this portion of the Manual was actually required to be changed with the changing specifications for highway construction and improvement. After the draft was prepared, the Committee met on 6th September 2008 and discussed the draft and approved it with some suggested modifications. Modifications were incorporated in the draft guidelines.

The Personnel of G-3 Committee is given below:

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Secretary General, IRC	(A.N. Dhodapkar)

The draft finalized by the Environment Committee was discussed by the General Specifications and Standards Committee (GSS) in its meeting held in New Delhi on 20th November 2008. The document finalized by the GSS Committee was approved by the Executive Committee in its meeting held on 30th November 2008 and approved by the Council in its meeting held on 13th December 2008 respectively.

1 SCOPE

1.1 India is witnessing a major change in infrastructure development vis-à-vis the transportation network of the country; *viz.*, the National Highways and State Highways. Various highway improvement projects are being undertaken by different State Governments and Government of India. Implementation of National Highway Development Project (NHDP) is the major step in this direction.

1.2 There is always a conflict between development and environment and, therefore, a trade off is necessary to balance the two, so that, development is sustainable. The first adverse consequence of widening, from environmental point of view, is the inevitable felling of trees growing along the highways. On the hill sides and other fragile environmental settings, much more adverse impacts are expected on the surroundings.

1.3 It is the responsibility of the road agencies to offset the loss of trees and other changes resulted into the surroundings. There is a need to follow the approach of "Corridor Development & Management", rather than "Highway Development". Apart from mitigating the environmental losses, road agencies must plan to enhance the aesthetics of the highway corridor from all possible angles. Highways should not be looked upon merely as a means of transportation, but as a part and parcel of the environmental and socio-economic milieu.

1.4 The land needed for the avenue plantation and landscape improvement has to be considered during the project formulation stage itself. As a result, after construction, when the plantation is actually to start, the land is available for planting. The width of the remaining ROW is, many times, not sufficient enough to accommodate even a single row of plants;

whereas at some places, three to four rows can be planted. To ensure availability of sufficient width for avenue plantation, the requirement of land for tree plantation should be assessed and included in the land acquisition plans prepared for a highway widening project.

1.5 Landscape treatment of roads embraces the following measures at different stages of development:

- Designing of horizontal alignment, vertical profile, structures like bridges and retaining walls and road furniture, such as, signs, signals, lighting system etc., so that these components are not out of scale with the surroundings.
- Stabilising the embankment and cutting areas to smoothen the earth profile and unifying the landscape.
- Grass turfing and planting of trees and shrubs.
- Enhancement of surroundings and creation of necessary service facilities for rest, recreation, etc., for the road travellers.

1.6 It is not possible to lay down rigid and uniform standards for landscaping. The treatments to be adopted vary from place to place depending on the topography, climate and other environmental features. Accordingly, this Manual lays down only broad guidelines, subject to such modifications as may be governed by local site conditions.

1.7 Highway design and landscaping should be regarded as complementary and tackled as a single planning task. The detailed project reports prepared for the road projects must include landscaping and tree planting as an integral part of the design. The landscape features must be studied during the design process and specific drawing, designs, and specifications must be prepared. There should be no compromise on the cost.

1.8 The Manual is divided into 11 Sections to focus attention on different aspects of landscaping and broad guidelines on landscaping and plantation, types of species, etc. In brief, Sections 2 and 3 deal with general considerations relating to landscaping, Sections 4 and 5 with specific aspects relevant to rural and urban highways, Section 6 with points deserving consideration with respect to the highway structures, Section 7 with road-safety and roadside amenities, Section 8 with the desired treatment in special areas such as waterlogged or sandy tracts, Section 9 with the landscaping problem of existing roads, Section 10 deals with maintenance of the landscaping facilities and Section 11 deals with broad guidelines on landscaping and plantation along highway.

2 MAIN FACTORS AFFECTING LANDSCAPING

2.1 Several factors, topography, environment, climate and operational considerations govern the landscaping of roads and need to be kept in view in each case. More important

among these are highlighted below:

2.1.1 Terrain

Terrain has an overriding effect on geometric design features of a road; for instance, gradients, radii of curves, sight distance, central reserve, the extent to which the road is in embankment or cutting, etc. On one hand, these components would determine the appearance of the road and on the other the measures that could be adopted to beautify the road landscape. The objective should be to design the road in such a way that it fits into the existing terrain and harmonises with the general landscape.

2.1.2 Surroundings

2.1.2.1 The surroundings of the road, whether rural or urban, are an important factor affecting landscape design.

2.1.2.2 For roads in rural areas, land width for roadside plantation and other landscape measures is generally not a problem. Also, advantage of existing scenic spots etc., can be easily taken to make these a part of the highway landscape.

2.1.2.3 Important rural highways carrying long distance traffic also have their own requirements. There is need for roadside rest areas and other facilities at periodic intervals for rest and relaxation of the travelling public.

2.1.2.4 Urban roads, on the other hand, show up a somewhat different picture. Generally, the right-of way is limited and surrounding area is characterized by buildings, paved verges, frequent road intersections, utility services, etc. Also, unlike rural areas; pedestrians, cyclists and other slow-moving vehicles form an important part of the road user. The need to screen off unsightly dumping yards, slum areas, etc. adds to the problem.

2.1.3 Highway speed

2.1.3 Highways are classified under different categories, e.g., Expressways and Highways and each category is designed for a specific speed. Speed of travel is a factor in landscape design. On fast speed highways, overall composition of the landscape as it unfolds while driving is of greater significance. On the other hand, on slow speed roads, the driver will have an eye even for minor wayside details. Safety is also a concern with respect to the highway speed. On fast speed highways, the landscape improvement and tree plantation needs to be planned while ensuring safety of the travellers.

2.1.4 Climatic factors

2.1.4.1 Climatic factors like rainfall, humidity and temperature influence road landscape design in a number of ways. For one thing, climate controls the type and extent of vegetation which forms the most important component of road landscape. Nature has devised vegetation in a manner that only specific varieties thrive in particular climates. Plantation of vegetation as a part of landscaping should, therefore, be restricted as far as possible to local species already thriving in the area.

2.1.4.2 Similarly, climate affects drainage characteristics in a marked way especially in high rainfall areas. In such cases, particular attention has to be paid to the design of drainage system so that it does not disturb the natural environment adversely.

2.1.4.3 There are also other factors like erosion, wind blows, and snow drifts etc., which may affect landscape design.

2.1.5 Public opinion

Views of local inhabitants who are directly affected should also as far as possible, be taken into consideration while formulating landscape designs.

3 GENERAL CONSIDERATIONS NEEDING ATTENTION DURING LANDSCAPING

3.1 Conservation of Existing Features

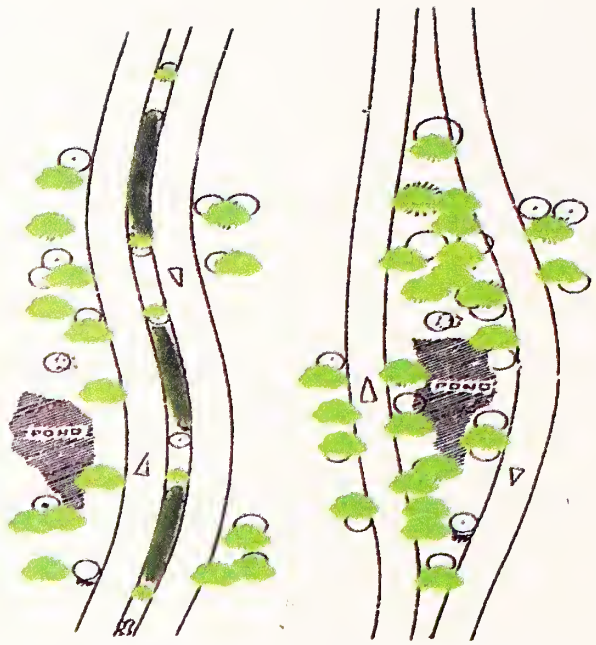
3.1.1 Existing features along a road alignment, whether natural or man-made, can contribute significantly to general road landscape and every effort should be made to preserve, incorporate and integrate these into the landscape. A reconnaissance survey should be made to identify all valuable natural features such as natural wooded areas, streams, ponds, rock outcrops, scenic vistas etc., in addition to man-made features like historical buildings, monuments, gardens, etc. During design, and later during construction, every care should be taken to avoid damage to them. Natural beauty of the landscape can be considerably enhanced by blending the existing features into the road system.

3.1.2 While planning the highways, it may be desirable to design the median with a varying width so as to conserve natural features along the alignment, hence making the highway safer and more interesting to drive, (Fig. 1). However, since this involves acquisition of additional land, this option should be used in exceptional cases, where the features to be preserved can not be relocated. The best option is to realign the road rather than splitting the highway.

3.1.3 Similarly, wherever feasible, religious structures, old monuments, gardens etc. having a special architectural character should not only be saved when building a road but suitably incorporated in the general highway landscape even if this means making special efforts (Figs. 2 and 3).

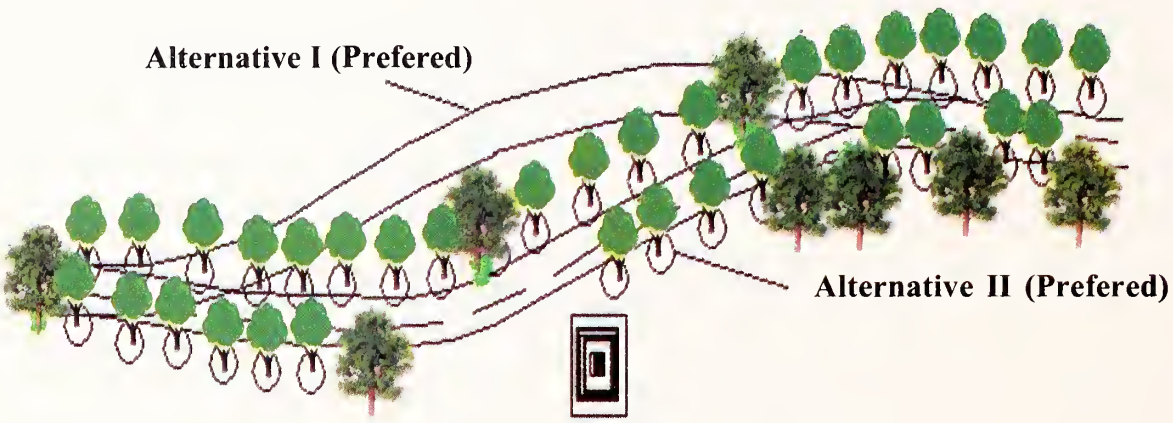
3.1.4 Conservation of existing grass and plant growth needs no emphasis. In all road cuttings, top soil should be preserved and re-applied after completion of grading operations, on slopes, medians etc., to help growth of vegetation.

3.1.5 While constructing roads in forest areas, felling of trees should be kept to minimum. Fire should never be used in cleaning operations as this will destroy natural regeneration of young trees and drive out wildlife The effect of felling on undergrowth and wildlife also needs to be kept in view.

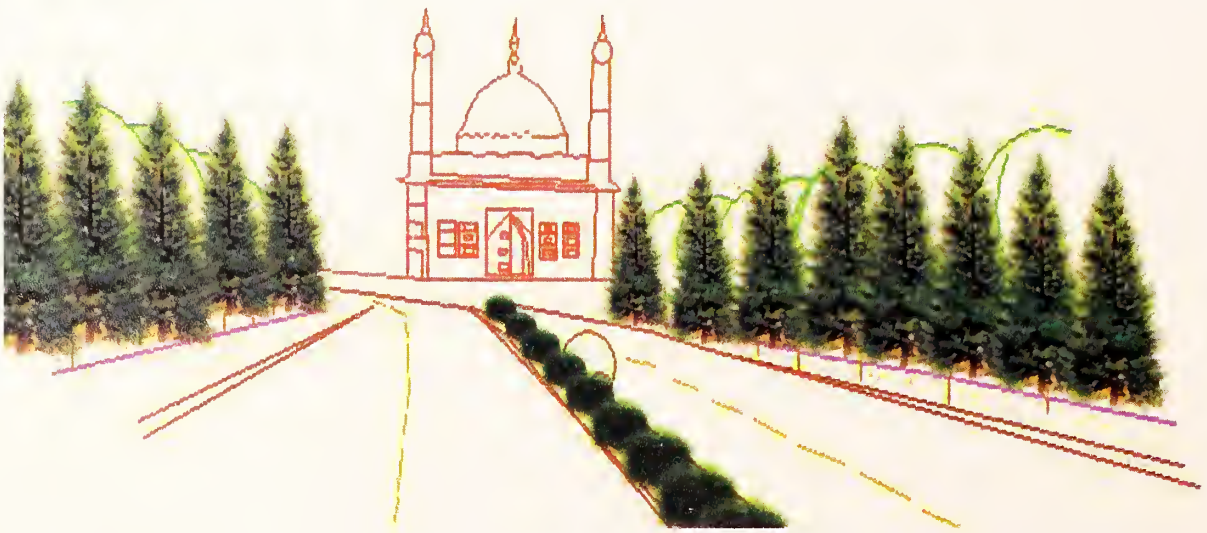


By Realignment By Widening the Median

Fig. 1 Preservation of Natural Landscape Features by Suitably Adjusting the Median



(a) Plan



(b) Perspective View with Alternative

Fig. 2 Incorporation of Historical Features in Road Landscape

Fig. 3 Religious Structure Adjacent to Highway

3.2 Conservation of Land Values

3.2.1 The effect of road construction on the adjoining land is two-fold:

(i) acceleration of industrial, commercial, agricultural and other activities; and

(ii) undesirable impact on environment due to increase in noise, dust and fumes from traffic.

3.2.2 An important objective of any road construction programme should be to minimize the adverse effects mentioned at (ii) above. In this respect, proper landscaping measures can play a vital role.

3.2.3 Acquisition of adequate Right-of-Way, and proper design of the road cross-section with provision for green buffer strips between the shoulders and land boundary, can help a lot to improve the landscape along the road. In urban areas with appropriate screen planting, the nuisance of noise, dust and fumes on account of traffic can be vastly reduced. Attractive landscape treatment will help in preservation of the residential land values.

3.3 Fitting the Road into Landscape

3.3.1 While deciding the alignment of the road, the aesthetic factors must also be considered along with usual economic, engineering and administrative considerations.

3.4 Road to Follow Natural Terrain

3.4.1 The road should follow the natural terrain as closely as possible. While ascending hills, it is advisable to align the roadway at an oblique angle to the contours. Deep cuts for

the sake of straight alignment should be avoided. In some cases, it may be advantageous to locate the road along rivers, sea shore or water courses to facilitate full enjoyment of the landscape potential.

3.5 Geometry of Road with respect to Landscape

3.5.1 Alignment of the road can be made more pleasing by providing larger radii and spiral transitions or gentle coordinated curves, both in the horizontal and vertical plane. This should be accompanied by appropriate contouring and planting on both sides of the road to yield an overall pleasing effect.

3.6 Spacing of Carriageways

3.6.1 While building divided highways, the two carriageways need not always be sited adjacent to each other or at the same level if the fall of the ground is across the general direction of the road. Not only will this improve landscape design but will also lead to economy. The fall between the two roads can be effectively utilized as central green space (Figs. 4 and 5).

3.6.2 Similarly, spacing between carriageways can be varied to preserve special environmental and cultural features by adjusting these between the two carriageways instead of cutting across (Figs. 3 and 4). This should, however, be opted only in exceptional cases.

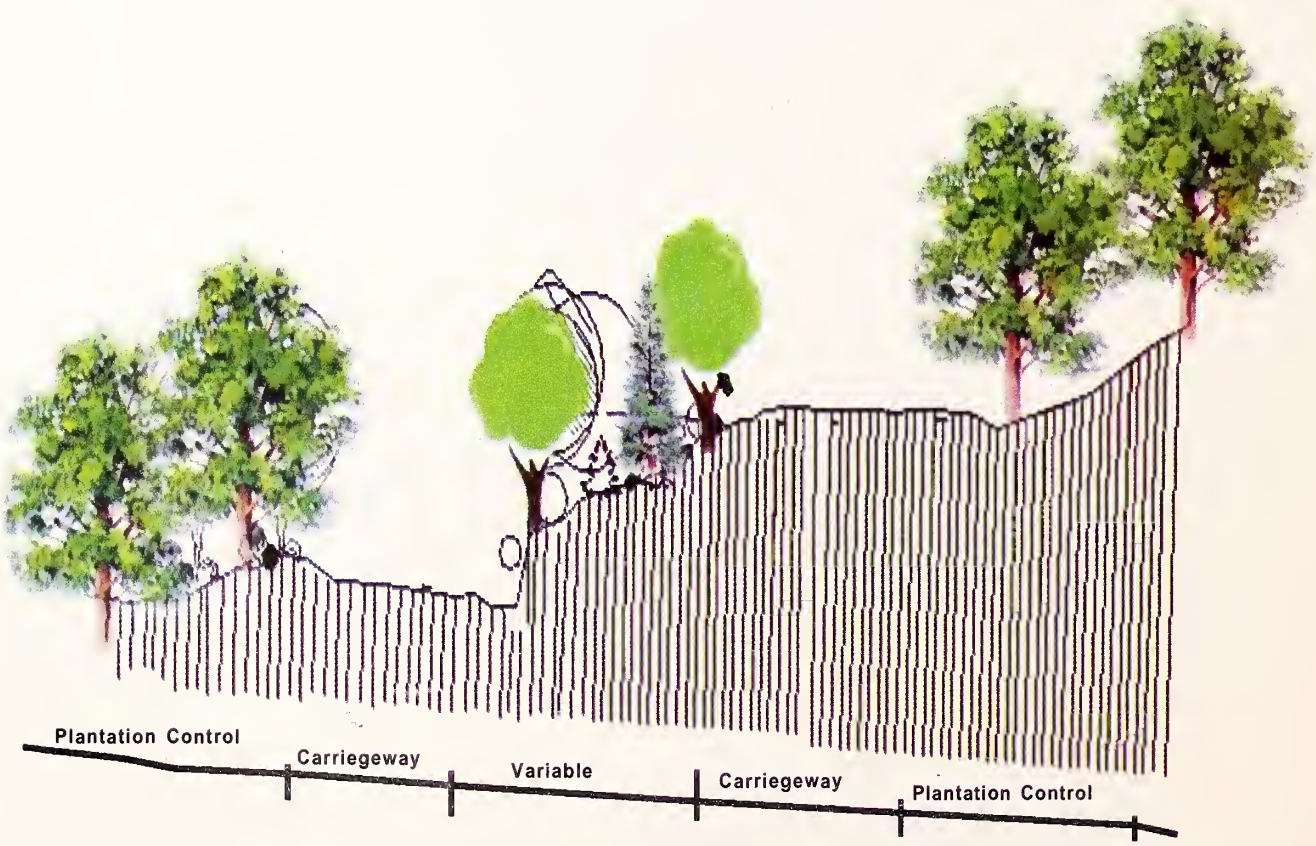


Fig. 4 Cross-Section of a Rural Highway having Carriageway at Different Levels

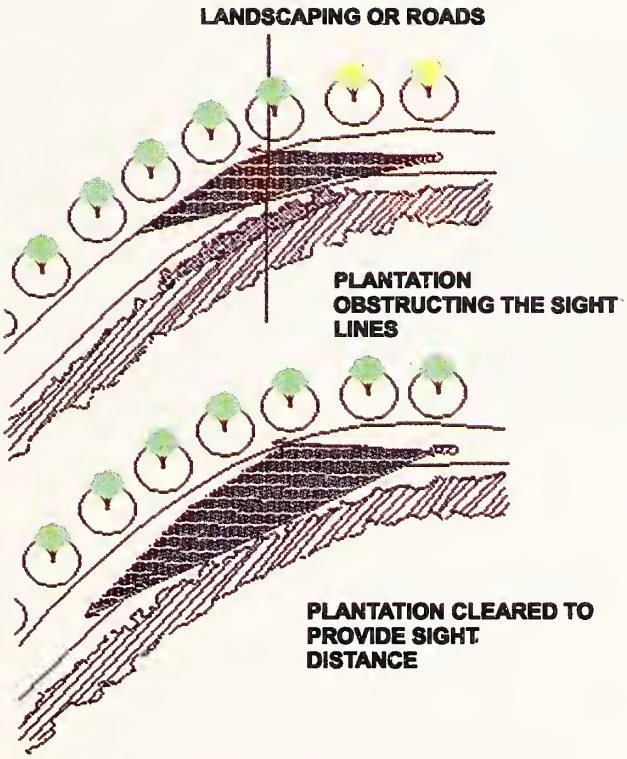


Fig. 5 Set-Back of Plantation at Horizontal Curves to provide Requisite Sight

3.7 Tree Planting or Arboriculture

3.7.1 Tree planting or arboriculture is the most important component of landscaping. Planting may be functional, or for aesthetic effects, but in either case the objective should be to help restore the unity of the landscape. Functional planting applies to such problems as protection of slopes against erosion, screening of unsightly views, reducing headlight glare, providing shade in summer and so on. In most cases, such planting also improves the appearance of the road and enhances the natural landscape, planting for aesthetic effects is also by and large functional but goes beyond that to blend the road into the surrounding countryside and enhance the overall beauty (Figs. 6 and 7).

Fig. 6 Well-Planted Multi-Lane Urban Highway

Fig. 7 Well Planted Multi-Lane Urban Highway

3.7.2 Roadside planting of trees may be in the form of avenues, groups or groves. Where conditions are favourable, for example in groves, fruit bearing trees may be preferred.

