TCVN 5729: 2007

FREEWAY/EXPRESSWAY STANDARD FOR DESIGN

HANOI - 2007

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1. Applications

This specification is applied for designing new freeway/expressway outside the city, rehabilitating and upgrading highway into freeway/expressway.

In some special cases, some other standards may be applicable but it must be technically analysed and approved by the Authorities.

2. Standards and reference document

Regulations for traffic road, No 26/2001/QH10;

Decree 186/NĐ-CP dated November 05 2004 regarding the Regulations in management and protection of road transport infrastructure..

- TCVN4054 Roadway Design Standards

−TCXDVN 104 Urban Road - Design Criteria;

− TCVN 2737 :1990 Loading Capacity and Effect - Design Standards;

−TCVN 4527 :1988 Tunnel for Railway and Roadway - Design Standards;

− 22 TCN 272 Bridge Design Standards;

− 22 TCN 221 Transport Project in Earthquake Area - Design Standards;

− 22 TCN 211 Soft Pavement - Technical Specification for Design;

− 22 TCN 223 Procedure for Hard Pavement Design;

− 22 TCN 237 Roadway Signal Regulation;

− 22 TCN 278 Experiment Procedure for Determining Roughness Index by Sand Spreading;

− 22 TCN 345 Thin Asphalt Concrete with High Roughness Index - Technology of Executing Procedure and Checking before Acceptance;

− 22 TCN 277 Standard for Inspecting and Appraising Road Surface by International Roughness Index;

− 22 TCN 242 Procedure of Appraising Environment Effect on Feasible Study and Design Stage;

− 22 TCN 262 Procedure of Survey and Design Embankment on Soft Soil Area;

− 22 TCN 171 Procedure of Geology Survey and Design Method for Stabling Erosion Embankment.

Note: For the standards showing published year, apply the listed version. In the case there is no published year, apply the currently effective version.

3. General regulations

3.1. Definition:

The term “expressway” in this standard should be understood as follows:

The freeway/expressway is only used by car with the following specifications: separating two directions (each direction requires a minimum of two lanes; each direction needs the emergency lane). There should be no level crossing with other traffic flows. The expressway shall have appropriate equipment and service to ensure smooth and comfortable traffic condition. The expressway only allows car to enter and exit at the regulated locations (besides these entry/exit locations, the expressway is fully separated from the residential areas and other forms of transport).

Regarding its function, the expressway is the form of transport that has high flexibility with priority to shorten the travel time and ensure safe car traffic (predominantly to provide high effectiveness for long-distance car travelling).

3.2. Freeway/expressway grades

Freeway/expressway is divided into 4 grades based on calculated speed:

- Grade 60 with the design speed of 60 km/h

- Grade 80 with the design speed of 80 km/h

- Grade 100 with the design speed of 100 km/h

- Grade 120 with the design speed of 120 km/h

Grade 60, 80 are applied for the mountainous, hill topography and areas with other restrictions, the grade 100,120 for plain topography.

3.3. In case of improving the old highway into freeway/expressway, this specification must be obeyed although making the best use of the available works is encouraged.

Note: If the quality of the old highway is too bad, highly populated residential developments on both sides of the expressway, the freeway/expressway should be newly designed (separately from the old route).

3.4. Freeway/expressway has to exist outside the planned area arid to be suitable for the city plan in the future (except for the method of using viaduct over the city). When designing, it is. necessary to have the measures to ensure the transport relation between the city and freeway/expressway (even the measure of gathering traffic in the out / in point located on freeway/expressway). Besides we have to mention the solutions for protecting natural and social environment, preventing the impact on the life of resident along the freeway/expressway, especially the solutions to ensure the comfortable transport for the residential areas to be separated by the freeway/expressway.

3.5. In the preparation stage of the freeway/expressway construction project, especially in establishing pre-feasibility and feasibility study, there must be studies with the following content:

3.5.1. Study of defining the necessity of freeway/expressway, defining the control point to establish alignment alternatives, comparing and selecting route and evaluate the economic and financial effectiveness of the selected route.

3.5.2. Study of defining the number of lanes (if more two lanes for each direction required) based on evaluation of traffic capacity with the correlative service, study of the necessity of effectiveness of constructing the lane of slope for slow cars (see item 5).