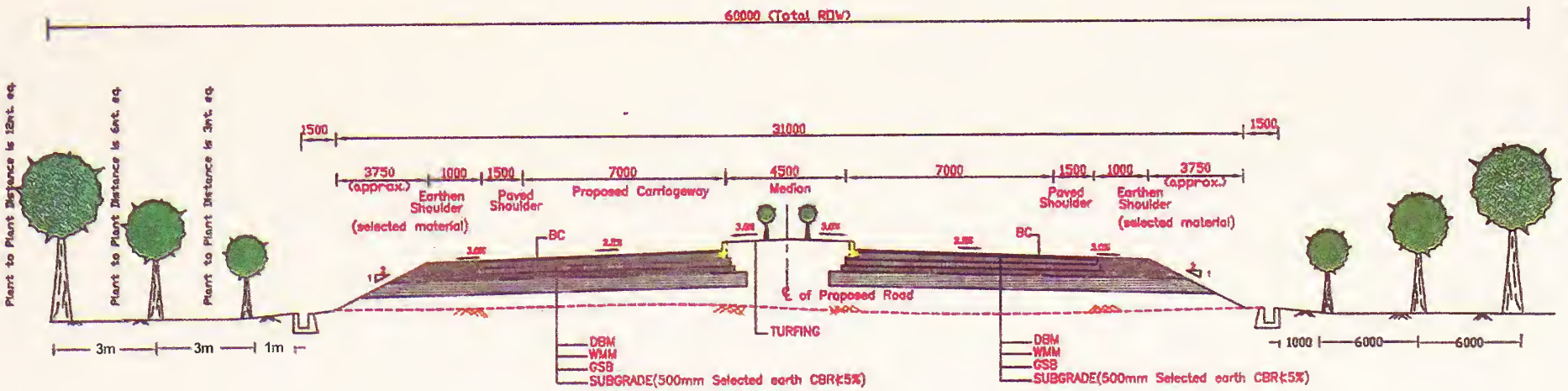
3.7.3 The amount of planting to be provided at different situations needs careful attention. While roads in landscapes devoid of trees or woodlands may require little or no planting, extensive planting is necessitated in settled rural landscapes where a new road may introduce more new elements than the countryside can absorb.

3.7.4 In the design and development of arboriculture, certain restrictions imposed by engineering, traffic and safety requirements should be kept in view. Some of these are:

- Position of trees on either side should be fixed taking into account the ultimate development of the roadway with regard to future widening.
- Trees should be offset upto and beyond 1 m back from the ultimate edge of the roadway so that they are not a safety hazard or affect the required sight distances (Fig. 8).
- Considerations of sight distance and safety being of primary importance, these should in no case be subordinated to aesthetics.
- Shrubs and trees should be planted clear of roadside drains and other drainage structures so that their root system do not interfere with efficient working of the drainage facilities.

3.7.5 To facilitate systematic execution of operations involved in roadside arboriculture, it will be advisable to prepare a detailed work plan including necessary drawings for field use. These should cover the scope and extent of the proposed activities, pattern, type and location of plantings, plant species to be used etc. and should be simple enough to be easily followed by field crews.

3.7.6 For detailed guidelines about roadside arboriculture, Please refer to Section 11.



TYPICAL CROSS SECTION FOR NEW 4 LANE ALIGNMENT IN RURAL AREA

Total Number of Plants/Km.

Sr.No	Rows	Number of Trees
1	Ist. Row	333
2	IInd. Row	166
3	IIIrd. Row	84
4	Total	583

Note: – All Dimensions are in mm.

Fig. 8 Typical Cross Section For New 4 Lane Alignment In Rural Area

3.8 Transplantation of Large Tree

Occasion may arise when a grown-up tree has to be cut for making room for constructing a road, a building or other structure. It would be desirable to save this plant by transplanting it at a suitable site. To do this successfully some time is necessary. In winter when the tree is dormant or less active, it should be pruned heavily leaving a bare framework of the large branches. A 40 to 50 cm wide trench 1 to 2 m deep should be dug around the stem as much distance away from it, depending upon the stature of the specimen, cutting all the roots, big and small, in the process.

The trench should then be compacted with dry leaf, straw or any such material followed by heavy irrigation which would be repeated from time according to necessity. In spring, new shoots will come out along with a new set of fibrous roots. These will grow during the summer months. It would be desirable to execute the transplantation under expert supervision.

In the beginning of rainy season, the trench would be reopened by removing the packing materials, thereby exposing the new roots. The big earth ball at the base of the tree would be wrapped firmly with burlap. The trunk should simultaneously be covered with several rounds of gunny on which a strong iron chain will be tied like a belt.

Now a crane would be summoned and the tree securely attached to it through the iron chain. The basal roots would then be cut to free the tree from the ground and carried on a vehicle to the new site where a suitable pit has already been dug to receive the huge earth ball. The tree would be placed in this pit with its trunk in an upright position. The cavity of the pit would be filled-up with manured soil followed by heavy irrigation.

The tree would grow vigorously in the new place and in 2 to 3 years will put forth so much vegetative growth that it will be difficult to recognize it as a displaced specimen. The percentage of success is very high, if all the operations are done carefully and properly.

4 LANDSCAPE DEVELOPMENT – RURAL AREAS

4.1 Road Land Width

4.1.1 Land width is usually not a serious constraint in rural areas. The width acquired should be as liberal and feasible with adequate provision for current as well as anticipated requirements. While taking a decision in this regard *interalia* the following factors deserve consideration:

- Need to have stable side slopes for cuts/fills;
- Requirement of contouring in portions of deep cut or high fill to bring these into scale with the surroundings;

- Provision for roadside arboriculture including screen plantations for shielding unsightly areas;
- Desirability of a wider median or central verge in the case of dual carriageways to avoid headlight glare;
- Incorporation of adjacent plantations and beauty spots in the general road landscape.

4.1.2 The minimum land width should normally not be less than that recommended by the Indian Roads Congress. Apart from above, consideration should be given to acquisition of additional land width to take advantage of existing plantations, scenic spots, cultivated areas etc., forming a part of the highway landscape and to provide at intervals group plantations and other landscape treatments. Such measures will not only improve the aesthetics of the road, thereby reducing monotony for the road users, but also help in preservation and propagation of natural plant and animal life towards maintaining ecological balance in the area.

4.1.3 Acquisition of adequate land width by itself is, however, not enough. All efforts should be made to ensure that the land acquired is not encroached upon. It is also advisable to lay down restrictions regarding building line, set-back distance, control line, height of buildings, etc. Guidance in this regard can be had from IRC:SP:15-1996.

4.2 Route Location and Road Alignment

4.2.1 Route location and road alignment are key elements affecting the road landscape. The alignment should be fluent and blend with the surrounding topography. It should create the impression of moving naturally through the countryside instead of being forced through. To achieve best results, the following points should be kept in view:

i) Uniformity in design standards is an important factor in road alignment. Consistent application of a standard on a given length of a design element over a given length of road can considerably increase aesthetics and safety. For instance, a short sharp curve in an otherwise good alignment will lead to poor appearance besides creating an accident-prone spot. Similarly, if a change in standards becomes unavoidable, for instance where a hill road enters the plains, it will be desirable to effect the transition smoothly by introducing successive sections with gradually increasing design speed;

ii) A flowing line which conforms generally to the natural contours is preferable to one with long tangents slashing through the terrain. In this way, construction scars can be kept to the minimum and natural slopes and plant growth preserved;

iii) A winding alignment composed of short curves or broken-back curves (broken-back curve is one which has a short tangent section between two

curves in the same direction) is aesthetically and operationally poor and should be avoided;

iv) The alignment can be made more pleasing by providing large radii curves with suitable transitions;

v) The alignment should be logical and consistent. Sharp curves should not be introduced at the ends of long tangents. Sudden change from areas of easy curvature to areas of sharp curvature should be avoided;

vi) For small deflection angles, curves should be sufficiently long to avoid appearance of a kink;

vii) In designing a road alignment, the designer must keep in mind that the road is a three-dimensional entity and does not just consist of a plan and profile. Coordination of plan and profile is, as such, necessary to ensure safety and beauty in appearance.

4.2.2 For more information on geometric design features of road, reference may be made to IRC:73-1980 "Geometric Design Standards for Rural (Non-Urban) Highways".

4.3 Highway Cross-Section

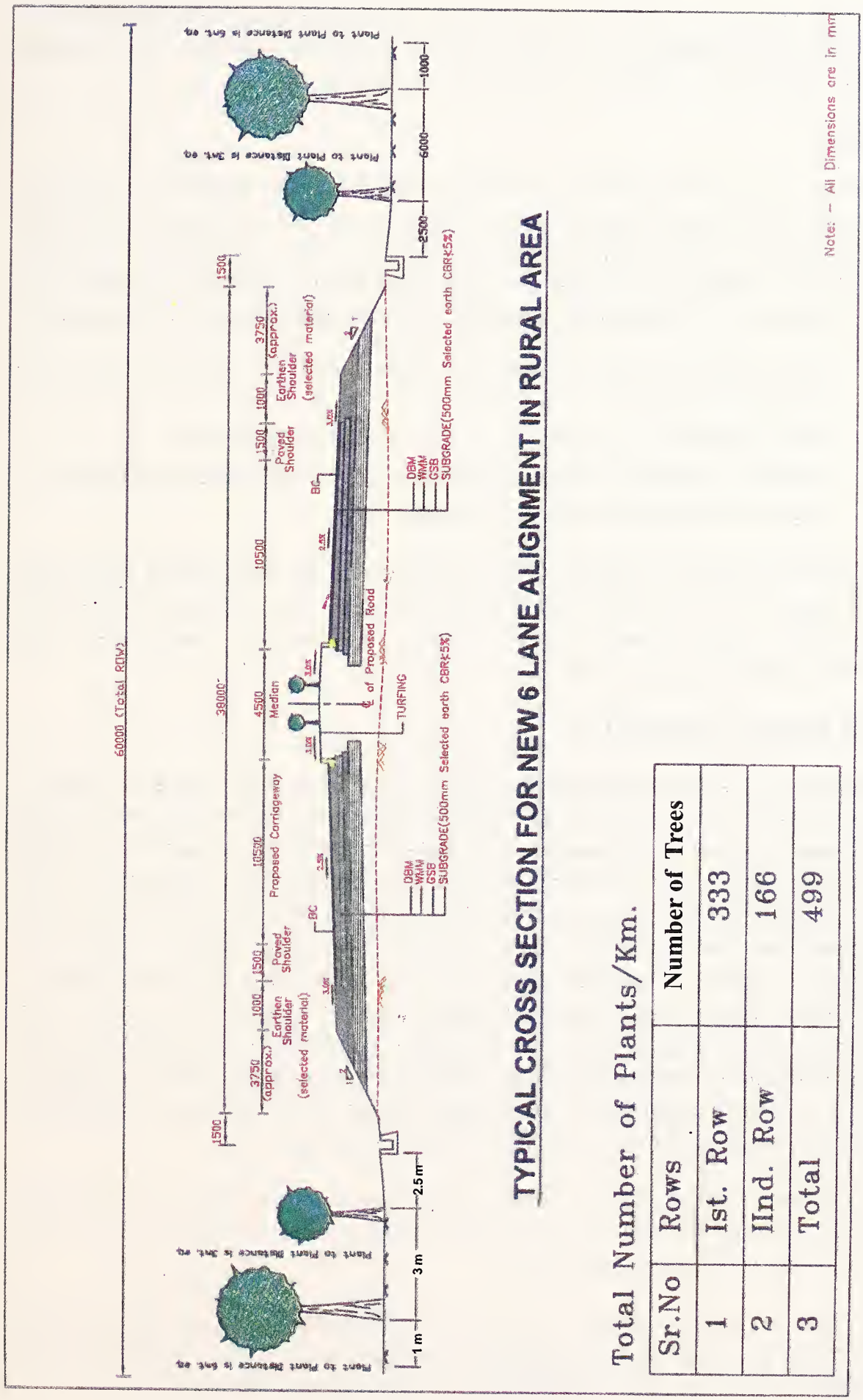
4.3.1 Cross-Section is an important constituent of highway design as it determines the special relationship between roadside and the component parts of the highway. The elements involved in highway cross-section are the carriageway, shoulders, median, embankment slopes, cut slopes, drainage system and roadside land. Design requirements for these are laid down in relevant standards, for example, IRC:73-1980, but from landscape point of view certain special considerations are required and are highlighted in Fig. 9.

4.4 Carriageway

4.4.1 Proper marking of the centre-line, edge-line and other pavement markings, and neat and unbroken delineation of the joints between the pavement and shoulder can improve road aesthetics a great deal besides safety. Attention should also be paid to maintain these features in proper order. Guidance about pavement and road marking details are given in IRC:35-1997.

4.5 Shoulders

4.5.1 Shoulders are the portions of a roadway continuous with the carriageway. This is essentially intended for accommodation of stalled vehicles, for facilitating crossing manoeuvres' or other emergency use and lateral support of the pavement courses. From landscaping point of view, it is desirable that the shoulders should be kept maintained to given lines and levels.



Total Number of Plants/Km.

Sr.No	Rows	Number of Trees
1	Ist. Row	333
2	IInd. Row	166
3	Total	499

Fig. 9 Typical Cross-Section for New 6 Lane Alignment in Rural Area

4.5.2 On high speed highways, it is advisable to surface the shoulders with the same material as the main carriageway. On other roads, the shoulders may be turfed or treated with gravel, stabilized soil, metalling or bituminous surfacing.

4.6 Median

4.6.1 Median is provided primarily to separate opposing traffic streams. To meet this objective, it should have good visibility both during day and night. Moreover, the median should contrast well with the through traffic lanes. A larger width for the median is desirable but this should be in balance with other components of the highway and consistent with economy. In deciding on median width, consideration of following factors will be helpful:

i) Preservation of natural vegetation or beauty spots by including these within the median area;

ii) Adequate space for screen planting to check headlight glare;

iii) Sufficient separation between roadways to eliminate head-on collisions;

iv) Space for emergency stopping of traffic.

4.6.2 Considering the width of about 4.5 m, it is normal to provide kerbs on both sides. But, if the median is considerably wider by any chance, the preferred course from landscaping point of view will be to grade the median area suitably towards the middle where a central drain may be provided.

4.7 Side Slopes in Cut and Fill

4.7.1 Roads may be in embankment, cutting, or partly in cutting and partly in embankment depending on the natural topography of the area. From safety and stability angle, side slopes in cut or fill will depend on the type of material encountered, the height/ depth of fill/cut and other related factors. However, from landscape considerations it will be desirable to adopt gentler slopes with corners rounded off smoothly. Flatter slopes improve appearance, prevent erosion, permit seeding, encourage growth of grass and contribute to road safety. In cuttings more than 6 m deep, it will be good practice to provide benches at intermediate heights alongwith softening of profile at top and bottom so that the long cutting slopes fit into the landscape comfortably. High embankments, especially at isolated over bridge crossings, warrant similar care and effort in design to avoid looking unduly conspicuous in the natural skyline. In these cases, satisfactory treatment will usually require taking of more land for contouring.

4.7.2 The top and bottom of fills and cuts and all other sharp corners in the highway cross-section, should be smoothly rounded off and turfed so that they flow into the natural contours and blend with the original ground.

4.7.3 Likewise, the transition areas between cut and fill slopes should be treated carefully in order to make the earthworks confirm to the adjacent terrain, encourage rapid establishment of vegetation cover and ensure economy in maintenance.

4.7.4 Slopes of cutting and embankment should be covered with vegetation to prevent erosion and integrate the road with the surrounding landscape. Seeding may be done on freshly graded slopes concurrently with grading or immediately thereafter. Grass is the basic erosion control material for highways but it requires maintenance. The primary function of grass is to stabilize slopes against erosion until voluntary shrubs, trees and weeds can establish themselves on the slopes.

4.7.5 An alternative to turfing is to encourage growth of ground cover consisting of bushy, dense-foliaged plants which have water holding capacity, along with iow growing shrubs which afford protection against erosion. Rapid growing species with inconspicuous flowers may be preferred from the point of view of maximum survival and avoidance of artificial effects. The governing principle should be preservation of natural growth and use of local varieties of grass, creepers and shrubs. Where low growing shrubs are used as ground cover, they are better planted in irregular masses or colonies rather than in rows. In heavy rainfall areas, preference should be given to broad leaf shrubs as they have better resistance against erosion.

4.7.6 The erosion control devices, such as, kerbs and paved gutters, if required, should be so designed and located that they are not unsightly.

4.8 Drainage

4.8.1 Drainage of surface and sub-surface water is a vital requirement of road design and construction. From landscape angle, the concern is mostly with surface water. Any ponding of water either on the roadway or in an uncontrolled manner on the adjoining road land is not only injurious to the road structure, but also not permissible from landscape angle.

4.8.2 Care should be taken to disturb natural drainage to the minimum. In many cases, it should be possible to develop low-lying areas by the roadside into beauty spots by a suitable plantation scheme taking advantage of the natural tendency for water to pond.

4.8.3 For ensuring better surface water drainage, the road camber should be consistent with the rainfall of the area and the rugosity or surface texture of the road surfacing. Shoulders should also have the requisite slope and there should not be any break in profile between the pavement and shoulder. Side drains should be properly connected to natural outfalls. The drainage system should be so located that it merges into the surrounding landscape. Where necessary, intercepting drains should be provided and other measures taken to protect natural surfaces from water erosion.

4.9 Roadside Borrow Areas

4.9.1 Roadside borrow pits disturb the natural setting of the ground and as such are undesirable from landscaping angle. Effort should be to balance the cuts and fills as far

as possible, so that borrow pits are altogether avoided, but this is not generally practicable in plain terrain especially where high embankments are involved.

4.9.2 In selecting roadside borrow areas, due consideration should be given to the requirements set out in IRC:10-1961. Desirably, the borrow areas selected, as also the waste disposal areas, should not be visible from the highway if it can be so managed.

4.9.3 Roadside borrow areas should be suitably treated, so that these do not have an adverse impact on the road landscape. Basic requirement is that the neighbouring ground should be rendered acceptable in appearance. To achieve this, the cut faces should be moulded to a flatter slope and the corners rounded off. Bottom of the pits should be sloped towards available natural outfalls so that water does not stagnate. If the borrow area is sufficiently large, possibility of converting it into a water spot to serve as a landscape feature should be explored.

4.9.4 After every major construction or repair work involving borrow of earth, it is essential that the borrow sites should be closely examined for all possible remedial measures to minimize damage to the environment. This should not be left over as a secondary task but regarded as a part of the project itself.

4.9.5 Where the above measures are not practicable, adequate space should be provided to allow for installation of screen planting.

4.10 Roadside Arboriculture

4.10.1 Apart from the consideration of alignment, grades, cross-section, etc. the most important factor in landscaping is tree plantation and preservation. Unless this is done with care, the highway landscaping will not be complete. Plants placed wrongly or badly maintained may, in fact, mar the environment and cause danger to high speed traffic through obstruction of sight distance, risk of collision with tree trunks, and skidding caused by fallen leaves.

4.10.2 Appropriate planting also contributes to road aesthetics and visual enjoyment by motorists which can act as a check on excessive speeding. For detailed guidelines about roadside arboriculture, refer to Section 11.

4.11 Highway Structures and Appurtenants

4.11.1 Different structures like bridges, culverts, subways and flyovers, apart from abutments such as guard-rails, delineators and road signs are encountered along the rural highway. In hilly mountainous terrain, retaining walls and breast walls are a frequent occurrence. Design and construction of all such structures requires care so that these blend well into the natural landscape without being out of scale with the surroundings.

5 LANDSCAPE DEVELOPMENT – URBAN AREAS

5.1 General

5.1.1 Principles of landscape development are essentially the same, whether the situation be urban or rural. But their application in and around cities has its own ramifications since the environment is mostly man-made and the scope for natural landscape features is greatly restricted. In larger cities the position is still more difficult because of almost continuous built-up areas along the existing roads. Due to these differences, urban landscape efforts normally require more careful and skillful designs to plan and execute than rural highways.

5.1.2 The more important factors affecting landscape development in urban areas are discussed below with a view to evolving appropriate designs in such cases.

5.2 Road Land Width

5.2.1 The factors influencing land width for roads in urban areas are:

i) City zoning requirements as per regional/master plan;

ii) Functional classification of the road e.g. arterial road, local street, etc;

iii) Present and anticipated traffic;

iv) Need for service roads, footpaths, cycle tracks, medians, space for under and over-ground services, rotary intersections, etc;

v) Provision for environmental protection and landscape development measures, such as noise barriers, screen plantations, etc.;

vi) Requirement of open space for recreation;

vii) Cost of land

5.2.2 Besides the above factors and the tangible economic as well as the intangible aesthetic benefits of roadside, landscape should be weighed while taking a final decision about the land width.

5.2.3 Road land in urban areas is highly susceptible to encroachment.

5.3 Road Alignment

5.3.1 Location of urban roads is often dictated by the type of road system decided upon in the regional/master plan of the area. It is, therefore, necessary that landscape requirements of these roads be given due consideration at the time of preparation of such plans. Guiding principles should be that the road fits into the city surroundings and is so landscaped that it has a healthy effect on the development of adjoining areas. As such, the landscape measures should fully keep in view the requirements of residents of the locality

besides those of users of the route. Overall attempt should be that residents, pedestrians and road users all derive maximum possible benefit and enjoyment.

5.4 Highway Cross-Section

5.4.1 Cross-section of the road determines the relationship of the roadside to pavement and other component parts of the highway. Guidelines with regard to design of different cross-section elements from landscape angle given in para 4.3 for roads in rural areas apply to urban areas as well, but with certain variations. Important among these are:

i) Some definite space should be earmarked for underground/ overhead services. The services should be so located and planned that these do not interfere, in any way, with traffic operations and are not out of scale with overall appearance of the road.

ii) Careful consideration should be given to the location and spacing of all access points including terminals, railway stations, parking areas etc., so as to ensure safety and freedom from congestion.

iii) The cross-section should have provision for footpaths, cycle tracks, service or frontage roads, etc., depending on the anticipated requirements.

iv) Due care should be taken to maintain the median plantation in order to avoid its spread beyond the median margins. On urban highways the medians should be provided with a continuous line of shrubs to cut off headlight dazzle. However, in such cases where the median is too narrow (say upto 1.5 m) to permit plant growth, it should be turfed with grass and flowering plants. Narrow medians may be covered with suitable contrasting material or paved with hard materials like chequered tiles for improving the appearance.

v) It may be necessary in certain cases, for reasons of engineering and cost of land acquisition, to use retaining walls in lieu of slopes (Fig.10). The relationship of the height of the retaining wall to the width of the roadway is important from the stand-point of appearance. Retaining walls may be faced with stone masonry to yield an attractive appearance. As a better alternative, creepers could be trained on the retaining walls to beautify the surroundings.