3.5.3. Study of the necessity of arranging the sections for each direction at different evaluation to reduce the quantity of freeway/expressway base works (if freeway/expressway goes along the mountain slopes, hills or the existing two-lane road is rehabilitated into one part of freeway/expressway).

3.5.4. Study of defining the entry/exit points, study of selecting form and comparing the locations of intersections on freeway/expressway.

3.5.5. Study of defining vertical alignment at residential crossings, especially at the soft ground areas.

3.5.6. Studying and comparing the location of toll gate.

3.6. Freeway/expressway has to be designed with the traffic estimation of 20 years from the first in-service year. It bases on the plan of the railway, marine, traffic, aerial transport network at present and in the future so that it can be made the best use in the common transport network. Besides spare land for enlargement of lane and intersections should be paid attention.

3.7. Although having to consider road use in the far future, the stage investment modes must be considered in preparation of freeway/expressway project. We have to analyze and compare these modes on the base of evaluating effectiveness and advantages in the same condition.

3.8. Design of freeway/expressway requires the space coordination of alignment elements to ensure safe, comfortable, steady, continuous feeling, clearly showing alignment optically and psycho-physiologically to users, at the same time doing landscaping along the freeway/expressway by plants or works for protection of environment.

Design of freeway/expressway section with the above specification requires perspective presentation and 3D model to verify and evaluate the coordinated solutions.

3.9. Design of freeway/expressway at earthquake area which is forecasted level 7 or above (following MSK64 scale) must be obeyed standard 22 TCN 221.

4. Basis for designing freeway/expressway

4.1. The vehicles that are allowed to run on expressways are cars which are allowed to run on public road network and motorbikes which has appropriate power specified by the Authorities (recommended to be over 175cm^3). The size of cars on freeway / express is regulated in TCVN 4054 Highway - Design standards for determination of technical standards for geometrical elements and traffic clearance on freeway/expressway.

Besides the above-mentioned cars and motorbikes with appropriate power, people and other vehicles wish to use the expressway should obtain permits from the Authorities.

4.2. Traffic regulations on freeway/expressway

4.2.1. The vehicles must run on the correct lane; overtaking is allowed on the left lane; if there is auxiliary lane, it is only used by slow and heavy vehicles; if the car exits from freeway/expressway, it must run on the auxiliary lane and reduce speed; if it enters the freeway/expressway, it must run on the auxiliary lane, waiting for merging into the freeway/expressway.

4.2.2. The vehicles shall not be allowed to stop on freeway/expressway (except for the urgent situation, it can stop on the side road)

4.2.3. The vehicles is just allowed to turn its direction at the next intersection or at the stipulated points in item 7.4.3 (the empty sections on the separating line for reservation only)

In geometric design, guiding and warning elements must follow the above regulations.

4.3. Except for the special case, construction of freeway/expressway is considered if the evaluated traffic is from 25.000 units /day-night. It must not be understood that we have enough basis to approve the freeway/expressway construction project if the traffic is over the mentioned number. This number is only the guidance. In any freeway/expressway construction project (irrespective of how big traffic), it require

report of evaluating economic and financial effectiveness with the consideration of political, army, cultural and social requirements and international relation and exchange.

The traffic is understood as the average traffic all day and night per year of the vehicles allowed to run on freeway/expressway. It is changed into the passenger car equivalent unit (PCU) according TCVN 4054 - Highway Design Standard.

4.4. There may be some parts of different grades and this parts must be 15km-long or more and evacuated speeds at two continuous parts cannot be over 20km different. In case of over one grade (20km/h), there must be one of these parts with the minimum of 2km longer according to the standard of the middle grade.

4.5. Defining the number of necessary lanes on freeway/expressway

4.5.1. Defining the number of necessary lanes subscript format of each direction on freeway I expressway is based on the evaluated traffic each direction at peak k of the evaluated year (unit/hour) and designed traffic capacity of each lane (unit/hour-lane) as follows

$$N_{lx} = \frac{N_k}{N_{tk}}$$

N_k and N_{tk} are evaluated in PCUs. The quantity of necessary lanes for each direction shall not be less than two.