5.5 Drainage

5.5.1 Surface drainage in urban areas is generally ensured through a gutter and kerb arrangement with drain inlets connected to the storm water system. Desirably, all unpaved areas in the highway cross-section should be provided with erosion-proof turf to prevent soil from being carried into the storm sewer system. Lack of effective erosion control may result in unsightly small channels or eroded areas, which may be costly to repair.

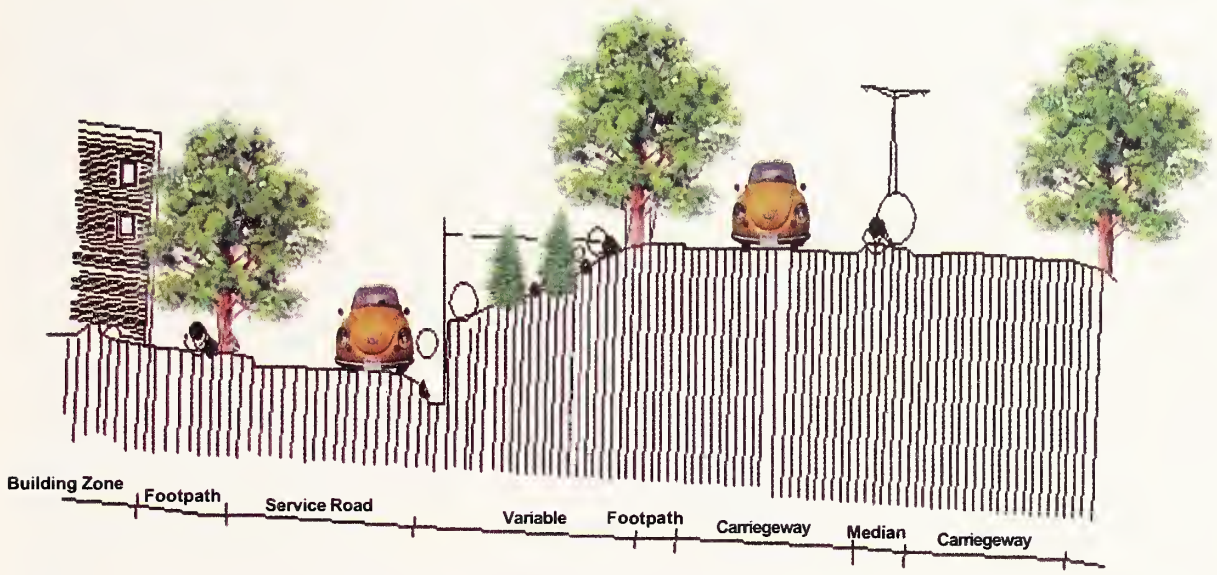


Fig. 10 Economy and Pleasing Effect Achieved by Reducing the Height of Retaining Wall

5.6 Borrow Areas

5.6.1 Borrow pits should not be allowed in urban areas though these may occur in sub-urban situations. Landscape treatment of such pits should be taken up on lines discussed in Para 4.9.

5.7 Roadside Arboriculture

5.7.1 Because of the high cost of land, Right of Way available is often a limiting factor in urban areas as to the extent and character of landscape development. The land width may vary from an extremely narrow strip, enabling only limited opportunities for planting, to areas of sufficient width, which have all the space required for this purpose. At the same time, if suitable plantation in the form of shrubs, flower beds, avenue trees, etc. can somehow be provided, it can considerably enhance the economic and aesthetic value of area in and around the highway (Figs. 11 and 12).

Fig. 11

Fig. 12 Avenue Plantation

5.8 Highway Structures and Appurtenants

5.8.1 Besides structures like bridges, culverts, subways etc., a large number of miscellaneous appurtenants such as lamp posts, bus shelters, overhead service lines, kiosks etc. frequent the roadside in urban areas. Road intersections occur more frequently and are usually of different type compared to rural highways. Some relevant aspects in this regard are brought out in Section 6.

6 HIGHWAY STRUCTURES AND APPURTENANTS

6.1 Bridges and Approaches

6.1.1 In the choice, design and construction of bridges and approaches, the basic consideration is that these should not only be structurally sound but pleasing in appearance and appropriate to the setting. The following points may be kept in view in this regard:

i) The bridge structure including appurtenants like railings, parapet walls etc. should be designed to contribute to the overall aesthetic quality of the road and landscape.

ii) The size of the obstacle (e.g. river, railway line etc.) to be crossed, engineering requirements and the physical properties of the site largely determine the type of structure. The general character of the surrounding land, its topography (flat, rolling, hill etc.), and its use (e.g. rural, agriculture, wooded-land, built-up, industrial, etc.) will be relevant to the distant or near view of the bridge. These factors along with the natural/man-made features

will help to determine the scale of the bridge, its proportions and general design including that of railings, parapets etc.

iii) Where a new bridge is to be built in lieu of an old historic structure, it will be desirable to site it a little bit away, so that a view of the existing bridge is available. It is equally important that the scale and height of the new bridge should be in consonance with the setting.

iv) Consideration should be given to the use of building materials of such type, colour and texture that these not only make the structures architecturally attractive but also help to harmonise them with the natural landscape of the area. For instance, coarse finished or stone-faced structures will be more appropriate in forest areas.

v) Approaches to bridges should blend with the terrain of the land, retaining natural beauty of the surrounding areas. Where possible, the approaches to major bridges should be so aligned that the bridge is visible from a distance and catches the eye of the road users, thereby breaking the monotony of travel.

vi) Adequate planting and other landscape measures in the proximity of bridges can enhance the beauty of the area (Figs.13 to 16).

vii) Where adequate level ground is available in the vicinity of bridges, the same could be developed into a roadside rest area so that travellers may halt there for short periods and enjoy the beauty of the river, bridge and the landscape.

viii) Proper merging of bridge structure with the approaches, each of whom normally has a different cross-section, is an important factor which will affect aesthetics of the highway. The transition should be smooth and gradual for better appearance and safety.

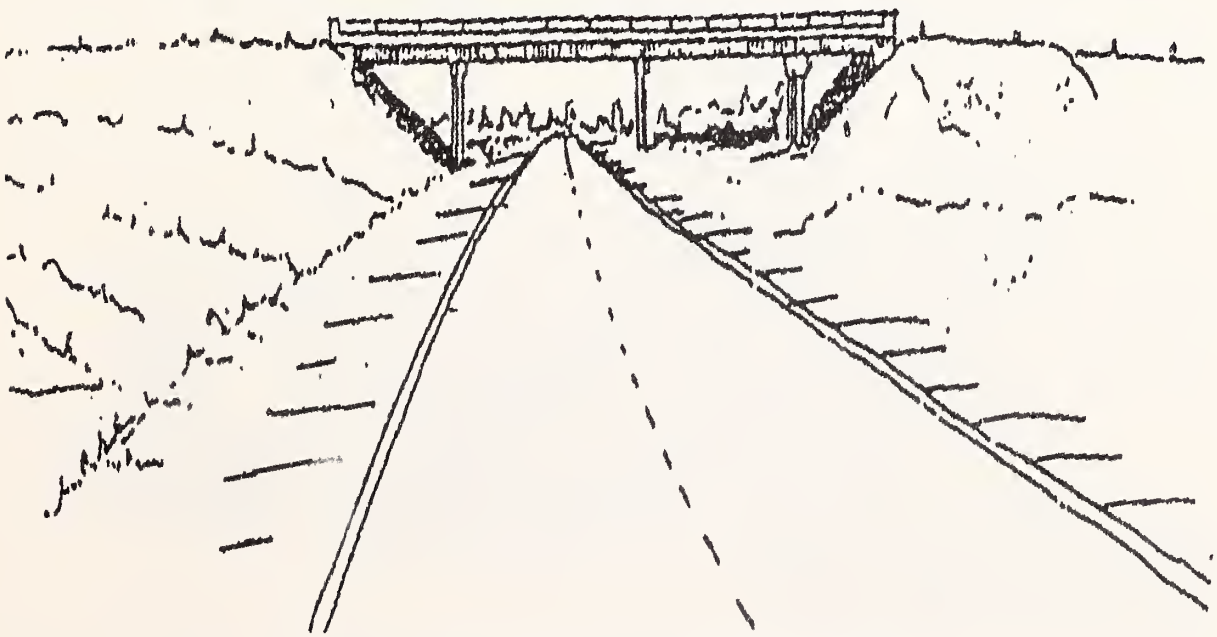


Fig. 13 Underpass without Landscape Treatment

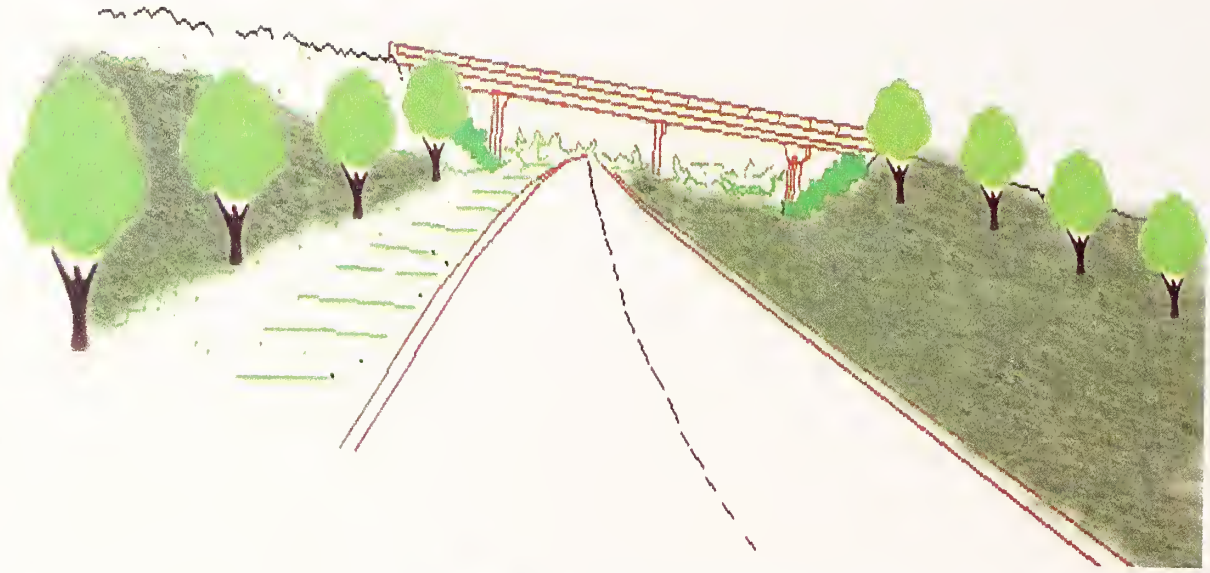


Fig. 14 Underpass in Fig. 13 after Landscape Treatment

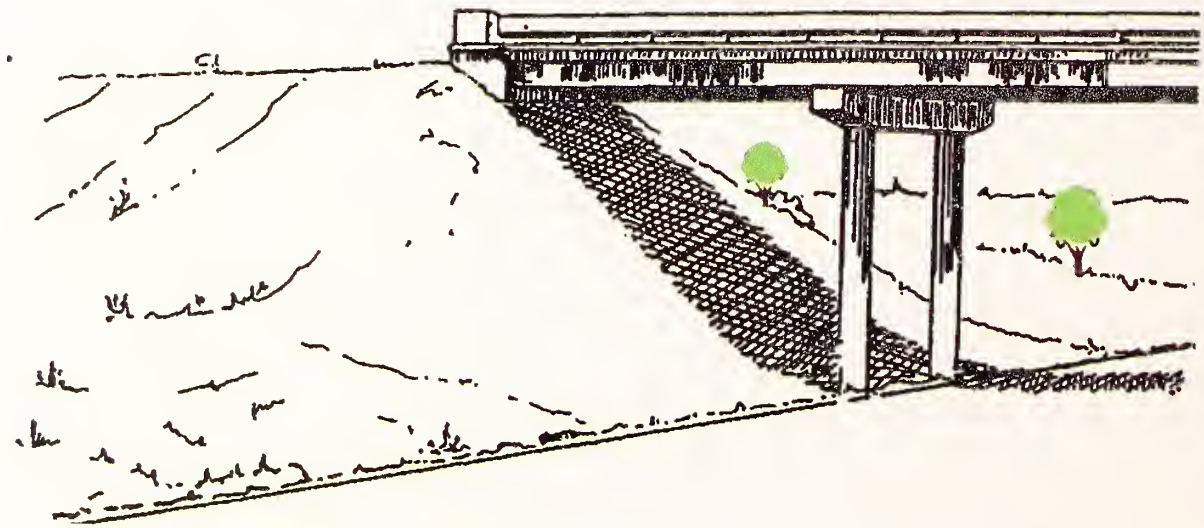


Fig. 15 View of Underpass without Landscape Treatment

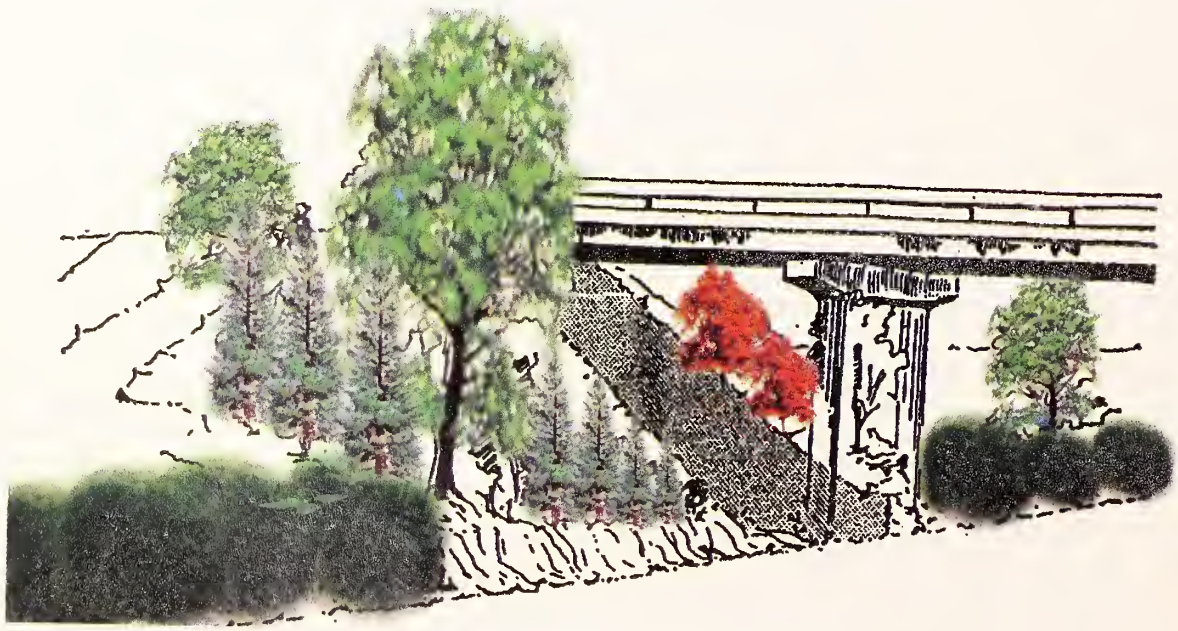


Fig. 16 Underpass After Landscape Treatment

6.2 Crash Barrier

6.2.1 These are generally warranted on approaches to bridges, high embankments and other similar locations. Proper thought should be given to the layout and choice of material for the rails so that these easily blend with the surrounding landscape.

6.3 Tree Guards

6.3.1 Tree guards should be of appropriate design to so that these are functional and at the same time add to the aesthetic view of the highway (refer Section 11).

6.4 Road-Intersections – Rotary/Roundabout

6.4.1 Road intersections are main nodal spaces and are of vital importance in terms of road aesthetics. Proper landscaping of the traffic islands and the surrounding areas should integrate these features with the surrounding landscape. The lay out of traffic intersections should be fixed by the traffic needs of the junction. The landscape design should consider the basic standards of height limitations, appropriate sight lines and other geometric design elements that are applicable to each type of traffic intersection.

6.4.2 Different types of intersections are met with along a road. In rural areas, these are generally of channelised type. Occasionally, rotaries with low kerbs for the central island are also used. Grade-separated interchange may also be necessary in certain urban and rural locations.

6.4.3 Basically, the type and layout of an intersection will depend on the volume and turning movements of traffic. Appropriate landscaping measures at these locations can improve the aesthetics as well as contribute to safety. While the actual landscape treatment will depend on the individual site conditions, the following guidelines will be helpful:

i) The intersection should be visible for sufficient distance from all the approaching roads;

ii) Smooth flowing lines and liberal turning curves will improve the appearance, besides safety.

iii) Traffic islands should be turfed and provided with flower beds or short growing shrubs. Central island sand corners of rotaries offer great potentiality for such a treatment. In such cases, particularly in urban areas, provision of fountains and coloured lighting in the central island will not only enhance the overall aesthetics but also provide a place for rest and recreation (Figs. 17 and 18).

iv) At grade separated intersections, the entire interchange area should be designed as a unit in relation to the surrounding topography and potential land use development of the adjacent area. Slope grading, drainage; erosion control and turfing should be co-related with the design of all roadways and

structures, both to enhance the appearance of the area and to keep construction and maintenance costs to the minimum. Effort should be to make the interchange complex as less out of scale with the surroundings as possible. While preparing the detailed design of the ramps, loops and interchanges, planning should be done with the help of landscaping architects.

Fig. 17 Well Planned Scheme of Planting on Approach Island of a Rotary

Fig. 18 Landscape Treatment of a Large Rotary and included Corners through various Measures

6.5 Road Signs

6.5.1 Road signs are an important component of the traffic control system. Type, size colouring and lettering pattern of the signs should be as per IRC: 67-2001 "Code of Practice for Road Signs". The sign system can be made more pleasing by treating an entire road section in one go, instead of sporadic actions at individual locations. At intersections, the

signs should be planned in a logical sequence, instead of haphazard placement. On the whole, there should be no proliferation or clustering of signs, especially in conjunction with different utility posts, which could lead to unsightly conditions.

6.6 Miscellaneous Roadside Appurtenants

6.6.1 Design and construction of roadside appurtenants like railings, parapets, retaining walls, light poles etc., need careful consideration with regard to their effect on the landscape. It will be advantageous to associate landscape architects/urban designers in the design of their appurtenants. A typical design for a roadside railing in urban areas is shown in Fig. 19.

Fig. 19 Typical Design for Road Side Railing in Urban Area

6.6.2 Lamp posts on urban roads should be of appropriate design, so that in combination with other posts and verticles they produce a pleasing appearance. In historic towns or other areas of special architectural character and on roads having completely open vistas, the effect of some forms of lighting installations which tend to be over prominent can be completely devastating to the surroundings. Special care in the selection of lighting fixtures is, as such, necessary.

6.6.3 Bus bays and bus shelters should satisfy the functional requirements and also suitably merge with the landscape of the road so as to enhance the general view.

6.6.4 Letter boxes, telephone junction boxes, electric transformers, overhead power/ telephone lines etc., need similar care in design and erection so that these do not spoil the beauty of the road.

6.6.5 In urban areas, both along the road as well as at junction corners, amenity of the surroundings can be considerably enhanced by constructing small water fountains with lighting arrangement, green grass strips, flower-beds etc. But it should be carefully planned with the help of an architect.

7 ROAD SAFETY AND ROAD AMENITIES

7.1 Road Safety

7.1.1 The landscaping and plantation along highway play an important role in providing road-safety for road users as under:

- To define the toe and median of the carriageway, specially horizontal sharp curve during night time.
- Prevention of glaring from headlight of incoming vehicles.
- Control of erosion by turfing the slope of the embankments
- Trees along the embankment slopes and near major water bodies play a major role in control of erosion. Similarly, green cover in the form of turfing stabilizes steep slopes and high embankment.
- Moderating the effect of wind and incoming radiation
- Large and spreading shade trees, with thick foliage provide much needed shade.
- To provide much needed shade on glaring hot roads during summer
- To define the historical places by landscaping and turfing as per the existing scenario.

7.2 Roadside Amenities

7.2.1 General

7.2.1.1 Importance of roadside amenities along trunk highways needs no emphasis since such amenities can contribute greatly to the safety, convenience and enjoyment of road travellers.

7.2.1.2 Roadside amenities are of the following types:

- Roadside rest areas
- Truck parks
- Off strip parking places (roadside lay byes)
- Service Stations

7.2.1.3 Choice of location, the type of facility and its frequency will depend on the classification of the highway, traffic volume, topography and other related factors. Overall consideration should be that the amenities fit into the natural surroundings and are designed and treated in such a way that these form a part of general road landscape.

7.2.1.4 Specific features of the different types of roadside amenities are discussed further.

7.2.2 Roadside rest areas

7.2.2.1 Roadside rest areas are intended for rest and relaxation of long distance travellers

and may occasionally provide facility for over-night stay also. These may be in the form of rest houses specially developed for the purpose. In the selection of individual sites, due consideration should be given to the topography, existing vegetation growth, scenic and historic values, cost of land, land use pattern, availability of facilities like water supply, sewerage etc. and the distance from other similar areas.

7.2.2.2 Drinking water supply, toilets, provision for food/snacks, shady or covered areas for rest, space for parking are some of the essential facilities to be provided at roadside rests. Accommodation for over-night stay may also be provided, where feasible.

7.2.2.3 At the rest areas, ample shady trees should be developed for parking of cars in summer and to provide shade to travellers who may like to use grassy lawns for recreation. The lawns may be provided with proper footpaths to preserve the grass. Footpaths should be planned and constructed in a manner that these become part of the landscape. Suitable plantation for screening the noise of moving vehicles on the highway may also be provided.

7.2.2.4 Furniture items like benches, tables, litter boxes, etc. should be of natural design so that these form part of the landscape and involve minimum maintenance. The benches could be made of wooden logs, stones etc. All these aspects should be carefully planned in consideration with the natural surroundings.

7.2.2.5 Normally, spacing of roadside rest spots along National Highways and State Highways should be 100-125 km. In actual location, preference should be given to sites which are of interest to the travellers such as dam sites, bird sanctuaries, water falls and other places with beautiful vistas like snow-clad mountains, river/canal banks or sea shore.

7.2.2.6 Typical layout design for a roadside rest area is shown in Figs. 20, 21 and 22 which show the views of a roadside rest area developed along a National Highway.

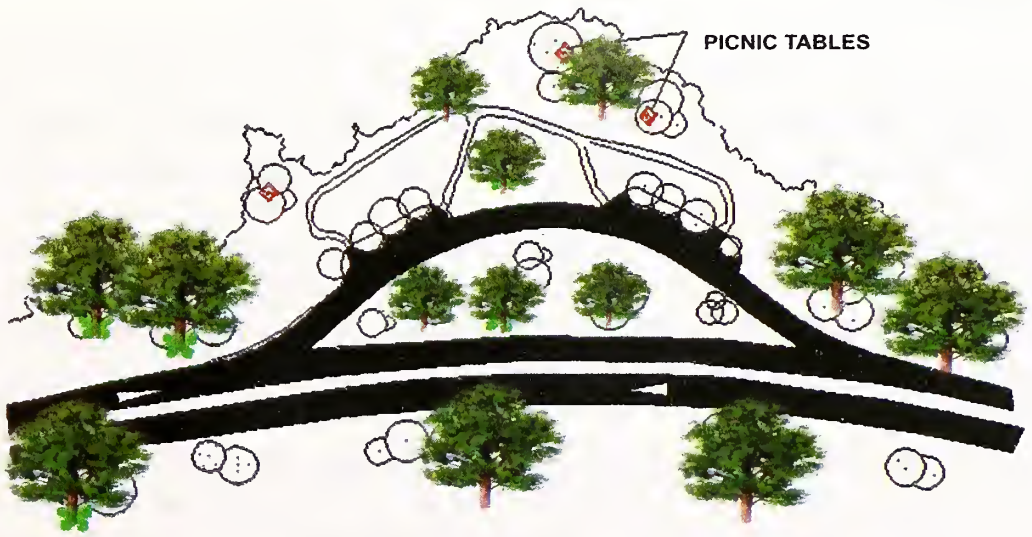


Fig. 20 Typical Layout Design for a Roadside Rest Area

Fig. 21 View of a Roadside Rest Area along a National Highway

Fig. 22 Another View of Rest Area

7.2.3 Truck lay byes

7.2.3.1 Truck lay byes are intended mainly for the convenience of long distance truck operators. These must provide the same basic facilities as at roadside rest areas (vide para 7.2) but the parking lots will have to be bigger in area to accommodate a larger number of trucks.

7.2.3.2 Truck parks are generally developed near check barriers or at inter-state borders or at places of conventional stops of the truck operators. These places should have ample space for parking where big trees are planted to provide shade for trucks, besides lawns for the relaxation of truck operators. The trees and shrubs should be of hardy type. In order to break harshness of the big parking area, some green pockets should also be developed. As regards open area, it would be advantageous to go for a combination of paving and grassing so as to reduce maintenance cost. Proper screen planting may also be required to insulate the area from the highway. Typical layout for a truck park is shown in Figs. 23 and 24.

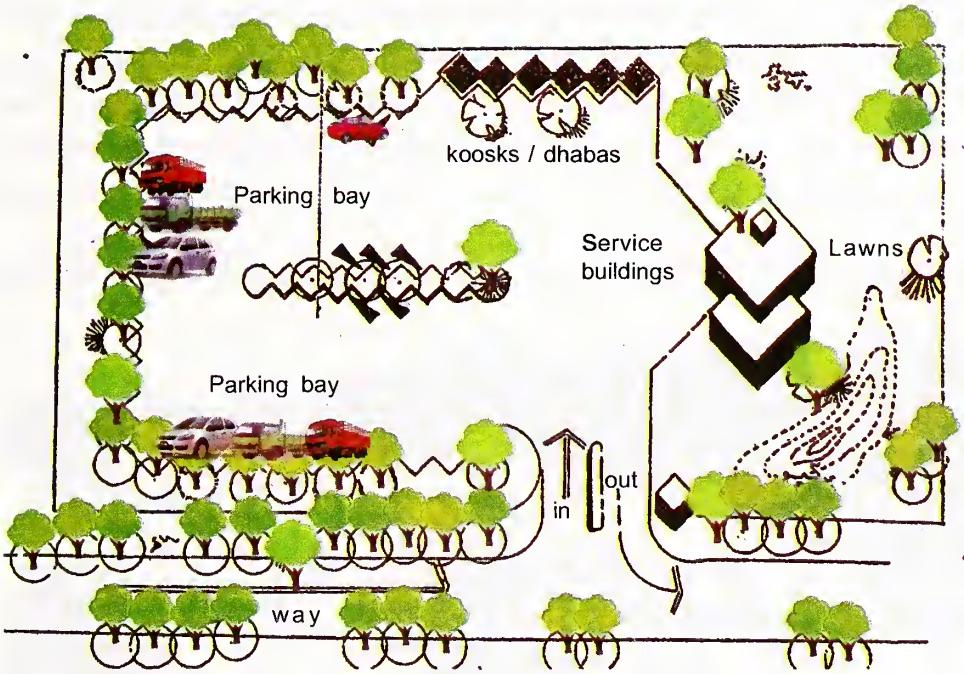


Fig. 23 Typical Layout Design for a Truck

Fig. 24 Screen Plantation along Urban Highway

7.2.4 Off-strip parking places (bus lay byes)

7.2.4.1 Off-strip parking places are basically roadside lay byes constructed parallel to the road. They serve a purpose similar to roadside rest places, except that these are smaller in size, have comparatively limited facilities and are intended to be used for short periods, mainly for stoppage of buses. Because of the nature of their usage, the spacing of such lay byes is generally much closer than full-fledged rest areas. On busy trunk routes, it may be desirable to aim at a spacing of about 70-80 km. At times, it may be advantageous to start with a smaller off-strip parking place and develop it gradually into a bigger rest area.

7.2.4.2 The direction of the sun may also be considered while planting the shade trees in order to ensure that the shade is available to the parking vehicles. If feasible, the position of off-strip parking places should be adjusted to combine with any natural scenic lookouts by the side of the road. In such locations, besides planting of new trees, existing trees

should be preserved for the purpose of shade and beauty. Benches and tables and a small shelter could also be provided for the facility of drivers. The architectural treatment of these features should be such that they merge with the surroundings and do not appear isolated. Similarly, if any railing is provided, it should be rustic in appearance and made of local materials. An important consideration should be that the maintenance cost is minimum.

7.2.4.3 Fig. 25 illustrates the salient features of an off-strip parking place in plain terrain.

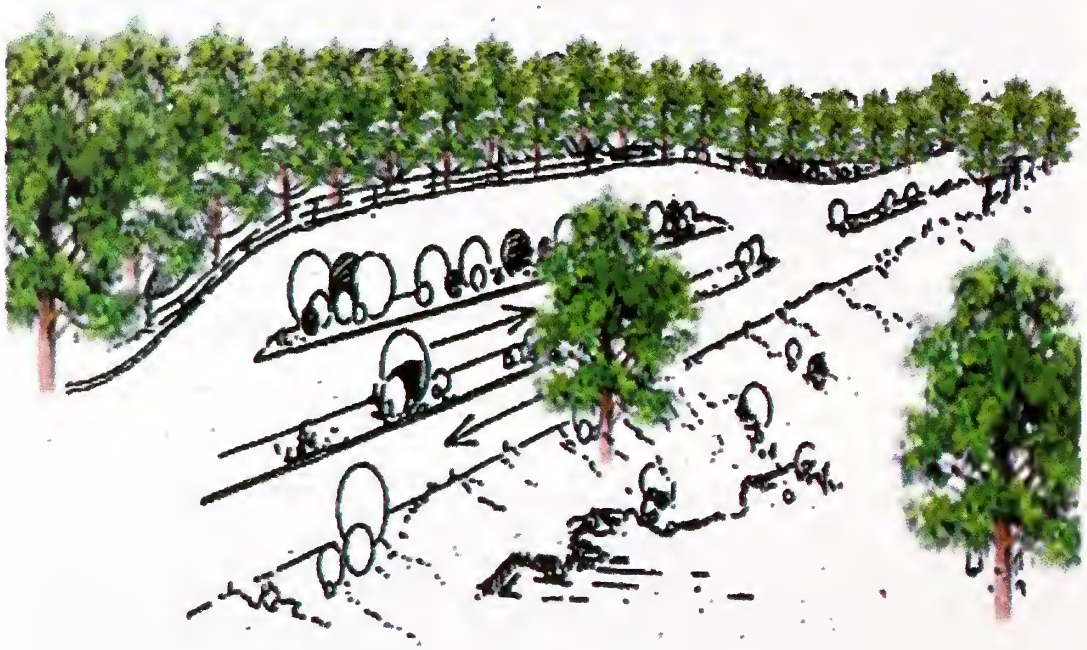


Fig. 25 Typical Layout of an Off-Strip Parking Place in Plain Terrain

7.2.5 Service stations

7.2.5.1 Service stations catering to fuel, oil and repair requirements of vehicles are needed to be spaced out at more or less regular intervals along important highways and as such the choice of sites with respect to the road landscape will generally be restricted. All the same, it should be ensured that these do not adversely affect the natural beauty. All efforts should be made to blend the service stations with the natural landscape by choosing suitable designs for structures and necessary planting.

8 LANDSCAPE TREATMENT FOR SPECIAL AREAS

8.1 Special points needing attention when dealing with landscape treatment of roads passing through industrialized belts, water-logged areas, sandy/desert tracts, forest areas and coastal regions are dealt with in this Section. These are in addition to the basic design considerations discussed in this Manual, which remain the same.

8.2 Landscaping Treatment at Sensitive Noise Receptors

8.2.1 All along the highway corridor certain sensitive receptors for noise should be identified, like the Schools, residential colonies and Hospitals. Special treatment should

be given to all these sites in terms of landscaping and planting. A lot depends on the space available for providing noise barriers. Within the limitations of the available space, physical noise barriers and plantations can be combined to reduce the noise levels considerably. At these sites the first row should be of tall shrub of 1.5-3 m height with dense foliage for the purpose of maximum possible screening effect. Species like Cassia alata, Cassia biflora, Hemelia patens, etc are used for this purpose. Last row could be planted with trees like Neem (Azadirachta Indica), Mango (Mangifera Indica), Shisham (Dalbergia Sisso), Imli (Tamarindus Indica), and Karanj (Pongamia sp.). The intermediate rows may have flowering trees like Amaltas, Gulmohar, Kachnar etc. As far as possible, three rows of plantation may be planted for reducing the noise levels.

8.3 Landscape Treatment for Highly Industrialized Areas

8.3.1 If some heavy industry already exists by the side of the road, it will be advisable to provide planting on both sides of the road to screen out any possible unsightly views (Fig. 26).

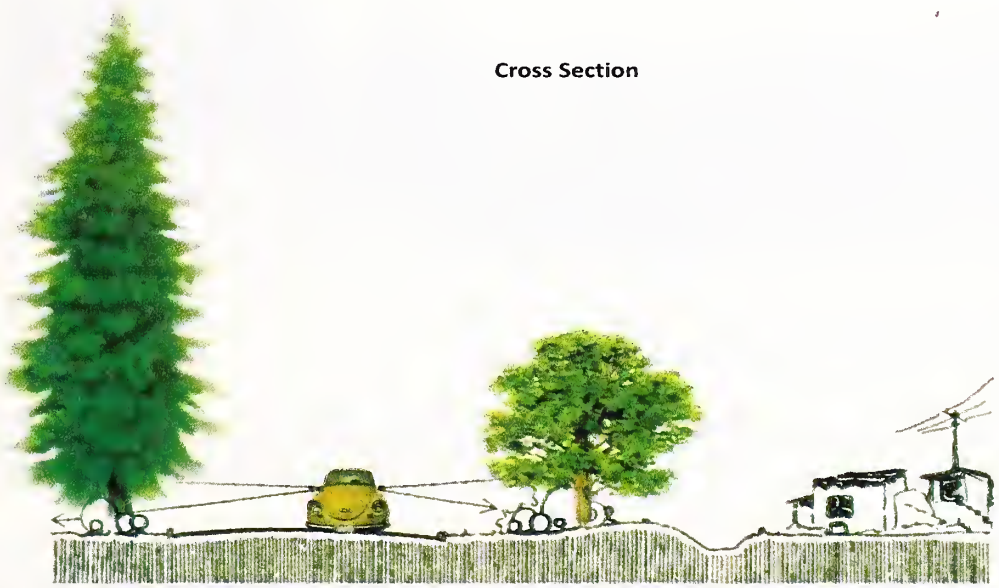


Fig. 26 Use of Screen Plantation to Insulate Slums and Other Unsightly View

8.3.2 Where a new industrial area is to be developed, requirements of landscape should be kept in view at all stages of planning, design and construction.

8.3.3 In areas where some chemical industry has been set up, it is possible that fumes from factories may prove injurious to the drivers or create difficulties in safe driving. To minimize these effects, it will be desirable to create a thick green buffer between the highway and the industrial area, using plants which can safely grow in such environment.

8.4 Landscape Treatment in Waterlogged Areas

8.4.1 The type of landscape treatment to be given will depend upon the extent of water logging in the area.

8.4.2 If the surrounding area has standing water on both sides of the road, it may not be possible to treat land in the usual way. In such cases, aquatic plants like water lilies, lotus, etc., should be introduced to make the area beautiful.

8.4.3 At some places where water level is very high, the water logged portion could be developed into a pond or lake for use as a rest spot by the road users.

8.4.4 Plantation scheme for such areas should be so decided that the plants can grow well under the waterlogged conditions, do not need much maintenance and, if possible, can even help in lowering the water table. For plantation details, refer to Section 11.

8.5 Landscape Treatment in Sandy/Desert Areas

8.5.1 In sandy areas, only such species of vegetation are recommended which have the least water requirement and are of succulent and spring type with thinner leaves. As far as possible, local plants should be preferred from the angle of easier maintenance and bringing up.

8.5.2 Besides beautification, one of the functions of vegetation in desert areas is to act as a barrier against shifting sand. Where it is not possible to grow plants for this purpose all along the road, effort should be to develop at least smaller pockets at intervals which could also act as rest areas. Such rest areas in the desert will be able to provide considerable relief to road users in intense heat. For more details about plantation, refer to Section 11.

8.6 Landscape Treatment in Forest Areas

8.6.1 As far as possible, no new road should be aligned through the forest. Only under unavoidable circumstances, a road may be planned with restricted ROW.

8.6.2 Cutting of trees should be avoided, as far as possible. But wherever road passes through animal corridor, it may be ascertained that there is minimum disturbance to the forest and the animal life. This is illustrated in Fig. 27.

8.6.3 In continuously wooded areas, there might be scenic spots and open vistas hidden behind vegetation. By selective thinning and pruning of vegetation, contrasting views could be developed so as to break the monotony of travel, (Fig. 28).

8.7 Landscaping of Coastal Highways

8.7.1 Desirably, the road should be aligned along the sea coast so that the travellers can fully enjoy the natural scenery. At the same time, the road should not be so conspicuous and close to the waterline that there is an adverse effect on the overall surroundings. For instance, the route could be located behind sparingly planted groups of trees which will permit full views to the travellers and yet disturbance as regards visitors to the beach will not be so much. At places, dense plantation could be made use of to screen private areas and undesirable views.

Landscaping of Roads

A. Undesirable Method:

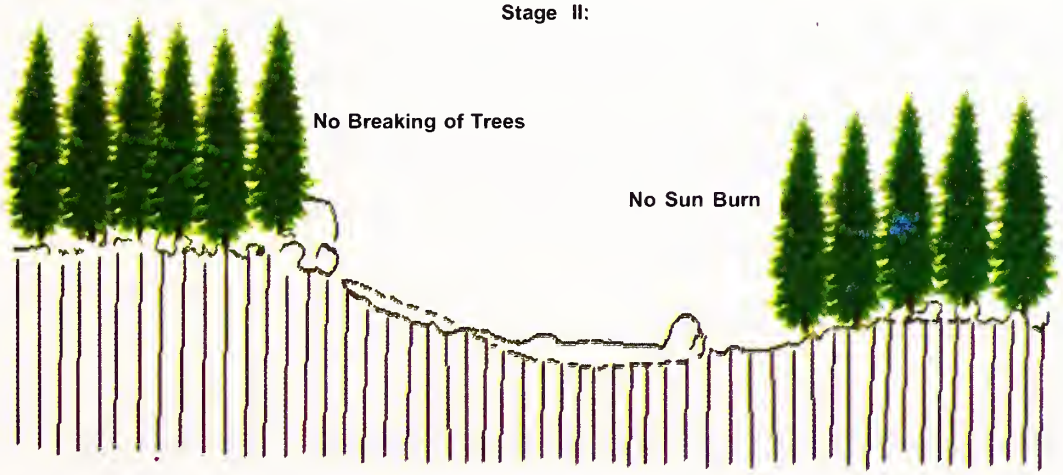
Felling of Tree in one Stroke at the Time of Road Construction may Result in Breakage of Trees by Wind Effect Due To Lack of Gradation of Plantation, and Sunburn on Account of Sudden Exposure of Fresh Trees to hot Sun.

B. Desirable Method Stage I:

(I) Initially Thinning of Forest should be done Along the Road Alignment.

(II) Simultaneously, New Plantation should be Provided on the Road Side.

Stage II:



After The New Plantation Cones Up the Central Portion should be Cleared for Road Construction.

Fig. 27 System of Felling Trees in Forest Area

Fig. 28 Exposing Scenic Spots and Open Vistas in Continuously Wooded Areas through Selective Pruning of Plantation

9 IMPROVING LANDSCAPE OF EXISTING ROADS

9.1 To improve the appearance of existing roads through landscaping measures, can prove to be a variably difficult task because of several limitations, e.g. restricted land width, difficulties in road realignment, presence of man-made features not conducive to aesthetic treatment, etc. Yet, every possibility of beautifying the landscape should be investigated and feasible steps taken.

9.2 Inventory of Existing Features/Facilities

9.2.1 The first stage in formulation of a viable programme for beautification of an existing road will be to prepare an up-to-date inventory of all landscape features including existing plants and other amenities by the side of the road. The inventory should be depicted on linear plans together with indication about potential locations where scenic lay byes, roadside parks, group plantations etc., could be developed. The existing features and roadside shoulders should be maintained properly.

9.3 Acquisition of Additional Land

9.3.1 Based on the inventory, an action programme should be prepared as regards additional landscaping measures and traveller amenities. If available land width is insufficient to implement this programme, acquisition of additional land should be seriously considered keeping in view the following requirements:

i) To provide flatter side slopes in cuts and fills alongwith contouring of the adjacent land.

ii) To provide enough space for planting suitable trees and plants.

iii) To provide sufficient area for parking, look out spots and other aesthetic features.

9.4 Borrowpits

9.4.1 Treatment to borrowpits should be planned on the following lines:

i) Improvements to the existing borrowpits by remoulding them into water spot.

ii) Grading the sides of existing borrowpits with suitable curves to minimize the effect of harsh vertical faces.

iii) Avoiding future borrowpits, or if absolutely necessary regulating their excavation according to prescribed norms.

9.5 Arboriculture

9.5.1 Detailed guidelines about arboriculture are given in Section 11. On existing roads, the following points deserve special consideration:

i) Adopting an integrated scheme of planting so that the new trees and shrubs go well with existing vegetation.

ii) Grassing/turfing for erosion prevention.

iii) Screen planting to block unsightly views.

9.6 Other Measures

9.6.1 By properly regulating the advertisement boards and improving the illumination, the road may be made more pleasant to the traveller.

9.6.2 Sides of roadside drains should be dressed and trimmed properly to improve the appearance. Where there is a steep fall in levels along the drain, small weirs may be constructed at intervals to allow the water to fall in cascades, which will create a pleasant effect.

9.6.3 Ugly manure pits, dilapidated huts and other unsightly spots which mar the beauty of the landscape should be removed or screened off suitably.

9.6.4 Removal of tree branches obstructing smooth traffic movement and good view should be carried out judiciously. Similarly, old tree stumps should be removed and the area made presentable by suitable means.

10 MAINTENANCE OF ROADSIDE PLANTATION

10.1 Maintenance of roadside arboriculture includes a number of operations such as (i) tending saplings of trees and plants till they can stand by themselves, (ii) selective pruning of shrubs, trees etc., from considerations of traffic operations and safety, (iii)

maintenance of grass in turfed areas and (iv) keeping the rest areas neat and clean.

10.2 For detailed guidelines about tending saplings of trees and plants, refer to Section 1.

10.3 Selective pruning or cutting of trees and shrubs will be required at situations where these (i) interfere with sight distance, (ii) come in the way of effective street illumination, (iii) are too close to the carriageway so as to be hazardous, (iv) conceal desirable views and scenic vistas and (v) have become too old or dead.

10.4 Maintenance of vegetation should be scheduled for the most effective seasons for each class of work. For example, grass mowing should be at intervals governed by growth rates, fertilizing of turf should precede maximum growth periods and selective pruning of plants should precede the dormant period. Some items of roadside maintenance such as tree removal and tree care, which are not seasonal, may be scheduled for other periods.

10.5 On heavily trafficked highways in urban areas, rising dust is a continuous problem, particularly during the dry weather. The dust may settle on roadside plants and shrubs and spoil their beauty. Where the problem is acute, plants and shrubs should be periodically given a wash to remove the dust.

10.6 The trees and plants should be maintained under the supervision of horticulture staff and new plants put up, wherever necessary, in adequate time, especially to replace the dead and old trees. Proper working plans should be prepared where the work involves felling of mature trees/plantation.

11 BROAD GUIDELINES OF ROADSIDE/MEDIAN PLANTATION

11.1 General

11.1.1 This Section gives broad guidelines about different aspects of roadside arboriculture. For proper selection of plant, native plant species have been recommended for different climatic regions, In Appendix-I principal details of each of the species, such as, their name in different languages, characteristics of growth and the suggested location of use has been described.