4.5.2. Defining N_k

The meaning of N_k: in the evaluated year, there is only k hours with the same or bigger traffic N_k is stipulated from 30 hours to 50 hours (the 30th rush-hour and 50th rush-hour in this year).

If there is no anticipation of N, designer is allowed to apply the following relation to define N_k:

$$N_k = K.N_{tbnam}$$

of which:

$$K = 0.13 \div 0.15$$

N_{tbnam} is the average traffic all day and night per year for each direction in the evaluated year (unit/day-night).

For each direction of freeway/expressway there may be different N_{tbnam}

4.5.3 Defining N_{tk}

Designed traffic capacity of one lane is defined as follow:

$$N_{tk} = Z.N_{ttmax}$$

of which:

.N_{ttmax} is the biggest practical traffic capacity of one lane in the standard condition (unit/hour-lane) for freeway/expressway, applied .N_{ttmax} = 2,000 unit/hour-lane.

Z is the factor of using traffic capacity, defined as follows:

Plain and hilly freeway/expressway applied *Z* = 0.55; mountainous one applied *Z* = 0.77.

4.6. Traffic clearance on freeway/expressway is showed in figure 1.

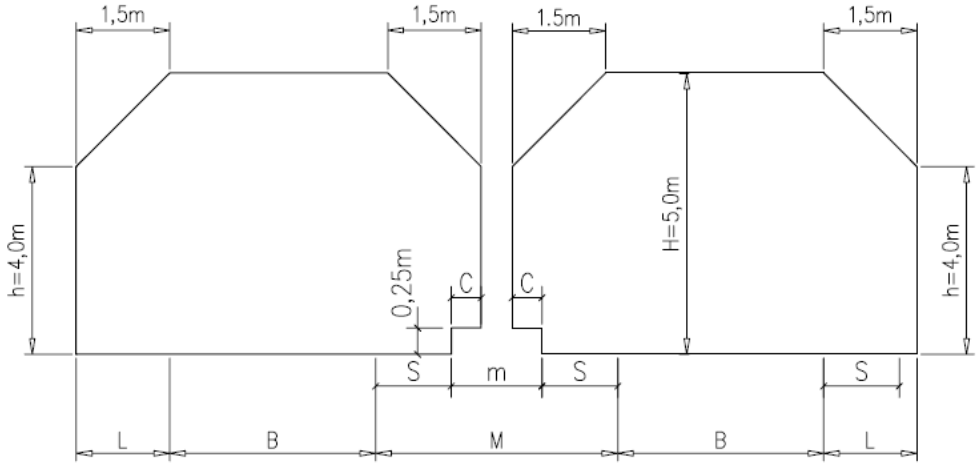


Figure 1 - Traffic clearance

of which:

m - the width of separated band, measured by meter.

M - the width of middle band, measured by meter

S - the width of the safe band, measured by meter.

B - the width of the road surface, measured by meter.

L - the width of hard shoulder (excluding the grass-growing) , measured by meter.

The values m, M, S, B, L are considered in according to the item 4.1 depending on the grade of freeway/expressway and the structure of separated band.

The factor c is stipulated as 0.3m for the grade 120; 0.25m for the grade 100, 80 and 60.

H = 4.75m is the elevation of overhead space limitation, measured from the highest point on the road surface B, measured by meter.

h = 4.0m is the height from the edge of shoulder.

4.7. The clearance limit of freeway/expressway tunnel is regulated in Figure 1 with the following notes:

4.7.1. Scale L-S is equal to the width of pedestrian road across the tunnel, it is 1.0m for freeway/expressway of grade 60 and 1,25m for freeway/expressway of grade 80 or more. The factor h is defined as follows:

$$h = \Delta h + 2.5$$

of which

Δh is the difference between the height of road surface and safe band surface S (h = 0.40m)

- 2.5 is the clearance for pedestrian, measured in meter.

4.7.2. With freeway/expressway tunnel which is longer than 1000m, the clearance limit at opening for the emergency lane is also regulated as figure 1 with value L, depending on the freeway/expressway grade.