11.1.2 Tree plantation is the most effective, economical and useful remedy for control of environmental pollution. Besides, it is the cheapest way of landscape improvement. Trees have innumerable direct and indirect benefits of supplying timber and fuel at maturity. During their life time, they supply fodder, fruits, seeds, help in controlling soil erosion and water conservation, offer shade and are oxygen producing industries to combat ever increasing air pollution (Appendix-II). Big foliage trees also help in reducing noise and dust pollution.

11.2 Objectives of Tree Plantations

11.2.1 The main objectives of planting along the Highways are as follows:

- To provide for aesthetic enhancement of the project corridors
- To reduce the impacts of air pollution and dust, as trees and shrubs are known to be natural sink for air pollutants.
- To provide much needed shade on glaring hot roads during summer.
- To reduce the impact of ever increasing noise pollution caused due to increase in number of vehicles.
- To arrest soil erosion at the embankment slopes.
- Prevention of glare from the headlight of incoming vehicles.
- Climatic amelioration,
- Moderating the effect of wind and incoming radiation
- To define the ROW especially, to highlight sharp horizontal curves during night

11.3 Selection of Tree Species for Landscaping

11.3.1 Trees, shrubs and climbers have been used to enhance the soft natural ambience against harsh elements in most of the enhancement schemes. The planting species are decided based on the physical growth characteristics of trees, like form and shape, foliage pattern, growth rate, branching pattern, soil characteristics and conditions of the strip like water logged areas etc. While selecting the species of trees for landscaping, great care should be taken to choose the species, which already exist along the project corridor.

11.3.2 The selection of plant types and planting arrangement should be based on the following considerations:

- Aim and objective of plantation
- Shape (spread of the tree) and size
- Texture and colour of foliage/flower/fruits in different seasons and stages of growth.
- Adaptability and suitability to agro-climatic regions/zones
- Growth rate (slow/fast) average age of maturity and replacement cycle
- After-care and maintenance required for sustenance and growth
- Economic and other social/recreational benefits
- Drawbacks and demerits, if any, like prone to insects/pests disease, animal grazing and human interference.

11.4 Screening

- Plantation of pollution resistent dwarf shrub species in the median to prevent glare from the vehicles moving in opposite direction during night.
- A mix of medium and large trees along roadside to screen the evening glare for the traffic moving towards west-northwest.
- Screen plantation as a visual barrier in schools, hospitals, residential colonies, etc.

11.5 Aesthetics

- Provision of flowering trees in the urban sections and major crossings
- Provision of flowering shrubs in the median
- Softening of vertical surfaces of the retaining walls of grade separators and raised sections of the carriageway by climbers.

11.6 Shade

- One of the main objectives of Roadside Avenue is to provide shade. Large and spreading shade trees, with thick foliage are proposed to provide much needed shade on glaring, hot roads during summer. Evergreen trees do not have substantial leaf fall, which avoid the nuisance of clogging of lined drains.

11.7 Other considerations

- Trees along the embankment slopes and near major water bodies play a major role in the control of erosion. Similarly, green cover in the form of turfing stabilizes steep slopes and high embankments.

11.8 Plantation Pattern

11.8.1 A soft landscape should be developed envisaging a holistic approach to the entire stretch. A concept should be evolved so as to maintain visual characteristics and uniformity in terms of landscape along the stretch. In the absence of uniform land availability for the plantations, different schemes may be worked out in tune with the local variations in the design. To achieve this, entire stretch of the project corridor should be divided into homogenous landscape sections based on similarity in terms of soil conditions, climate (temperature and rainfall) and topography. A study on the local flora and vegetative cover native to these sections should be carried out as part of the field surveys to enable the choice of suitable species for particular section.

11.8.2 Earlier, the first row of plantation along the highways used to be done by using tall shade bearing trees. But with the development of high-speed highways, the concept needs

to be changed. For the sake of better road safety and for enhancing aesthetics, it has now been felt better to provide the shade plants in the last available row. In the first or the only available row; and other intermediary rows, small to medium sized ornamental trees should be planted.

11.8.3 The planting type should be decided based on the requirement and feasibility at various sites along the project corridor. Physical growth characteristics of trees, like form and shape, foliage and rooting characteristics, growth rate, canopy type and branching pattern are the major criteria in the selection of plantation type and density. The space available in the ROW is one major guiding factor for different themes of landscaping applied in the entire corridor.

11.8.4 Depending on the available ROW, plantation pattern should be worked out as follows:

i) The first row along the Highways will be of small to medium sized ornamental trees.

ii) Subsequent rows, depending on the availability of width, will comprise of ornamental and/or shade bearing species, of more height than those in the first row. In rural sections, the last row will always be of shade bearing tall trees.

iii) Planting of shrubs in the median.

iv) Planting of herbaceous species as ground cover in the median, special landscapes and embankment slopes.

v) Turfing with grass in the median, special landscapes and embankment slopes.

11.9 Ornamental Species

11.9.1 The first and subsequent rows of plantations along the highway, except the last row, should be worked out based on the land availability within the ROW along the various sections. In case of urban and semi-urban areas, where because of land constraints, only one row of plantation possible, ornamental species should be planted instead of shade bearing species. A combination of ornamental, shade and screening trees have been recommended. The number of rows and the repetition of the trees and their type vary with the landscape section, the typical cross-section and the space available in the ROW for tree plantation.

Table 1 and 2 list a few species, which can generally be planted throughout India for this purpose.

Table 1 Species Recommended for Ist Row of Avenue Plantations

S.no.	Soil	Botanical Name	Local Name	Flowering Month/Colour
1.	Normal Loamy soils	Acacia auriculiformis	Vilayati babool	Sep-Oct./Yellow
2.		Bauhinia sps.	Kachnar	Feb-Mar./Pink
3.		Cassia fistula	Amaltas	May/Yellow
4.		Cassia nodusa	Cassia	May June/Pink
5.		Delonix regia	Gulmohar	May/Yellow
6.		Jacaranda mimosaefolia	Jacranda	April/Blue
7.		Peltophorum ferrugineum	Peltophorum	Oct./Yellow
8.	Water logged areas	Cordia dicotma	Lasoda	
9.		Syzygium cuminii	Jamun	
10.		Terminalia arjuna	Arjun	
11.	Alkaline soils [Usar]	Albizzia lebbek	Kala Siris	
12		Pongamia pinnata	Kanji	
13.		Terminalia arjuna	Arjun	

Table 2 Species Recommended for 2nd and Subsequent Row, Except the Last Row of Avenue Plantations

S.no.	Soil	Botanical Name	Local Name	Flowering Month/Colour
1.	Normal Loamy soils	Albizzia lebbek	Kala siris	
2.		Dalbergia sissoo	Shisham	
3.		Gravillea robusta	Slver Oak	
4.		Malia azadiracta	Bakain	
5.		Pongamia pinnata	Kanji	
6.		Terminalia arjuna	Arjuna	

11.10 Shade Plants

11.10.1 One of the main objectives of Roadside Avenue is to provide shade. The shade trees in the last available row should be planted at a spacing of 8-12 m. These tree species should be of local significance and should be mostly evergreen in nature, which ensure no substantial leaf-fall in winters preventing the problem of blockage of roadside drains. Trees with the following characteristics will be planted as shade trees:

i) Trees with high crown forms secure better visibility and are therefore ideal.

ii) Trees that retain their foliage longest are preferred to deciduous trees

iii) Trees with long gestation period and having rapid growth and a capacity to resist fungal and insect attack form ideal avenues.

The tree species recommended as shade plants for roadside avenues are given in Table 3. These species can be planted almost though out India.

Table 3 Shade Trees Recommended for Roadside Avenues

Soil	Species	
	LOCAL NAME	BOTANICAL NAME
LOAMY	Arjun	Terminelia arjuna
	Imli	Tamarindus indica
	Jamun	Syzynium cuminii
WATER LOGGED AREAS	Mahua	Madhuca indica
	Mango	Mangifera indica
	Neem	Azadirachta indica [at pH up to 8.5]
	Kanji	Pongamia pinnata [upto 9.0 pH]
ALKALINE [USAR]	Peepal	Ficus religiosa
	Paker	Ficus infectoria
	Shisam	Dalberjia sissoo
	Neem	Azadirachta indica
SANDY	Shisam	Dalbergia sissoo

The above lists represent common species, which can be planted almost throughout India. Region-wise specific lists have been provided in Annex A to F. It is recommended that local experts from the Forest Department and Horticulture Department should be consulted before finalizing the choice of species for a particular stretch.

11.11 Species for Median

11.11.1 The shrubs to be planted in the median should be of low or medium height for prevention of the headlight glare. One to two rows of flowering shrubs will be provided according to the varying width of the median in different sections. In sections where the median width is less than 1.5 m, only turfing of grass is proposed. Some herbaceous species may also be planted as a ground cover, not only on the medians but on special landscapes and embankment slopes also. The species proposed for the purpose of turfing/ ground cover are: Cynodon dactylon, Cythocline perpurea, Solanum nigrum, Alternanthera, Chlorophytum, Eupatorium, Wedelia, Duranta, Portulacca, Ipomea, Pelia cadrii, Beleprone oblongata, Tradescantia, Asparagus, Opheopogon grass etc. The shrub species proposed in the median are mainly Bougainvillea and Thevetia nerifolia (Kaner). However, other suitable species may be planted in consultation with the local horticulture specialists. Region-wise specific lists have been given in Annex A to F.

11.12 Plantation Agency

11.12.1 The entire highway network can be divided into two categories based on the legal status of the existing road-side plantations. In most of the areas, the existing plantations along the highways have been notified as protected forests. For these areas, permission for tree cutting is required to be taken from the Forest Department under the Forest Conservation Act, 1980. While granting the permission, the Forest Department stipulates the conditions not only for compensatory afforestation but also for avenue plantations. In these cases, the amount for plantation is deposited with the Forest Department and normally the work of avenue plantation is taken up by them.

11.12.2 In other category, such highway corridors are considered where the existing road side plantations have not been declared as Protected Forests. In these cases, as in the cases of bypasses also, the plantation may be taken either through the contractor (if it is a BOQ item), Forest Department as an agency for plantation, or, from a private contractor.

11.13 Concept of Plantation in Different Areas

11.13.1 Rural Areas

11.13.1.1 Common plants generally recommended for National Highways and State Highways passing through rural areas are Amaltas (Cassia fistula), Neem (Azadirachta indica), Jamun (syzygium cumini), Imli (Tarmarindus indicus). Tall trees like Eucalyptus are not suitable (except for waterlogged areas) as they interfere with electric and telephone lines and are safety hazards on the road. Medium trees like, Acacia auriculiformis, Gravillea robusta, are ideal for screening. In a tropical country like India, where the temperature during summer months may rise up to a maximum of 46°C or more, the 'shade' is of greatest value to the travelers. Thorny trees like Acacia Arabica and Ber (Zizyphus jujuba) are avoided, as these create a nuisance for the pneumatic tyre of motor vehicles.

11.13.2 Urban Areas

11.13.2.1 Near market places and congested areas, the trees known for behaving as 'pollution sink' are proposed. Though, trees in general absorb the pollutants, filter the air from pollutants, and act as noise barrier, but some trees like Neem (Azadirachta Indica), Mango (Mangifera Indica), Shisham (Dalbergia Sisso), Imli (Tamarindus Indica), Karanj (Pongamia sp.), and some flowering trees like Amaltas, Gulmohar, Kachnar etc. can do it in a better way.

11.13.2.2 Near sensitive areas like schools and hospitals, tall trees with thick canopies can create a wind screen through which the air can be filtered and the noise levels be reduced to some extent. Some such trees are Pongamia sp., Acacia auriculiformis and Gravillea robusta. Tall shrubs like Casia biflora, hamelia patens etc. are also provided at the sensitive noise receptors for maximum possible screening.

11.13.3 Edges Along Clear Zone

11.13.3.1 The clear zone along the road is of varied nature depending upon the different embankment heights. Some areas have steep gradients that need intensive stone pitching treatment. In order to increase the structural stability, this type of treatments, plant materials such as shrubs and ground covers, can be introduced in the interstices. They can be used with emphasis on their rooting characteristics, so that they help in binding the stone pitching treatments. In areas of high water table or water logging, special emphasis should be given on the selection of plant materials that can survive in moist conditions.

11.13.4 Water Logged Areas

11.13.4.1 Waterlogged areas along the roads are generally due to inadequate drainage pattern. The road acts as a bund and contributes to water logging in the region of high water table or the low lying nature of the terrain.

11.13.4.2 This type of situation is common throughout the plains in the country. Planting of such sites after proper drainage is now a common practice. T. Arjuna, Jamun and Eucalyptus are usually recommended for waterlogged areas. Bamboos can also be planted in such areas.

11.13.5 Alkaline Soils

11.13.5.1 Alkaline (Usar) soils are frequently encountered along the highways through out the country. The species recommended for such soils include; Azadirachta indica, Ailanthus, Terminalia arjuna, Pongamia, Albizzia lebbeck, A. procera.

11.14 Specifications for Avenue Plantations

11.14.1 The technical specifications for planting along the Highways are as follows :

Ornamental Plants (Except Last Row)

Distance from embankment	1.0 m away from the toe of the embankment
Spacing between plant to plant	3 m
Spacing between rows	3 m
Size of the pits	60x60x60 cm (in alkaline soils, kankar panes to be broken by augur. In waterlogged areas, mound with height varying depending on water level)
No. of plants per km	333
Height of the saplings at the time of planting	1.5 m to 2 m
Survival percentage of plantation	90% at any time

Shade Plants (Last Row)

Distance from preceding rows	3.0 m
Spacing between plant to plant	8-12 m (6 m if high mortality expected)
Size of the pits	60x60x60 cm (in alkaline soils, kankar panes to be broken by augur. In waterlogged areas, mound with height varying depending on water level)
No. of plants per km	84 (167 at 6 m spacing)
Height of the saplings at the time of planting	More than 2 m
Survival percentage of plantation	90% after replacement of casualities in first two years. 80% afterwards

11.14.2 In localities where a really bad patch of saline soil (usar) occurs, there is a need to dig deep pits by augur [mechanical device] to break the kankar pan down below and replacing the soil by good quality soil. The pits should be filled with the soil amender, Gypsum (1 to 3 kg per pit, depending on the pH) along with 2 kg compost and sand. The treatment helps in lowering down the pH and thus enabling better survival of plants.

11.15. Protection Measures

11.15.1 The fencing of single row plantations is generally done by using iron/brick/cement guards Fig. 29 (a) (b). Locally available bamboo guards or thorn fencing should be used where protection can be ensured through them. The description and specifications for the iron and brick guards are as given in Figs. 29 to 31.

Fig. 29 (a) Circular Iron Guard

BRICK TREE GUARD

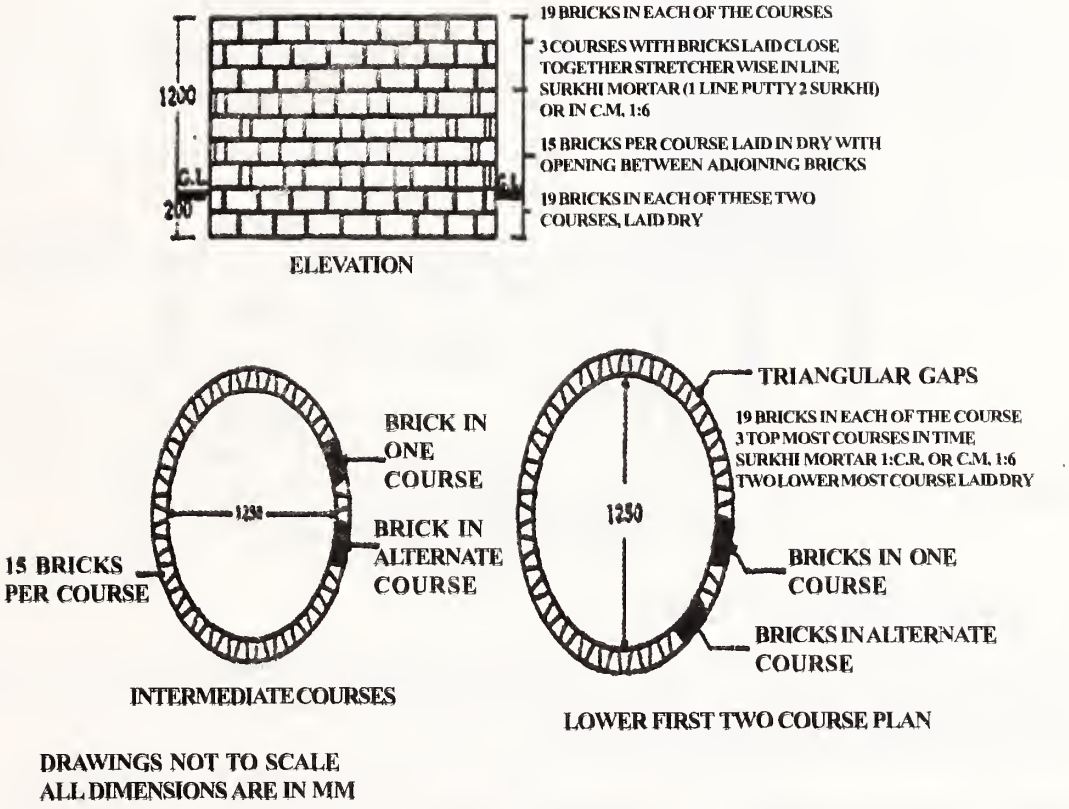


Fig. 29 (b) Ornamental Tree Guard with M.S. Bars

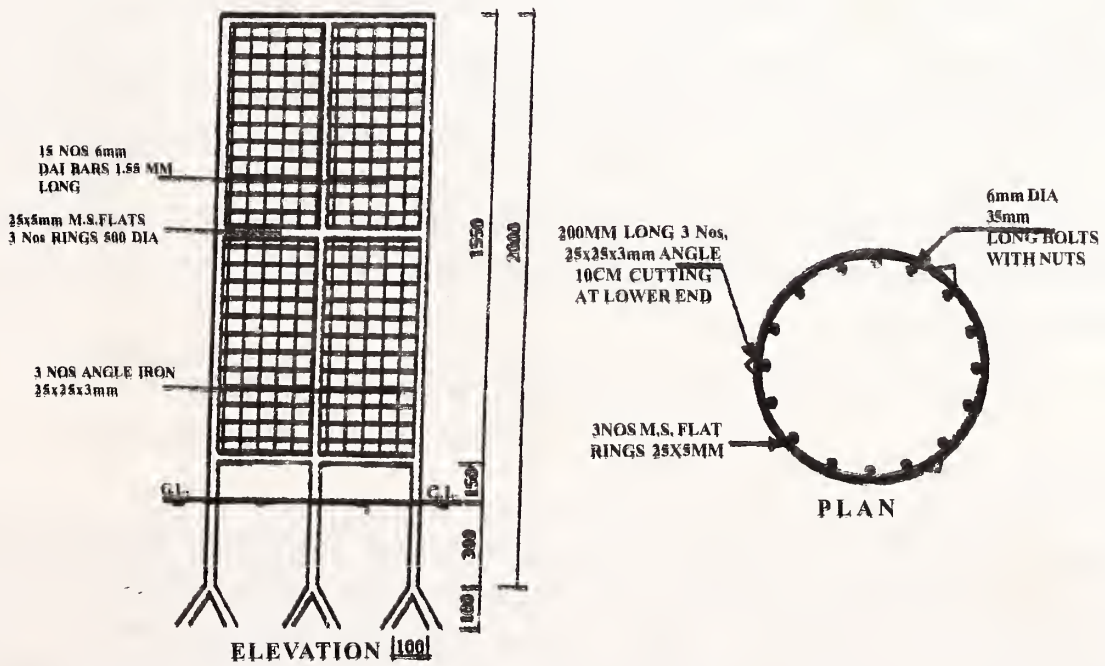


Fig. 30 Ornamental Tree Guard with M.S. Bars

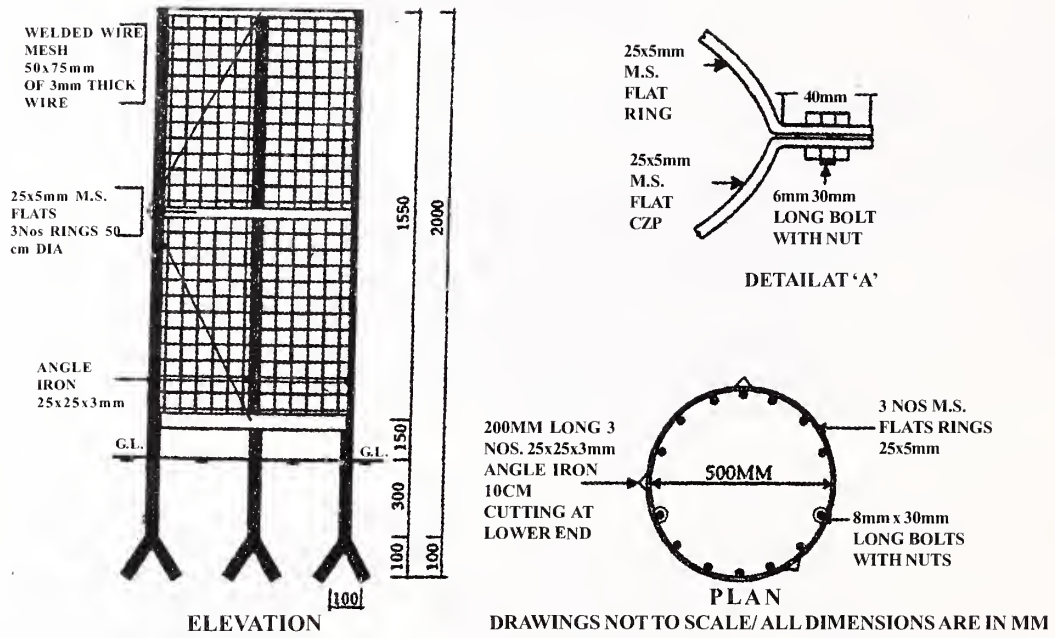


Fig. 31 Ornamental Tree Guard with Welded Mesh

11.15.2 Circular Brick Tree Guard

The internal diameter shall be 1.25 m, height above ground level 1.20 m and depth below ground level 0.20 m, walls half brick thick.

This shall be built of bricks of class designation 75. Bricks should comply with the specifications described in 6.1 with the exception that they may not be well burnt and may have a reddish yellow colour throughout or may be over burnt. The first two courses from bottom shall be built dry (without mortar) with the bricks laid close to each other, without honey-comb. Subsequent courses up to 0.30 m from top of tree guard shall be built dry in honey-combed patter, using 15 bricks in each course, with equal opening in between. Thereafter the top three courses shall be built without honey-combing, in lime surkhi mortar 1:2 (1 lime putty: 2 surkhi) or in cement mortar 1:6 (1 cement : 6 fine sand) as directed in the bottom most 2 courses and in the top most 3 courses. Bricks in adjacent courses shall be laid with 10 cm laps. In the honey-combed portion of the work, the vertical edges of bricks in alternate courses shall be in the same line. The laps of bricks on either side of openings shall be equal.

11.16 Ornamental Circular Iron Tree Guard with Bars (Fig. 31)

The tree guard shall be 50 cm in diameter.

The tree guards shall be formed of (i) 3 Nos. 25x25x3 mm angle iron verticals 2.00 m. long excluding splayed. Outward at lower end upto an extent of 10 cm (ii) 3 Nos. 25x5 mm MS flat rings fixed as per design (iii) 15 Nos. 1.55 m long 6 mm diameter bars. Each ring shall be in two parts in the ratio of 1:2 and their ends shall be turned in radially for a length of 4 cm at which they are bolted together with 8 mm diameter and 30 mm long MS bolts and nuts.

The vertical angle irons shall be welded to rings along the circumference. 15 nos. bars shall be welded to rings at equal spacing along the circumference of ring. The lower end of the angle iron verticals shall be splayed outwards upto an extent of 10 cm. The lower end of the flat of lower ring shall be at a height of 45 cm and upper end of the flat of top ring shall be at the height of 2.00 m. The middle ring shall be in the centre of top and lower ring. The bars shall be welded to rings as shown in the drawing. The entire tree guard shall be given two coats of paint of approved brand and of required shade over a priming coat of ready mixed primer of approved brand. The design of the tree guard shall be as shown in the drawing.

11.17 Ornamental Circular Iron Tree Guard With Welded Mesh (Fig. 32)

The tree guard shall be 50 cm in diameter.

The tree guard shall be formed of:

i) 3 Nos. 25x25x3 mm angle iron verticals 2 m long excluding splayed outwards at lower end upto and extent of 10 cm.

ii) 3 Nos. 25x5 mm MS flat rings 50 cm diameter as per design.

iii) 1.55 m high welded mesh 50x75 mm size of 3 mm thick wire. Each ring of the tree 1.55 m high guard shall be in two equal parts and their end shall be turned in radially for a length of 4 cm at which they shall be bolted together with 8 mm diameter, 30 mm long bolts and nuts.

The vertical angle iron shall be welded to rings along the circumference. Welded mesh shall be welded to rings in such a way so as to make it sufficiently strong. The lower end of the angle iron verticals shall be splayed outwards upto an extent of 10 cm. The lower end of the lower rings shall be at 45 cm height and middle ring shall be in the centre of the two. The entire tree guard shall be given two coats of paint of approved brand and of required shade over a priming coat of ready mixed primer of approved brand. The design of the tree guards shall be as shown in the drawing.

11.17.1 The fencing of multiple row plantations should be done preferably by barbed wire. A five strand barbed wire fencing, with cross strands, stretched on angle iron poles fixed at a distance of 4 m from one another; is recommended. Live fencing/bamboo fencing/ thorn fencing should be used where protection can be ensured through them.

11.18 Specifications for Grass Turfing

11.18.1 The surface is to be prepared adequately for grass sowing. The grass and shrub planting is done to provide a strong surface cover but needs a well-prepared surface. All masses of loose debris should be removed. Any convexities should be removed and similarly any concavities are to be filled by good soil. The surface should have sufficient layer of good quality soil [upto 45 cm] so as to have better growth and survival of grasses and shrubs.

11.18.2 Grass lines are used to provide a strong surface cover but need a well-prepared surface in which to be planted. If grass is to be an effective form, then it must be allowed to establish properly on a slope which does not subject it to undue stress from erosion and mass movement in its initial stages.

i) Sowing of grasses is intended to create a strengthened surface that is resistant to erosion.

ii) It is the responsibility of the contractor to ensure that the condition of the site is good enough for the successful establishment of grasses.

iii) The contractor is required to supervise all field operations like preparation of surface, sowing of grasses and quality of grass seeds used.

iv) A cover of 25 gram of grass seed per square meter of surface should be achieved.

v) The timing of sowing is of utmost importance. The seed sowing must be carried out before the onset of monsoon [May & June] so that they yield desired results. The watering of the surface will be done by tankers till the onset of the monsoon.

vi) After sowing, mulch of prepared and dried out herbs should be laid over the whole seeded area in a thin layer so that the direct sunlight and transpiration loss may not affect the grasses.

11.19 Specifications for Plantations

11.19.1 The species to be planted in median should be of low or medium height with ornamental value to enhance the visual experience of the road corridor. It will also act as a screen to prevent glare from the incoming vehicles.

11.19.2 One or two rows of flowering shrubs are recommended in accordance with the varying width of the median in different sections. In sections where median width is less than 1.5 m, only grass turf is recommended. One row of shrubs is recommended on medians of upto 3 m width. Two rows of shrubs should be planted on 4.5 to 5 m wide median, at a spacing of 1.5 m from the inner edge of the median.

11.19.3 The plants should be at spacing of 3 x 3 m and size of the pits for planting should be 60 x 60 x 60 cm. Therefore, total no. of plants per km will be 333 in case where single row is proposed, and 666 in case of two rows.

11.19.4 The species recommended for median are mainly Bouganvillia & Kaner. Bouganvillia is considered as the most suitable species as it has a great aesthetic value and it is found in various colours and shades. It can withstand extreme temperature and climatic conditions and also has low requirement of water. The species have been proposed considering the climatic conditions, requirement of water and future management. However, other species listed in the appendices may also be used.

11.19.5 The surface for the median plantation should be well prepared. The masses of loose debris on the median and any convexities should be removed and similarly any concavities should be filled by good soil. The surface should have sufficient layer of good quality soil so as to have a better growth and survival of grasses and shrubs.

11.19.6 The height of the plants will not be less than 0.6 m and need to be in polythene bags until the planting.

11.19.7 All plants supplied must be planted within three days of removal from the nursery.

11.19.8 The plantation should be watered in case of insufficient rains after planting.

11.19.9 Size of the pits for planting shrubs:- 60X60X60 cm

11.19.10 No. of plants per km - 333 in one row

11.19.11 Use of compost and manure - 1/3 of volume of pit mixed with soil, and refilled

11.20 Activity Schedule

Plantation activities are highly time specific, as the plants respond to the seasonal variations in climatic conditions. Even in highly mechanized irrigated plantations, the growth of plants is not uniform throughout the year and is governed by the atmospheric factors. It is therefore, vital to plan the planting activities in advance as per the prevailing climatic conditions of the area, especially the time and duration of monsoon. Generally, plantations works are started in our country with the onset of monsoon. However, if it is possible to provide irrigation, it is advisable to utilize the high temperatures of summers. Generally, plants respond well to irrigation during peak summer seasons, as the conditions are very favourable for growth if moisture is not the limiting factor.

11.20.1 Watering of Plants

Water is a essential component of living organism, since it constitutes 30-40 percent of their body weight. Most of the organic and inorganic substances are sparingly, partly and completely soluble in it. It is a major raw material for the photosynthesis by which plants produce their food.

The essential nutrient for plants are mostly transported by the water either by itself or when water mixes with other constituents like elemental, molecular or compound form. Sometimes, it may act as a bridge between two or more intra or inter-constituents which will help to supply the desired nutrients from soil and also from atmosphere.

The quantity of water requirement largely depends on the nature of species, soil quality, and depth of the first aquifer and on the climatic condition of that area. The relative humidity, temperature, wind speed and wind direction have major role in this regard. About 450 to

650 litres of water is required per plant per year since the very beginning of the plantation till it attains to its normal safe size and growth i.e. about 6-7 years from the date of plantation. The external supply of water is to be continued till the roots of that species may be able to absorb the required quantity of water from the soil strata. The quantity and frequency of watering is given in Table 5.

Table 5 Activities Schedule For Avenue Plantation/Median Plantation

Year	Month		Activities to be done
Ist Year	Jan-March	1	Surveying & cleaning of the area
		2	Digging of Pits
		3	Procurement of Angles Iron and barbed wire(or other fencing material), and erecting the fence
2nd Year	April-June	1	Purchase of Farm yard manure
		2	Brick/iron etc. guard for 1st row
		3	Plantation along the Highway
		4	Filling up of Pits with Farm Yard manure and Soil
	July-August	1	Transportation of Plants
		2	Planting of Saplings
		3	Watering
		4	Weeding and hoeing
	Sep-Nov	1	Weeding and hoeing
		2	Watering 4 times a month
	Dec-Feb	1	Weeding and hoeing
		2	Maintenance
	March	1	Watering 4 times a month
3rd year	April-June	1	Watering 6 times a month
	July-August	1	Casualty Replacement (20% of the total plants)
		2	Weeding
		3	maintenance by Mali
	Sep-Nov	1	Watering 2 times a month
		2	maintenance by Mali
	Dec-Feb	1	maintenance by Mali
	March	1	Watering 4 times a month
		2	maintenance by Mali
4th Year	April-March	1	Watering
		2	Casualty Replacement (10% of the total plants)
		3	maintenance by Mali

11.21 Monitoring Requirements

11.21.1 The following Table summarizes the monitoring schedule and the parameters for monitoring the progress and status of plantations:

Table 6 Proposed Monitoring Arrangements

Phase	Monitoring Parameter
1st Year (Advance Soil Work)	No. of pits
2nd Year (Plantation of Saplings)	Survival % of saplings
3rd Year (Maintenance of Plantation)	Survival % before & after Causality replacement. Height of plants
4th Year (Maintenance of Plantation)	Survival % before & after Causality replacement. Height of plants

11.22 Maintenance of the Plantation after 4th Year

11.22.1 Although, normally, the plantations get established by the end of 3rd year of planting, but in some cases the plantations require maintenance for some more years. It will depend upon the soil and climatic conditions, besides the nature of the plant. The following maintenance measures are recommended:

i) Regular maintenance of the barbed wire fencing or other fencing material used for protection

ii) Periodic pruning of trees planted in median so that branches do not spread on to the carriageway

iii) Casualty replacement of plants before monsoon

iv) Clearing of weeds where grass is sown

v) Removal of unwanted dried leaves during the summer season to prevent fire hazard.

vi) Watering in peak summer season

11.23 Training and Pruning of Shrubs

11.23.1 By nature of their growth habit, shrubs tend to take extra growth or unbalanced growth. Thus, regular training and pruning by cutting and removal of undesired parts of twigs is required.

11.23.1.1 Training

The process of providing desired form and size to a shrub plant is training. This is done by cutting away all growth that does not come in the desired frame, shape and size. Training

of plants is started when they are still young. 3-4 branches are allowed to grow from main stem near the ground, radially to different directions. These are further divided into 2-3 branches, each making oval shape of 3 m dia in spread near the ground and 1.5 to 2 m high. This process is completed in 3-4 operations of cutting and pruning in first 2 years of growth. The sequence of training is shown through sketches in Fig. 4. When the plants take their final size and shape, they are annually cut to this shape by pruning extra growth once or twice a year.

11.23.1.2 Pruning

Pruning involves cutting and removal of parts, twigs limbs or branches of shrubs. Besides, giving desired shape and size, pruning helps in:

- Encouraging vigorous growth by allowing proper air, light and food to the parts retained.
- Removing over-crowding and weak branches.
- Removing dried up, diseased and pest infested parts
- Regulating and increasing flowers/fruit/production.

While doing operations of training/pruning; proper tools and implements like pruning knife, pruning saw, tree pruner & shears etc. should be used. Care should be taken that bark of the plants is not damaged, ruptured, or peeled off. After deciding the framework to be retained, shoots should be cut back to desired size and shape. All the sick, thin and interwining twigs should be removed for allowing air & light to the desired ones.

Generally, flowering buds are produced in 6-8 month old shoots, which are usually cut away through repeated indiscriminate cutting without applying scientific principles of pruning. Consequently, neither these shrubs take their optimum spread (vertical & lateral) nor produce colourful flowers, as required.

Time of pruning is very important and it should be done only in the season of dormancy i.e. when the plants are not in active growth. In India, this period comes usually from December to January & May to June. Blooming time is February to June & September to December. However, light pruning and pinching of tips can be done any time when it becomes necessary due to other emergent reasons of safety and sanitation etc.

11.24 Special Treatment Required for Trees Planted in Median of Divided Carriageways

11.24.1 At many places medium size trees are also grown in the medians. But it has been observed that if they grow to their optimum height and spread, they may cover approximately 8 to 10 m space, both in height and spread. In that case, following problems may occur which should be considered at the time when these trees are still young and manageable in alternative ways:

11.24.2 Grown up trees may cover the entire median and may cause shade to the shrubbery planted in the median resulting into very poor growth or non-survival of shrubbery/bushes under shade.

11.24.3 Large size trees in median are more prone to cyclone damage resulting in accidents and disruption of traffic. Only those plants should be used in the median, which are not prone to cyclone damage.

11.24.4 During rains and wet weather, roads beneath the tree canopy get damp and slippery due to dripping of water for long time. This causes damage to asphalted road and makes it more prone to accidents due to skidding and slippages when emergency brakes are applied.

11.24.5 Large size trees develop a very strong and large taproot and lateral root system, which weakens the compaction and pavement of the carriageway with the passage of time.

11.24.6 Trees planted in the median provide shade in carriageway resulting in poor visibility especially during dawn and dusk.

11.24.7 It is advisable to avoid planting large size trees in median. Trees already planted in the median, which are still young, should be trained as Topiary and Bonsais as an innovation in the highway landscaping.

11.24.8 TOPIARY is an art of developing the plants and trees/hardy bushes in special features/figures by regular and repeated training and pruning and keeping them in fixed size and shape.

11.24.9 BONSAIS are trees developed into miniature or dwarfed forms. These are highly developed art forms of gardening originated in Europe and Japan. Illustration/sketches for artful Topiary and Bonsais for preparation in the median are given in Figs. 5 and 6.

11.25 Clearance on Curves

11.25.1 For the shade bearing large trees, an average spacing of 8-12 m requiring 84 plants per km will provide ample growing space for most species. Too many trees, apart from involving higher planting costs, very often unnecessarily reduce visibility for fast traffic. Excessive dense avenues serve no useful purpose, apart from affecting the tree growth adversely, also reduces visibility and proves to be dangerous to fast moving traffic. Growth of vegetation close on the road curves may lead to serious reduction of clear sight distance and may cause accidents. Such accidents can be easily avoided by avoiding planting on near the curves. Close spacing on curves and crossing can be dangerous. So best plan is not to plant the ornamental rows, and miss a tree or two of the shade row at such locations. Even the existing vegetation on such areas may need to be removed/thinned or trimmed.

In plain terrain, a stopping sight distance of 170 m corresponding to the design speed of 100 km per hour should be ensured on all curved sections, on the innermost lane of the curve.

11.26 No Plantation Zone

11.26.1 The plantation may not be carried out in the following areas:

- Within 1.5 m from the toe of the carriageway.
- At median cut and grade separator, at least 5 m blank space shall be left for clear view of the traffic
- At curve, dense and tall height tree reduce visibility in plain terrain, a stopping sight distance of 170 m corresponding to the design speed of 100 km per hour should be ensured on all curved sections, on the innermost lane of the curve.
- At median, medium and large size trees are more prone to cyclone damage resulting in accidents, disruption of traffic and clear view of the carriageway. Long rooted plants may also damage the carriageway.
- Screen plantation as a visual barrier in schools, hospitals, residential colonies, etc.

Annex A
(Clause 11.11.1)

List of Trees Suitable for Arid and Dry Regions of South Haryana, Rajasthan, Gujarat, Maharashtra, and Central Plateau

	Botanical Name	Common Name
1.	Ailanthus excelsa	Maharukh
2.	Azadirachta indica	Neem
3.	Alstonia scholaris	
4.	Acacia auriculiformis	
5.	Butea monosperma	Palas
6.	Bombox ceiba	
7.	Cassia fistula	Labernum/Amaltash
8.	Cassia siamea	Siamese Cassia
9.	Calistemon viminalis	Bottle brush
10.	Calistemon citrinus	
11.	Ceiba pentandra	
12.	Cochlospermum religiosam	
13.	Casuarina equisetifolia	
14.	Dalbergia sissoo	Sheesham
15.	Erythrina variegata	
16.	Ficus sp	Peepal, Bargad, Pakur, etc
17.	Gmelina arborea	Gambhari
18.	Heterophragma adenophyllum	
19.	Moringa oleifera	Sahjan
20.	Melia azadirachta	Bakain
21.	Millingtonia hortensis	
22.	Pongamia pinnata	Karanj/Papari
23.	Plumerio sp.	
24.	Parkinsonia aculeata	
25.	Syzygium cumini	
26.	Tecoma undulata	Rohira
27.	Tamarindus india	Imli
28.	Terminalia sp.	
SHRUBS		
1.	Bougainvellia	Garden glory
2.	Cassia glauca	
3.	Cassia alata	
4.	Jatropa podagarica	

5.	Nerium oleander	Kaner
6.	Poinciana pulcherima	
7.	Thevetia nerifolia	Yellow Kane

Trees suitable for Moist Areas

Moist locality consists of areas where rainfall is high and of longer duration. The soil remains moist but not necessarily waterlogged. High humidity pervades the atmosphere. Trees suitable for moist areas are:

1. Alstonia scholaris
2. A. macrophylla
3. Amherstia nobilis
4. Barringtonia acitamgi;a
5. B.racemosa
6. Bauhinia variegate
7. B.pupurea
8. Brownea coccinea
9. B.ariza
10. Cassia marginata
11. C.javanica
12. C.nodosa
13. Colvillea recemosa
14. Delonix regia
15. Dillenia indica
16. Guaiacum officinale
17. Lagerstroemia speciosa
18. L.thorelli
19. Millettia peguensis
20. Peltophorum ferrugineum
21. Samanea saman
22. Polyalthia lognifolia
23. P.pendula
24. Pongamia pinnata
25. Putranjiva roxburghii
26. Saraca asoca
27. Terminalia arjuna
28. Tamarindus indica

Trees Suitable for Marshy Areas

Areas which remain waterlogged for a considerable period of the year come under this ecological environment. Trees suitable for such areas are:

1. Barringtonia acutangula
2. B.racemosa
3. Eucalyptus rostrata
4. Hibiscus tiliaceus
5. Salix babylonica
6. S.tetrasperma
7. Tamarix articulate

Of the above species eucalyptus rostrata can not only grow under marshy conditions, but has capacity to draw up large quantities of water for transpiration. Sometimes this species is used for drying up marshy land.

Trees Suitable for Saline Tracts

Saline tract is present along the coastal areas where the tidal waves submerge the land periodically. Besides, vast saline tracts are met with in the country where waterlogging is a perennial problem. Here the accumulated body of water finds release mainly in to the atmosphere through evaporation leaving behind the salts on the surface. This condition for decades, or even for centuries, have turned the soil very saline. Trees suitable for such tracts are those that can stand drought as well as high concentration of salinity. The example of such trees are :

1. Acacia auriculiformis
2. Butea monosperma
3. Casuarina equisetifolia
4. Cochlospermum religiosum
5. Eucalyptus Citriodora
6. Heritiera macrophylla
7. Inga dulcis
8. Perkinsonia aculeata
9. Pongamia pinnata
10. Samanea saman
11. Tamarix articulate
12. Thespesia populnea
13. Tamarindus indica
14. Terminalia arjuna

Plants Disliked by Cattle

Truly speaking, this grouping of trees does not belong to the ecological classification. But

this group is useful where stray cattles are plenty and pose a problem for the protection of trees, particularly at the young age. Selection of plants that are disliked by cattle will help to ward off the menace from these animals. Some trees under this group are :

1. Cassia fistula
2. C.nodosa
3. C.javanica
4. C.siamea
5. C.renigera
6. C.multijuga
7. C.marginata
8. C.moschata
9. Holarrhena antidysenterica

List of Trees suitable for Arid and Dry Regions of South Haryana, Rajasthan, Gujarat, Maharashtra and Central Plateau

1. Acassia ausiculitrormis
2. Bombox ceaba
3. Callistemon citrinus
4. Ceiba pentandra
5. Cochlospermum religiosam
6. Erothrina variegatum
7. Heterosphrogma adenophyllum
8. Millingtonia hortensis
9. Pwmerio sp
10. Syzygium umini
11. Casurina equisetitioia
12. Perkirisonia aculiata

Annex B
(Clause 11.11.1)

Trees suitable for temperate and sub-tropical areas of North-West India, J&K, Punjab, Himachal Pradesh, Uttranchal, Part of U.P.