4.8. Clearance required underneath freeway/expressway

When freeway/expressway comes over the railway or other traffic road, under freeway/expressway is required. It is correlative with the standard of railway, traffic road, marine road to ensure the comfortable transport on those roads. If the public road with pedestrian, bicycle and other non-motorised vehicles goes under freeway/expressway the clearance height at this place is stipulated as 2,50m with the minimum width of 4,0m.

5. Cross section arrangement of freeway/expressway

5.1. The elements of freeway/expressway cross section arrangement is shown in figure 2. The standard width of the elements of cross-sectional profile for each direction of two lanes on freeway/expressway is stipulated in Table 1.

5.2. Super-elevation of road surface on the straight part requires the outside slope of 2%, on the curve part it requires the super-elevation i_{sc}%, stipulated in figure 3, in which the safe band on the back of curve must be the outside gradient of 2%.

5.3. The safety lane has to ensure that the vehicles can run at the high speed. Besides the safety lane on the pavement is used for emergency vehicles if necessary (also called the emergency stopping lane).

5.3.1. In 0,25m close to the edge of road surface, the bands at every side must be same as the structure of road surface (road surface is widened 0,25 each side): outside this scale, the rest of the safe band can be thinner, but for the safe band on the hard pavement, it must ensure durability when the vehicle stops suddenly in urgent case (not very often). The design for safe bank must follow standard 22 TCN 211.

5.3.2. In 0,25m of widening the referred surface, the paint of stipulated color required to draw a direction-guiding line of 0,20m close to the edge of road surface. This line must be visible at night (light-reflective material used).

5.3.3. The super-elevation of the safe fine in the area of separating band must be equal to super-elevation of road surface, both on the straight part and the curve part as in item 5.2 (figure 2 & 3).

5.3.4. On straight alignment, the super-elevation of the safe bank is 4% (figure 2). On curve alignment which super-elevation is i_{sc}, the super-elevation of urgent stopping line at inside curve is i_{sc}, outside curve is 2% (Figure 3).