	Botanical Name	Common Name
1.	Barringtonia accutangula	
2.	Cedrus deodara	Devdar
3.	Delinia indica	Chilla
4.	Grevillea robusta	Silver Oak
5.	Holoptelia integrifolia	Papri
6.	Juglans regia	Akhrot (Walnut)
7.	Michelia champaka	
8.	Myrica nagi	Kaphal
9.	Pinus sp	Chir
8.	Pterospermum acerifolium	
10.	Salix sp	Soal
11.	Sapindus musorossi	Reetha
12.	Taxus baccata	Thuner

SHRUBS

1.	Artabortrys odoratismis	
2.	Bougainvellia	Garden glory
3.	Hydrangea	
4.	Hibiscus sps.	
5.	Nerium oleander	Kaner
6.	Rhododendron/Azalias	
7.	Salix sps.	
8.	Thevetia nerifolia	Yellow Kaner
9.	TMC single and double	
10.	Tecoma	

Annex C
(Clause 11.11.1)

Trees suitable for Indo Gangatic Plains of Uttar Pradesh, Punjab, Bihar and West Bangal

	Botanical Name	Common Name
1.	Albizzia lebeck	Siris
2.	Albizzia proeera	Safed Siris
3.	Butea monosperma	Palash
4.	Bauhinia variegata	Kachnar (Pink)
5.	Cassia fistula	Labernum/Amaltash
6.	Cassia siamea	Siamese Cassia
7.	Cedrela toona	Toon
8.	Chikrassia tabularis	Chikasi
9.	Calistemon lanceolatus	Bottle Brush
10.	Dalbergia sissoo	Sheesham
11.	Emblica officinalis	Aonla
12.	Ficus sp	Peepal, Bagad, Pakur, etc
13.	Gravellea robusta	Silver Oak
14.	Hardwickia pinnata	Malabar Mahagani
15.	Lagerstroemia thorli	Pride of India/Jarul
16.	Lagerstroemea floriginea	-do-.
17.	Morus alba	Shahtoot
18.	Mengifera indica	Desi Mango
19.	Pterospermum acerifolium	Kanak Champa
20.	Putranjiva	
21.	Polyalthea longifolia	Ashok
22.	Syzigium cumini	Jamoon
23.	Terminalia arjuna	Arjun
24.	Terminalia belerica	Bahera
25.	Terminalia chebula	Harr/Myrobalam
26.	Tecoma argentia.	

SHRUBS

1.	Bauhinia alba	
2.	Bauhinia acuminata	
3.	Bougainvellia	Garden glory
4.	Cassia biflora	
5.	Cassia alata	
6.	Cassia lavigata	

7.	Calliandra	
8.	Duranta	
9.	Gardenia floria	
10.	Hamelia	
11.	Hibiscus sps.	
12.	Ixora	
13.	Nerium oleander	Kaner
14.	Thevetia nerifolia	Yellow Kaner
15.	Tecoma stans	
16.	TMS single and double	

Annex D
(Clause 11.11.1)

List of Trees suitable for North Eastern States, North Bengal, Assam, etc.

Botanical Name		Common Name
1.	Alstonia scholaris	Chatuni/Saptparni
2.	Albizzia lebeck	Siris
3.	Cryptomeria japonica	Dhupi
4.	Colvelia racemosa	
5.	Cratevea religiosa	Barna
6.	Cinchona sps	Cinchona (Quinine tree)
7.	Lagerstroemia floriginea	Pride of India
8.	Lagerstroemea thorali	-do-
9.	Michelia champaka	Champa
10.	Pterospermum acerifolium	Kanak Champa
11.	Shorea robusta	Saal

SHRUBS

1.	Bauhinia alba	
2.	Bauhinia acuminata	
3.	Bougainvellia	Garden glory
4.	Calliandra	
5.	Duranta	
6.	Gardenia floria	
7.	Hibiscus sps.	
8.	Ixora	
9.	Nerium oleander	Kaner
10.	Thevetia nerifolia	Yellow Kaner
11.	TMS single and double	

Annex E
(Clause 11.11.1)

List of trees suitable for Deccan Platue; Southern regions of Madhya Pradesh, Andhra Pradesh, Karnataka, Maharashtra; and Tamil Nadu.

	Botanical Name	Common Name
1.	Albizzia procera	Safed Siris
2.	Albizzia. amara	Cylone Siris
3.	Amhertia nobilis	
4.	Bischofia javanica	
5.	Colvelia recemosa	Kilbili
6.	Dalbergia latifolia	Black Shisham/Rosewood
7.	Delonx regia	Gulmohar
8.	Mengifera india	Desi Mango
9.	Michelia champaka	Swarnchampa
10.	Peltophorum pherugenium	Fellow Gulmohar
11.	Polyalthea longifolia	Ashok
12.	Palms	
13.	Saraca india	Sita Ashok
14.	Santalum album	White Sandal
15.	Tamrindus india	Imli

SHRUBS

1. Aphlandra
2. Bougainvellia
3. Bauhinia alba
4. Bauhinia acuminata
5. Calliandra
6. Crosandra
7. Duranta
8. Gardenia floria
9. Hibiscus sps.
10. Ixora
11. Nerium oleander
12. Musanda
13. Sanchezia
14. Thevetia nerifolia
15. Tecoma stans
16. Tecoma gaurichari
17. TMS single and double

Annex F
(Clause 11.11.1)

List of Trees suitable for Coastal Areas of Maharashtra, Goa, Karnataka, Kerala, Tamil Nadu, Andhra Pradesh and Orissa, etc.

	Botanical Name	Common Name
1.	Anacardium occidentale	Cashew nut
2.	Cinamomum camphora	Kapoor
3.	Casuarina equistifolia	Casuarina
4.	Dalbergia latifolia	Rosewood
5.	Mengifera indica	Mango
6.	Palms	
7.	Pterospermum acerifolium	
8.	Saraca indica	Sita Ashok
9.	Sweitenia mahogoni	Mahogoni
10.	Sweitenia.macrophylla	-do
11.	Tabubia spectibilis	
12.	Tabubea rosea	

SHRUBS

1.	Bougainvellia	Garden glory
2.	Bauhinia alba	
3.	Bauhinia acuminata	
4.	Calliandra	
5.	Crosandra	
6.	Gardenia floria	
7.	Hibiscus sps.	
8.	Hamelia	
9.	Musanda	
10.	Magnolia sps.	
11.	Nerium oleander	Kaner
12.	Tecoma stans	
13.	Tecoma capensis	
14.	TMS single and double	
15.	Thevetia nerifolia	Yellow Kaner

Appendix - I

(Refer Para 11.1.1)

BROAD DETAILS OF PLANT SPECIES NATIVE IN INDIA*

Abbreviations: Mar-Marathi Kan - Kannada Tam-Tamil Guj - Gujarati
Tel- Telugu Beng- Bengali Mal - Malayalam

S. No.	Latin Name	English Name	Hindi Name	Name in other Indian Languages	Main Characteristics in brief	Brief description, important habits and suggested locations for use
1	2	3	4	5	6	7
1.	Abies pindrow Abies Webbiana	Silver Fir			Large, Shady	Large evergreen tree, suitable for roadside planting. Grown at altitudes 2500-4000 m
2.	Acacia arabica		Kikar, Babul, Babul		Small, Thorny	Grows well in the plains of the Indo-Gangetic plain, especially the Punjab. It is also grown in U.P., Madhya Pradesh, Rajasthan and Maharashtra. Unsuitable for places of extreme winter frost. Its thorns and thinness of shade are drawbacks as an avenue tree, but it can be used in dry places for checking erosion since it sends deep roots. Good value for timber.
3.	Acacia modesta		Phulai		Small, Thorny	Small sized hardy tree, found indigenously in the Punjab. Suitable for sowing on rocky and dry ground where irrigation is impossible. Does not have a smooth and flowing appearance and is ragged looking. Should be tried only when nothing better will grow.
4.	Adansonia Digitata	Monkey bread tree	Gorakh imli	Gorak chinch (Guj) Perauka (Tam)	Large sized, leafless in hot weather	A large deciduous tree with tapering trunk. Branches spread widely and form a mushroom show head. Leaves are divided into separate narrow leaf lets. Large white flowers are borne single on long stalk. Suitable for dry areas.
5.	Ailanthus excelsa		Coloo		Tall, deciduous, thrives in hot regions	A tall quick growing tree with a straight trunk and spreading branch, leaves compound with serated margin. Deciduous, suitable for hotter region. Wood used for making catamaran.
6.	Albizzia lebbek	Woman's tongue	Siris	Chichola (Mar) Vagai (Tam) Dirsanam (Tel) Vaga (Mal) Bage(Kan)	Flowering, fast growing, drought resistant, weak wood	Large, handsome deciduous tree with a straight bole and a broad-topped crown with spreading limbs. Leafless during January-March. Extensively found in sub-Himalayan tracts and widely planted throughout India. Fast grow but easily uprooted. Not a good shade tree as it loses leaves half-way through the cold weather.
7.	Albizzia Procera		Sufed Siris		Large sizes, handsome, quick growing	This is white-stemmed siris with good height. Grown in the Gangetic plains and nearby hill. An excellent roadside tree.
8.	Albizza richardina				-do-	A lofty quick growing tree with a straight trunk, branches go up almost vertically upwards giving the tree a stable shape. A deciduous tree suitable for roadside planting.
9.	Alstonia Scholaris	Devils tree	Chatium	Chattim (Beng)	Large sized, shady flowering	Large evergreen tree, straight growing, branches spread laterally in whorls giving dense shade underneath, leaves palmately compound. Produces greenish white fragrant flowers. Timber used for making boxes, black boards, etc.
10.	Albizzia stipulata		Ohi		Large sized, handsome, quick growing	Large, handsome tree with bright green featleaves. Grows naturally in the low hills-especially in Kangra (Himahcal Pradesh), but does not thrive in the plains.

S. No.	Latin Name	English Name	Hindi Name	Name in other Indian Languages	Main Characteristics in brief	Brief description, important habits and suggested locations for use
1	2	3	4	5	6	7
11.	Anacardium occidentale	Cashewnut	Kaju	Munthri, Andimangottai (Tam) Jidimamidi (Tel) Parangimavu (Mal) Geru(Kan) Kaju (Beng)	Medium sized edible fruits	Medium sized tree, yielding fruits ripening in May-July. Common in west coast of India. Thrives on sandy and gravelly soils. Ideal for preventing wind erosion in coastal belt. Not suitable for avenues.
12.	Anogeissus acumenato		Dhao		Tall, evergree, flowering	A tall evergreen tree with drooping branches. Leaves long and pointed, borne on short stalks. Timber very strong.
13.	Anthogphal us cadamba		Kadamb	Kadam(Beng)	Large sized, flowering	A large tree, with beautiful flowers which are orange coloured and ball shaped. Thrives best on light sandy soil.
14.	Artocarpus integrifolia	Jack	Kathal	Phanas(Mar) Pala(Tam) Panasa(Tel) Pilava(Mal) Halasu(Kan) Kathal(Beng)	Large sized, thick foliage, edible fruits	Tree of considerable size with thick foliage of dark green leaves. Bears large size fruits. Grows in peninsular India, especially in the coastal belt where high rainfall and moist air previls. It has both timber and fruit value.
15.	Azadirachit a Indica	Margosa	Neem	Vembu(Tam) Vepa(Tel) Veppa(Mal) Nim(Beng)	Medium sized, quick growing, drought resistant	Tree of good size and stately presence, ideally suited as an avenue tree. In summer months it is in thick leaf giving excellent shade. Stands a dry climate, but not suitable for water-logged and frost susceptible areas. Yields good timber.
16.	Bambusa bambos	Bamboo	Bans	Mungil(Tam) Bongu Meduru(Tel) Mola(Mal) Biduru(Kan)	Poor shade, economic value	Bamboo grows in fairly moist climate. Not good for shade as its spread is limited. Not a tree for aveune. Bamboo has good economic value.
17.	Barriangton ia racemosa	Indian Oak	Lijul	Samundra(Beng)	Tall, evergreen, flowering	Straight, evergreen with a straight trunk and numberous spreading branches. Leaves broad near the apex, cluster near the end of the branches on short stalk. Bears long pendulous cream rosy flowers.
18.	Bassia Latifolia	Mowa	Mowa	Illuppai(Tam) Kippa(Tel) Irippa(Mal) Ippegida(Kan) Mohua(Beng)	Medium sized, thick foliage slow growth	Medium sized tree, common in the plains of India. Leaves fall off in February-April, and new ones appear in April-May. Affords good shade and is a good avenue tree.
19.	Bauhinia uariegata		Kachnar	Kandhan(Beng)	Small sized, quick growth, light foliage, flowering	Common in the northern hills of the country though also found in the Indo-Gangetic Plains. An ornamental tree while in flower, and of moderate size.
20.	Bombax malabari cum	Red silk cotton	Regai Simal Simbal	Mulilavu(Tam) Mundla Burga(Tel) Pula(Mal) Mullu Buraga(Kan) Simul(Beng)	Large sized, quick growth, light foliage, flowering	Fast growing deciduous tree, but short-lived (life about 20 years). Tall tree with a straight bole and branches in whorls. Needs high water table and light rich soil. Timber has great economic value. Grown throughout India, except in arid climate. Fairly good shade. Rather a formal tree, but is useful to mix with others.
21.	Borassus Flabellifera	Palmyra Palm	Thar	Panai (Tam) Thati(Tel) Pana(Mal) Pane(Kan) Tab(Beng)	Palm, slow growth, unbranched, edible fruits	The tree has economic worth because of the juice tapped from it. Well grown trees have large luxuriant leaves, long stems and sturdy trunks. Not for shade.
22.	Callistemon lanceolatus	Bottle brush	Lal botal brush		Handsome, evergreen, flowering	A low evergreen tree with slender drooping twigs, bark very rough and deeply cleft vertically into narrow ridges. Narrow smooth leathery leaves are clustered near the ends of the twigs. Produces bright red bottle brush like flower in abundances. Suitable for avenue planting.

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1	2	3	4	5	6	7
23.	Callophyllum inophyllum	Alexandrion laurel	Undi	Paunnai(Tam) Punnagamu(Tel) Punna(Mal)	Large sized	Tree of considerable size, commonly found near the sea coast. Particularly useful for conserving channel banks.
24.	Cassia auriculata	Tanner's Cassia	Tarvar	Avarai(Tam) Thanged(Tel) Avara(Mal) Avara(Kan)	Small sized, dense foliage, flowering	Small tree with dense foliage. Yellow flowers in winter make it attractive. An inhabitant of dry salt land. Very hardy plant, affording good ground cover against erosion.
25.	Cassia auriculata	Golden shower, Indian laburnum	Amaltas	Konnai(Tam) Rela(Tel) Konna(Mal) Kakke(Kan) Amultas(Beng)	Small sized, quick growth, light foliage, flowering	A small sized deciduous tree, leafless in February-March. The flowers are yellow colour when fresh, later turning to bright green. The tree gives good appearance because of colour of flowers. A good choice for ornamental planting but not suitable for avenue planting as it does not give much shade.
26.	Cassia siamea		Chechwa		Small sized, thick foliage, weak wood, flowering	Quick-growing tree, but short-lived and liable to damage from wind. A good shady tree in hot weather. Not a very good roadside avenue tree, but picturesque because of its yellow flowers in clusters. Drought resistant, grows in poor soils, Successful in Uttar Pradesh and Madhya Pradesh.
27.	Castanosper mum australe	Moretan Bay Chestnut			Medium sized, evergreen, thick foliage	This middle lized evergreen tree has a straight trunk, smooth grey bark, rather drooping branches and dense handsome imparipinnate foliage, very suitable for tropics as shade tree owing to its dense and handsome foliage.
28.	Cedrela Toona		Tuna Tun	Todu (Mar) Tundu(Kan)	Large sized, quick growth, light foliage	A large, remarkably handsome tree. Can be grown in the plain regions of the country and in lower hills. Does not thrive in dry area as it needs moisture. Generally needs rich soil. Susceptible to attack by twigboring moth.
29.	Cedrus Deodara	Cedar	Deodar		Large sized, thrives inhills	Common in the slopes of Himalayan Hills at altitudes 1500-3000 m. Great economic value for timber. Large handsome, dark-green tree. Suitable for roadside and groves in the hills.
30.	Ceiba pentandra	Kapok tree	Safed Simal	Swet Simal (Beng)	Tall, deciduous, flowering	A tall tree with straight trunk which is prickle when young. Numerous branches spring from the same level and radiate horizontally outwards. Leave fall in winter and creamy white flowers appear in clusters at ends of twigs before new leaves appear.
31.	Chorisia speciosa	Mexican Silk Cotton tree	Vilayti Simal		Large sized, deciduous, light foliage	A beautiful tree bearing large pink flowers in October-November on leafless branches. Gives shade in summer months.
32.	Cocos nucifera	Coconut palm	Nariyal	Thenga(Tam) Kobbari, Tenkaya(Tel) Thenga(Mal) Tengina(Kan) Narikel(Beng)	Tall, unbranched, edible fruits	Grows ideally in coastal belt with heavy rainfall. Good economic yield.
33.	Colvillea racemosa	Colville's glory	Kilbli		Large sized, handsome, light foliage flowering	A handsome tall tree. Leaves larger and dark greyish than gulmohar. Bears orange-scarlet flowers in drooping racemes in August-September. Suited to moist or moderately dry low country.
34.	Cordia sebestena	Scarlet Cordia	Lal Lasora	Virigi (Tel) Acchinarurihli(Tam)	Small sized, Flowering	A small tree, some times branching from the base. Has dark grey bark which is rough and marked with longitudinal furrows.
35.	Couroupita guianensis	Cannon ball tree	Shiva-lingam	Nagalingam(Beng)	Tall, evergreen flowering	A tall evergreen tree with a stout straight trunk and rough browish grey bark. Narrow pointed leaves cluster at the neds of short branches. The tree is remarkable due to its habit of bearing large and perculiar flowers on short twigs from the lower part of the

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1	2	3	4	5	6	7
						trunk. The fruit is large, hard, brown and spherical.Flourishes only in moist tropical climate.
36.	Crataeva religiosa	Bengal quince	Barna	Barum(Beng) Bilpatre(Kan) Varmo(Guj) Mili(Mal)	Small sized, light foliage, slow growth, flowering	A spreading tree with medium height. Leaves triplicate and deciduous. Very beautiful when laden with cream coloured flowers in April. A shady tree in summer. Hardy and drought resistant.
37.	Delbergia sissoo		Shis-ham, Siscoo		Large sized, good shade, economic value	Grows best in light sandy soil. Stiff soils do not suit it. Requires moisture and hence irrigation is needed in dry districts. Suitable for plains of Indo-Gangetic region for planting in avenues and in groups. Large branches and well-developed crown. Leafless in January-February. Timber has economic value in furniture making.
38.	Dillenia indica	Elephant apple	Chalta	Chalita(Beng) Karambal(Guj) Akku (Tam) Kalinga(Tel)	Medium sized, thick foliage, slow growh flowering	A medium sized tree of compact habit and roundly shaped form. Leaves large with serrated margin. Flowers large, white and fragrant. Prefer moist localities.
39.	Diospyros embryopteris	River ebony	Gab	Gab(Beng)	Small sized, evergreen, thick foliage, slow growth	An evergreen tree with a dense rounded crown of dark green shiny with low spreading branches which sometimes touch the ground. New leaves are bright red.
40.	Ehretea serrata		Punyan	Kulaaja(Beng)	Medium sized, evergreen, flowering	An evergreen tree of moderate size having white grey bark marked with longtitudinal cracks. Leave long narrow and pointed. Bears pretty white flowers.
41.	Enterolobium saman	Rain tree	Vitayti svis		Large sized, flowering	A large tree with pinnate leaves, grows very rapidly; flowers appear in pate pink clusters. Wind resistant. Suitable for planting in exposed places. Suitable for avenue planting
42.	Eucalyptus rostrata	Eucalyptus			Tall tree, quick growth,weak wood	Rapid growing tree, grows on ordinary soil. The tree has the disadvantage that large branches are liable to break off. A native of Australia, but has been successfully grown in various parts of the counrty.
43.	Ecucalyptus tereticerius	Grey gum			Tall tree, quick growth, weak wood	Elegant tall tree with think crown. Avenue may not be shady but appears elegant. A native of Australia, but has been successfully planted in different parts of the country.
44.	Eugenia jambolana	Indian cherry	Jaman	Jambul(Mar) Nerate(Kan) Negai(Tam) Neredu(Tel) Naval(Mal) Jam(Beng)	Large sized, quick growing thick foliage, ediblefruits	A fine large tree with shady evergreen foliage. Common in all parts of India except very dry areas. Yields edible fruits. Very suitable for shady avenues. Good value for timber.
45.	Feronia elephantum	Wood-apple	Dharkth Kaveet, Bhel, Kaitha	Vila(Tam) Velaga(Tel) Vilavu(Mal) Baelada(Kan) Kartbal(Beng)	Small sized, light foliage	Not a very shady trees. Grows in any soil and does not require much nursing and care. Not grown on the hills. Yields fruits having medicinal properties. Its leaves are used for worship in Hindu temples.
46.	Ficus Bengalensis	Banyan	Banyan Bor Bargad	Ala(Tam) Marri(Tel) Aal(Mal) Alada(Kan) Wad(Mar) Bat(Beng)	Large sized, Shady, unweildy for avenues	Large, spreading evergreen tree with aerial roots handing from branches. Not eminently suited for highway avenues as it becomes eventually unwieldy. Good for camping ground, and as isolated plantings at intervals along highway avenues. Does not grow in extreme cold or extreme dry climates.
47.	Ficus glomerata	Country Fig	Gular, Dumer	Atthi(Tam) Medi(Tel) Atthi(Mal) Atthi(Kan) Umbar(Mar)	Medium sized, quick growth, shady, weak wood	Medium sized tree with green leaves. Best planted on camping grounds and near wells. Good shade-giver. Quick growing and semi-evergreen. Has weak wood and should not be used for road avenues.