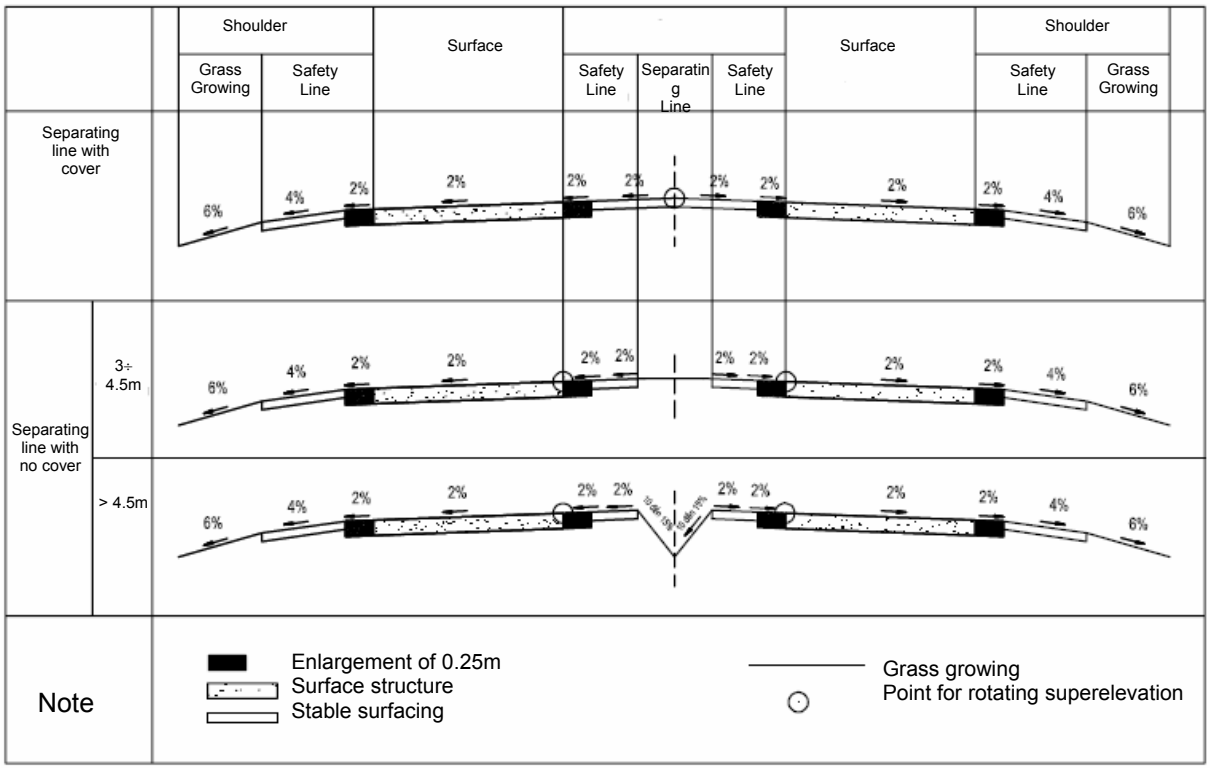


Figure 2 - Freeway/expressway Cross Section

5.4. The grass-growing pat must be slope outside the road base with the cross gradient of 6% (see figure 2 & 3).

5.5. The middle line includes two safe line s at two sides and one separating line to divide two directions of traffic, to reserve spaces for support of above road crosses signal structure, system, protective equipment, growing plants, anti-glaring devices (by headlight of opposite vehicles) and putting line, pipeline or drainage system. The width of separating line can be bigger than stipulation in Table I so that there is enough land for the mentioned works or widening the road in future if necessary.

unit: meter

Structure of separating line	Freeway/ expressway grades	Shoulder		Freeway/ expressway pavement	Middle line			Freeway/ expressway surface	Shoulder		Freeway express-way base
		Grass-growing line	Safe line		Safe line	Separating line	Safe line		Safe line	Grass-growing line	
1. with cover without column	60	0.75	2.5	7.0	0.50	0.5	0.50	7.0	2.5	0.75	22.0
	80	0.75	2.5	7.5	0.50	0.5	0.50	7.5	2,5	0.75	23.0
	100	035	3.0	7.5	0.75	0.5	0.75	7.5	3.0	0.75	24.5
	120	1.00	3 0	7.5	0.75	1.0	0.75	7.5	3.0	1.00	25.5
2. with cover and column	60	0.75	2 5	7.0	0.50	1.5	0.50	7.0	2.5	0.75	23.0
	80	0.75	2.5	7.5	0.50	1.5	0.50	7.5	2.5	0.75	24.0
	100	0,75	3.0	7.5	075	1.5	0.75	7.5	3.0	0.75	25.5
	120	1.00	3.0	7.5	0.75	1.5	0.75	7.5	3.0	1.00	26.0
3. without cover	60	0.75	2.5	7.0	0.50	3.0	0.50	7.0	2.5	0.75	24.5
	80	0.75	2.5	7.5	0.50	3.0	0.50	7.5	2.5	0.75	25.5
	100	0.75.	3.0	7.5.	0.75	3.0	0,75	7.5	3.0	0.75	27.0
	120	1.00	3.0	7.5	0.75	3.0	0.75	7.5	3.0	1.00	27.5

Table 1-The width of cross section on freeway/expressway

Note:

1) The column is arrange correlative with the elements on cross section from the left to the right in case two carriage-way is on the same freeway/expressway base. If difficult topography, each carriage-way of one direction can be placed on each base, the width of freeway/expressway consists of the width of one carriage-way direction and two pavement (for the right pavement, the width is the same as table 5.1., for the left pavement, the safe line is decreased to 1.25 the grade 120, 1.0m for the grade 100 and 0.75 for the grade 80, 60.

2) If each direction has 3 lanes its width of freeway/expressway surface must be plus 3.50m (grade 60) or 3.75 (grade 80, 100, 120) and the width of freeway/expressway base must be plus 7.0m (grade 60) or 7.5m (grade 80, 100, 120).

3) In any case the width of separating line is considered as the minimum.

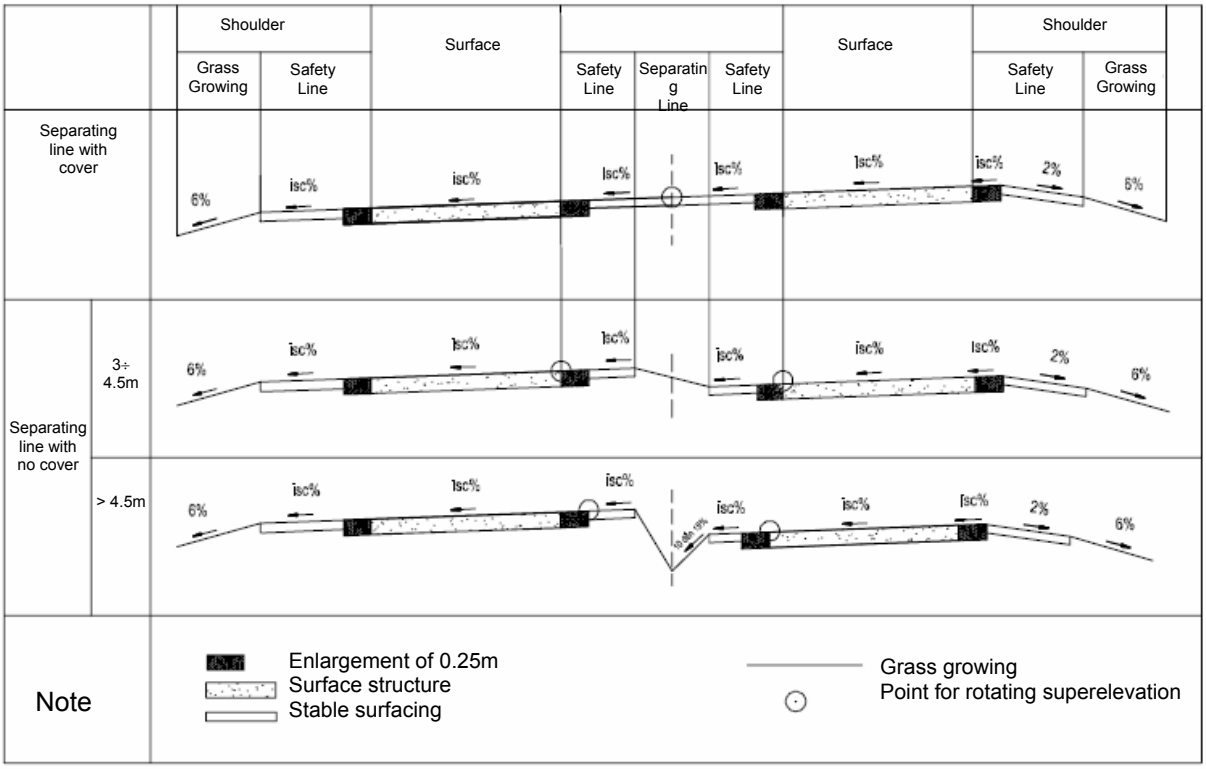


Figure 3 - Freeway/expressway Cross Section

5.5.1. If the width of the median is less than 3,0m there shall be a surfacing layer and the cross gradient of this layer from its centerline must be equal to the gradient of road surface in item 5.2 (see figure 2). For the median with curb and its width of 1.5m - 3.0m the surfacing layer is not required but it requires the solution to prevent sewage mixed with soil from the separating line from road surface (the land in the separating line between two curbs must be lower than the surface of bed) and preventing rainy water from the base of freeway/expressway (waterproofing layer of well compacted clay required).

5.5.2. If the width of the median is from 3.0 to 4.5m, there is no need for surfacing layer; planting is required with the cross fall of 0% for the straight section (figure 2). For the curve section, we can connect the outside of this safe line to the inside of that safe line after two parts of road surface of two directions are super-elevated separately (Figure 3).

In this case, no matter if the median is curbed or not, there must be longitudinal drainage system (constructing opened ditch, ditch with grated cover, permeable underground drainage pipe, infiltration trench etc.)

5.5.3. If the width of the median is more than 4.50m its profile must be designed into V shape with the cross gradient from the two safe line to centerline of 10% - 15% (see figure 2 & 3). The measure of showing direction at night and the bad weather condition (to showing the carriage way and the safe line clearly) is required to prevent vehicles from the median.