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1	2	3	4	5	6	7
48.	Ficus Infectoria		Parkar	Pakur(Beng)	Large sized, thick foliage, quick growing	A large shadey tree, practically evergreen. Grown in Uttar Pradesh, Maharashtra and Madhya Pradesh.
49.	Ficus religiosa		Pipal	Ashvatha(Mar) Arali(Kan) Peepul(Beng)	Large sized, light foliage	Large sized tree having religious significance for Hindus. Grows almost throughout the country in the plains. Suitable for roadside arboriculture. Does not look well when mixed with other species in avenues.
50.	Ficus retusa		Pilata	Nandruk(Mar)	Large sized, thick foliage, slow growth	Grows in the south and in the Indo-Gangetic plain. Fairly large tree with dense foliage. Frequently grown as an avenue tree. Grows well and is very hardy in tolerably warm climate.
51.	Gliricidia maculata	Madre tree			Small sized, Flowering	A small quick-growing tree with long feathery leaves. Leaf-fall in February, followed by sprays of pale pink flowers. Suitable for inner avenues of urban roads.
52.	Gamelina arborea	Candahar tree	Gamhar		Medium sized, deciduous, fast growth	A fair sized deciduous fast growing tree having a whitish bark and spreading branches which form a large shady head. The large leaves are heart-shaped with long points. The tree is drought resistant.
53.	Grevillea robusta	Silver Oak			Tall, columnar, thick foliage, slow growth, flowering	A tall narrow graceful tree with rough barks, short branches and deeply divided fernline leaves which are dark green above and silvery below. The tree forms a beautiful conical shape. Bears orange flower in March-April
54.	Harduickia binata		Anjan		Medium sized, thin foliage	Not very large tree. Slow grower and not a good shade giver, but ornamental. Thrives on rock and sandy soil, but not in water-logged locations. Planted in U.P., M.P., and Maharashtra
55.	Hetrophragma adenophylium				Medium sized, handsome, evergreen	A handsome evergreen tree of fair size with rough brownish bark marked with caracks, short branches dark green foliage consisting of very large leaves.
56.	Holarrhena antidysenterica	Eastern tree	Verra	Kurachi(Beng)	Small sized, Flowering	This is a low tree with rather rough, pale brownish bark and large narrow leaves set practically without stalk in opposite pairs along the smaller branches. White scented flowers grow in loose clusters at the ends of the twigs.
57.	Holoptelea Integrifolia	Indial Elm			Sub-Himalayan, Shady	A sub-Himalayan tree, planted for shade. A good tree for avenue planting.
58.	Jacaranda mimofaefolia		Nili gulmo-har		Small sized, Flowering	A small tree with fern-like bipinnate leaves andpyramidal panicles of blue flowers. Suitable for dry areas. Bears violet blue flowers in March-April.
59.	Juglans regia	Walnut	Akrot		Large sized, shady edible fruits	Suitable for roadside palnts in the northern hills upto altitudes of 3000 m. High economic value because of nut and timber. Admirable roadside avenue tree.
60.	Lagerstroemia flosreginae	Pride of India	Arjun	Jarul(Beng) Challa(Kan) Atampu(Mal) Kadali(Tam)	Medium sized, light foliage, flowering	A medium sized evergreen tree with a short trunk and bushy crown. Leaves are narrow with blunt points, becomes red before fall, bears brilliant lilac flowers. Timber has good value. Moisture loving tree, thrives on river banks.
61.	Mangifera indica	Mango	Amaltas	Manga(Tam) Mamidi(Tel) Mayu(Mal) Mavina(Kan) Am(Beng)	Large sized, shade edible fruits	Large evergreen tree with a dense found crown of dark-green leaves. Essentially a shade tree and has economic value because of fruits and timber. Practically grows on any soil, but rich loamy soil is preferable. Moisture

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1	2	3	4	5	6	7
						is essential but stagnant water near roots is fatal to be tree. It is very long-lived tree, but tends to develop hollows with age. Grafting is necessary from trees of a good variety. One of the most useful trees for roadside avenues.
62.	Melia eradirachta	Persian Lilac tree	Bakain	Ghoraneem(Beng)	Medium sized, deciduous, flowering	A handsome tree of moderate size, very fast growing, leaves divided into separate pointed leaflets. It resembles Neem. Deciduous, bears lilac coloured flowers in summer. Rather short lived.
63.	Mesua ferrea			Nagochampa(Mar) Naga Sampighi(Kan)	Small sized, quick growth, light foliage, flowering	A small sized tree yielding highly scented flowers. Good for isolated plantings.
64.	Michelia champaka		Champa	Champa(Mar) Sampighi(Kan)	Small sized, Flowering	A small sized tree yielding highly scented flowers. Good for isolated plantings.
65.	Millingtonia fortensis	Indian Cork Tree	Akas nim	Maramalli(Tam) Akasamalli(Tel) Katesam(Mal) Biratumara(Kan)	Large sized, light foliage, flowering	Lofty tree with exceedingly beautiful foliage. Tree is very brittle and shallow rooted and must be placed away from overhead utilities. Useful as an occasional avenue tree or group tree.
66.	Milletia Ovalifolia	Moulmein rosewood			Small sized, light foliage, flowering	A very beautiful small tree with a rounded crown and branches that have a tendency to drop. Bear brilliant lilac flowers in March-April.
67.	Mimusops elengi	Elengi	Mulsari	Magizh(Tam) Mukuzha(Mal) Ranji or Bakur Bakul(Beng)	Medium sized, thick foliage	Moderate sized tree, widely cultivated. Thrives in moist conditions.
68.	Mimusops hexandra		Khirni	Rayan(Mar)	Large sized, shady flowering	A large, ever green tree. Fruit is edible. Slow grower and requires initial watering for 2-3 years. Prefers moist alluvial soil. Grown in Maharashtra and Madhya Pradesh
69.	Nauclea Cadamba		Chota Kadam		Medium sized, flowering	The tree is of moderate size, having a short straight trunk, large broad rounded leaves covered with minute hairs on lower surface. Bears orange yellow scented flowers of compact spherical heads.
70.	Olea ouspidata	Olive	Kau		Medium sized, thrives in hills	Medium sized tree common in the northern hills upto an altitude of 2000 m. Timber has good value.
71.	Parkinsonia aculeata		Vilayti babool		Small sized, Flowering	A small tree with drooping branches. Leaves are very finely divided, bears bright yellow flowers suitable for dry and saline tracts.
72.	Peltophorum ferrugineum	Rusty Shield bearer	Piligul-mohar	Ivalvagai(Tam) Kondachinta(Tel)	Large sized, evergreen, flowering, handsome	A maginificent evergreen tree with smooth grey back, short branches and elegant dark green foliage. Makes a good crown and dense shade. Bears beautiful yellow scented flowers. Common in Bihar, Bengal and Western Ghats
73.	Phoenix dactylifera	Date-Palm	Khajur	Perichchu(Tam) Karajuramu(Tel) Tenicheha(Mal) Kharjura(Kan) Khejur(Beng)	Salt and erosion resistant, Palm, edible fruits	Tree yields date fruits. Gives good protection against soil erosion. Thrives in arid regions.
74.	Phyllanthus emablica	Indian gooseberry	Amla	Nelli(Tam) Usirika(Tel) Nellikay(Mal) Nellikai(Kan) Amalaki(Beng)	Medium sized, light foliage, quick growth, edible fruits	Medium sized tree yielding sour edible fruits. Not a shady tree.

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1	2	3	4	5	6	7
75.	Picea Smithiana	Spruce	Rai,Tos		Tall tree, thrives in hills	A large, evergreen, coniferous tree with tall straight trunk. Common in hills at altitudes 2000-3500 m. Good roadside tree at high elevations.
76.	Pinus excelsa	Blue pine	Kail		-do-	Common altitudes of 1500-3500 m in the Himalayan Hills. Coniferous tree with graceful appearance.
77.	Pinus longifolia	Pine			-do-	Common in the Himalayan Hills at altitudes 600-1500 m. Coniferous tree with graceful shape. A good roadside tree on hills slopes.
78.	Platanus orientalis	Plane tree	Chinar		Medium sized, thick foliage	Very shady tree with large lobed leaves, suited to northern cold parts of the country. Prefer damp climate.
79.	Polyalthia longifolia	Mast tree	Deodar	Debdaru(Beng)	Large sized, light foliage, quick growth	Tall, handsome, evergereen tree suitable for planting in avenues. A very common tree in Oudh and Allahabad
80.	Pongamia glabra	Indian beech	Kanji	Pungu(Tam) Ganuga(Tel) Punja(Mal) Honge Gida(Kan) Karanj(Mar) Kanaj(Guj)	Medium sized, quick growth, shady, flowering	Moderated sized, nearly evergreen, fast growing tree with good shady crown. Prefers moist localities, though it grows also in dry places. Have good timber value and seeds yields oil.
81.	Populus alba		Poplar		Tall, handsome	A very tall, graceful tree, forming magnificent avenue on highways in the Kashmir Valley.
82.	Prosopis apicigerra		Jand Cheonkar		Medium sized, thorny	A moderate sized thorny tree, native of dry regions of Rajasthan, Haryana and Punjab. The tree sends down deep roots and is well adapted for cultivation in dry districts.
83.	Pterospermum acerifolium		Much kand Kanak chmpa		Medium sized, thick foliage, flowering	An elegant middle sized tree with large rounded leaves dark green above and white below. The tree forms a good corwn and dense shade. Flowers cream coloured and fragrant, prefers moist climate.
84.	Putranjiva roxburghii	Child life tree	Jiva-putra		Medium sized, thick foliage, slow growth	This is a medium sized evergreen tree with dark grey bark, narrow shining dark green leaves which are arranged in two rows on either side of long drooping twigs. Provides dense shade, slow growing.
85.	Quercus incana	Grey Oak	Ban		Large sized, thrives in hills	A large evergreen tree with grey foliage. Very common in the hills at altitudes 1000-2500 m where rainfall is heavy. Good roadside tree.
86.	Quercus semecarpifolia	Brown Oak	Karsu Kreu		Large sized, thrives in hills	Large tree found at altitudes 2500-3000 m. Suitable for roadside avenues or groves at high altitudes.
87.	Rhododendron arboreum	Rhodod-endron	Bars		Small sized, flowering, thrives in hills	A small tree with grey foliage and handsome flowers. Thrives at altitudes 1500-2500 m. Suitable for growing in sheltered places on slopes of hills.
88.	Robinia pseudocacia	Robinia			Thrives in northern hills	Suitable for roadside plantings in hills of the north. Thrives on loose soil, but needs fair amount of moisture.
89.	Salix babylonica	Weeping willow			Resistant to waterlogging and erosion	Generally thrives in moist soil in the immediate vicinity of rivers and ponds.Fast growing but short-lived tree. Good for checking erosion.
90.	Salvadora persica		Pilu		Small sized, drought resistant	Small evergreen tree, grown in drier parts of the northern plains. Gives good shade, and when grown in groups, a handsome appearance.
91.	Sapindus detergens	Soapnut tree		Seege Kali(Kan) Chika Kai(Tam)	Medium sized, drought resistant	Grows in dry spots throughout the country, especially in the lower hills. Seeds have economic value.

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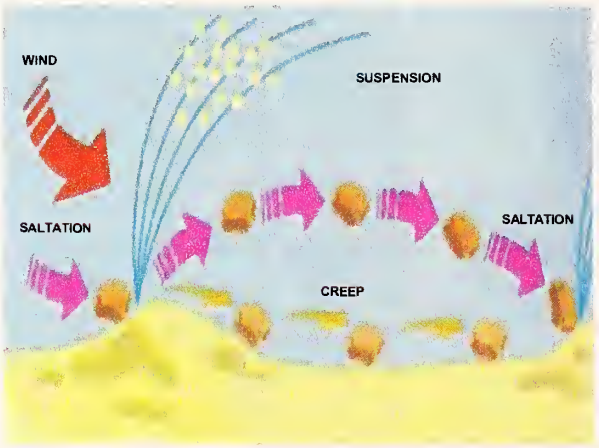
1	2	3	4	5	6	7
92.	Saraca indica	Ashoka	Ashoka	Achenga(Kan) Ashopalava(Guj) Aemapushpam(Mal) Asogam(Tam) Ashokamu(Tel)	Small sized, handsome, thick foliage, flowering	A very handsome evergreen tree with thick shade. Branches spread in all directions. Flowers in large compact clusters in February-March. Sacred for Hindus.
93.	Schieichera trijuga	Gum Lac tree	Kusum		Medium sized, thick foliage	This is a large tree with a dense shady crown, drops leaves only for a short period. Newly emerging leaves are bright red in colour for which the tree is very much preferred.
94.	Spathodea Campanulata	Tulip tree	Pichkari	Nirukavi(Kan) Patadi(Tel)	Tall, handsome, flowering	A fairly tall tree with short branches and dark green foliage. The large leaves are set in opposite pairs and divided into a number of pointed leaflets. It produces large cupshaped orange-crimson flowes on the top of the tree. Appears very attractive when grown in clumps or avenues.
95.	Sterculia alata	Buddha's coconut			Large sized, think foliage, quick growth	A very handsome tall evergreen tree with erect growing habit leaves broad, quick growing, makes a very good avenue tree.
96.	Swietenia mahagoni	Mahagoni	Maha-goni		Large sized, economic value	It is a maginificent tall and spreading evergreen tree with a stout trunk, forms a beautiful roundish crown. Leaves are delicately divided into narrow curved leaflets with tapering points. Produces one of the most famous timbers in the world.
97.	Tamarindus Indica	Tamarind	Imli	Puli(Tam) Chintamanu(Tel) Puli(Mal) Hunasehannue(Kan) Chinch(Mar) Tentub(Beng)	Large sized, light foliage, slow growth	Fairly big tree. Drought resistant and thrives in any soil. Not favoured in high altitudes and waterlogged areas. An excellent avenue tree. Has great economic value for fruit. Grows rather slowly.
98.	Tamarix articulata		Farash		Thrives in arid saline soil	A tree hardly, requiring little water when one established. Prefers a loamy soil, but grows when on saline soils, hard clay and sand. Rise to tall heights. Found in the northern plains of the country.
99.	Tectona grandis	Teak	Saguna	Thekku(Tam) Tekko(Tel) Thekka(Mal) Tegu(Kan) Segun(Beng)	Tall, poor shade, economic value	Tall tree with straight bole and foliage of large leaves. Does not yield good shade. Best planted in clusters for column effect. High economic value for timber.
100.	Terminalia arjuna	Arjuna Myrabalan	Arjuna, Aajan, Kahu, Kornaua	Vella Maruthu(Tam) Maddi(Tel) Marutha(Mal) Kaidaryayu(Kan) Arjun(Beng)	Tall, thin foliage, flowering	Tall, graceful tree and very good for avenue purposes, though does not yield much shade. Grows in any rich soil. Timber is valueable.
101.	Terminalia belerica	Belleric Myrobalan	Behera	Balra Beheda(Mar) Jare(Kan) Behera(Beng)	Quick growth	Easy to grow and makes excellent avenue tree.
102.	Thespesia populnea	Portia	Dumbla Paras Peepal	Bhendi(Mar) Huvarasi(Kan) Puvarasu(Tak) Gangaregu(Tel)	Small sized, thick foliage.	Small, evergreen tree with dense foliage. Not recommended for avenues because of twisted trunks and tendency to develop hollows.
103.	Ulmus Wellichiana	Big-leaved Elm.			Large sized, thrives in northern hills	Large, handsome, deciduous tree with large leaves. Grows in Himalayan hills at altitudes 1000-3000 m.
104.	Ulmus leavigata	Small leaved Elm			Large sized, thrives in northern hills	Large shade tree grown in hills.
105.	Zysyphus jujuba	Jujuba	Beer, Ber	Ilandai(Tam) Regu(Tel) Llanda(Mal) Bogari(Kan) Kul(Beng)	Small sized, thorny, edible fruits	Small thorny tree, having rapid growth. Not grown on hills. Timber and fruits have economic value. Grows fast and gives dense shade.

Appendix - II
(Refer to Para 11.1.2)

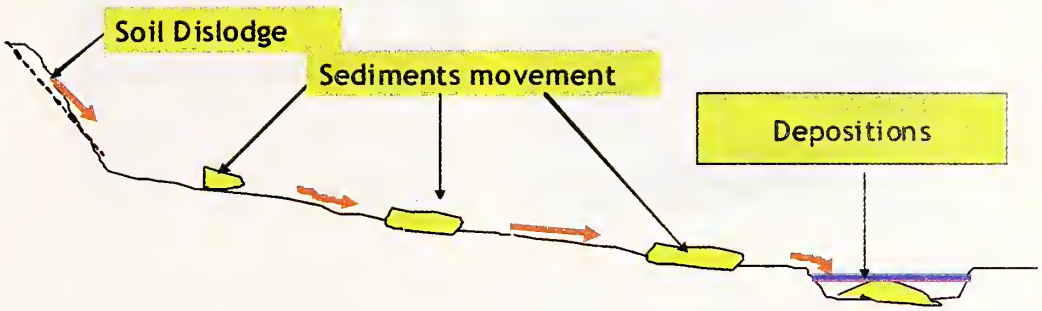
SLOPE PROTECTION AND LANDSCAPING

SOIL EROSION

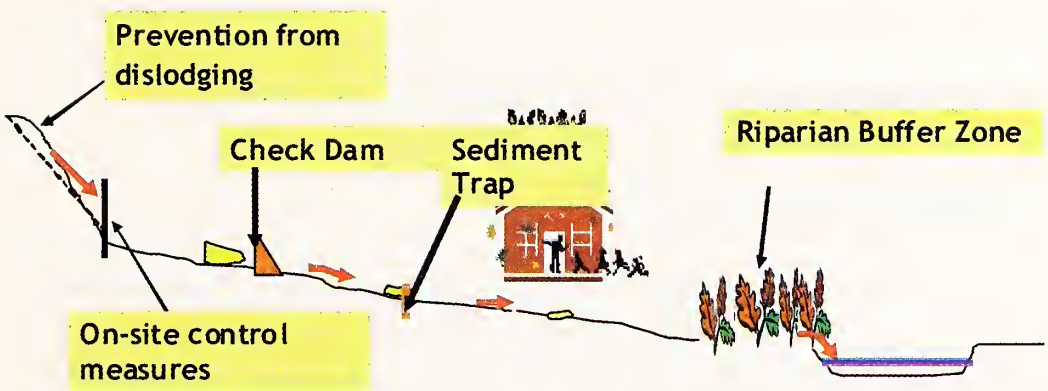


- *When soil erodes, particles move from the place of origin and are deposited elsewhere.*
- *Soil erosion destroys the ability to produce crops*
- *Results in deforestation*
- *Reduces storage capacity of water in Lakes, River, canal.*
- *Wind Erosion starts when the force of the wind overcomes gravity. Soil is carried by the wind in three ways-suspension, saltation and surface creep.*
- *Suspended soil particles can be carried by the wind for great distances. Coarser particles will be bounced along by the wind. The process is called saltation. Surface creep refers to a process where larger particles roll the direction of the wind.*

Typical Erosion Process



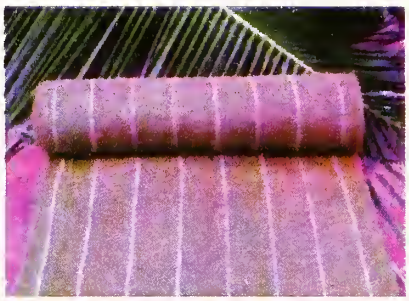
Controlling Erosion



SVFU Provides Eco-Friendly Innovative, faster and economical Solutions for:

- ***Eco Restoration of Mine Waste Dumps***
- ***Soil Erosion Control, Flood Control***
- ***Soil Stabilization, Hill Slope Protection***
- ***Water Courses, Irrigation***
- ***Mulching, Revegetation***
- ***Landscaping***

EROSION CONTROL BLANKETS



Erosion Control blankets protect soil and seed from erosion by providing a cover against the erosive forces of overland storm water flow and the effect of rainfall. Erosion Control blankets act as a non-deteriorating mulch that promotes seed germination beneath the mat. Vegetation easily grows through it because of it's high porosity.

SOIL EROSION CONTROL BLANKETS

BENEFITS OF COIR

- *Coir is natureal and 100% biodegradable. Coir is one of nature's strongest fibres and will maintain its tensile strength under soil & water. It is also highly UV resistant.*
- *Coir has the best content of Lignin and is resistant to mould and rot. Coir biodegrades very slowly over a 5-10 year period and*
- *Coir retains moisture, act as a mulch and provides an excellent microclimate for faster growth of plant and root system.*
- *Re-vegetation measures using coir encourage the restoration of terrestrial and aquatic riparian habitat.*

SOIL EROSION CONTROL BLANKETS

UNIQUE ADVANTAGES:

- *Faster Binding of Soil*
- *Excellent air and water permeability*
- *Enough sunlight passes through it*
- *Holds the seeds and saplings in place*
- *Excellent medium for quick vegetation*
- *Easy to Install*
- *Eco-friendly and non-polluting*

Naturalization	Hard Armoring
➢ Naturalization also called bio engineering, Involves working with Natural materials such as live vegetation and re-vegetation with the help of coco erosion control blankets	➢ It refers to soild installations of concrete, rip rap, or metal pilings
➢ Immediate stabilization that strengthens over time	➢ Immediate stabilization
➢ Ecomomical	➢ Expensive
➢ Provides fish and wildlife habitat	➢ Destroys fish and wildlife habitat
➢ Decreases water velocities	➢ Increases water velocities
➢ Provides shading and decreases water temperature	➢ Warms stream water
➢ Works with natural forces rather than fighting them	➢ More likely to cause downstream erosion
➢ Aesthetically pleasing	➢ Aesthetically displeasing

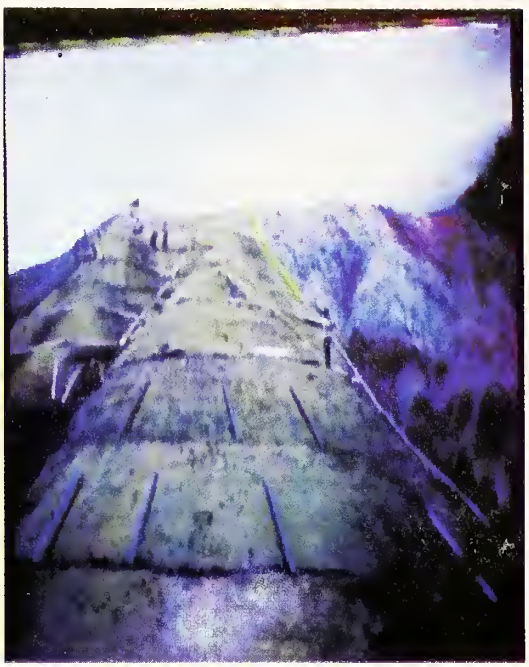
HIGHWAY EMBANKMENT

HILL SLOPE PROTECTION

Site before construction, October, 2002. Note old finish grade faces visible at the right hand 10% of the slope indicating volume and extent of loss

Site after third winter season, March, 2005. Areas at left and top received less compost

HILL SLOPE PROTECTION



(The Official amendments to this document would be published by the IRC In its periodical, 'Indian Highways' which shall be considered as effective and as part of the code/guidelines/manual, etc. from the date specified therein)