5.5.4. Along the median, at every 2 - 4km inverval, in front of major structures (bridge, tunnel), we have to set up one blank portion of 25 - 30m length so that the vehicles can turn its direction if necessary (the management and barrier is required here, this barrier is just opened in urgent case). The location of pausing section must be selected on the straight section or airy and visible curve section with the radius of 600m or more.

The end of the separating line at the beginning of the blank portion shall be rounded shall be made of semi-round.

5.5.5. For the separating line with curb, the curb must be 15cm higher than road surface, the traffic face of curb shall be made inclined (vertical face shall be avoided) outside is slope at the carriage way (not the longitudinal wall) and the upper traffic side corner must be made round.

In this case, the measure to drain water kept by curb on the curve required (drainage pipe or underground culvert with the intake point).

5.6. In difficult topography or for purpose of shortening the span of over and underground crossing structure on the freeway/expressway, the width of the cross section elements in Table 1 can be reduce as follows if approved:

- The width of freeway/expressway surface is reduced 7,0m. The width of separated line is not reduced.

- The width of the safe lines must not be reduced less than 0.5m. The width of the urgently stopping line must not be less than 2.0m or arrange the urgently stopping line of 30m length in each 500m.

- The grass-growing pavement must not be less than 0,75. For the freeway/expressway of the grade 60, it must not be less than 0.5m.

The length of the narrowed section as mentioned above must not be from 0.5km - 1km and more than 2km, also not less than 0.5 - 1km. The transitional section from the standard section to narrowed section must be 1° slope maximum compared with the centerline. The ends of the transitional section are connected with the curve sections which their radius is bigger than the correlative radius with the grade of isc = + 2% (Table 4).

5.7. If the carriage way of freeway/expressway is located on the separate base, the standard cross section of freeway/expressway is stipulated in item 1 - table 1.

5.8. If each direction has more than two lanes, the arrangement of the cross profile is still stipulated in table 1. For width of road surface, it needs 3,50m for one lane of the grade 60 and 3,75m for one lane of the grade 80, 100 and 120 (see note of table 1).

5.9. Up-hill auxiliary lane

5.9.1. Consideration shall be taken for the construction of slope auxiliary lane on 4-lane freeway/expressway in the following cases:

- The section with the longitudinal gradient of 3% or more and the length of the slope of 800m or more for the freeway/expressway of grade 100 and 120.

- The slope section with the vehicle speed is below the acceptable value in table 2, and the evaluated traffic volume on the going upside (2 lanes) is more than the designed traffic capacity in item 4.5.3 (N_{ttmax} is correlative with the definite gradient of the designed slope section; in primary evaluation the value N_{ttmax} for the going-up section at the average of 600 units / hour-lane).

Measured by km/h

The grade of freeway/expressway	120	100	80	60
The minimum acceptable speed for vehicles going up the slope	60	55	50	40

Table 2 - The minimum acceptable speed for vehicles going up the slope on freeway/expressway

- In the slope section which the speed of vehicles going up the slope is less than the acceptable value in table 2 and the length of the slope is more than 1000m the speed of vehicles going up the slope must be evaluated basing on the kind of vehicle, the grade and the length of the slope

- No consideration should not be taken for the construction of slope auxiliary lane for the 6-lane freeway I expressway (each direction has 3 lanes or more) and the 4-lane freeway/expressway crossing the big and high bridge, tunnel, deep base.

Note: In the above cases, the determination of the slope auxiliary lane to be constructed or not shall base on economic and financial study. The study trust mentions the time savings when light vehicles are going up the slope if another lane is constructed on the slope for trucks.

5.9.2. Structure and arrangement of auxiliary lane of going up slope

- The width of auxiliary lane of going up slope must be 3,50m; it can be reduced to 3,20m for the mountainous and hilly topography.

- The auxiliary lane shall be put close to the outside lane of carriage way with the separation line of 0,20m (this line is in the area of stoke auxiliary lane).

- The transitional section with triangular style from the outside main lane to sub lane is 45m long and put in the front of point of changing longitudinal slope, the outer side of transitory section must be connected with the curve line.

- At the end of slope, the transitional section shall be provided so that the trucks increase their speed for joining into the main lane: the length of this section. (from the peak to the foot of the slope) is stipulated in table 3:

Longitudinal slope after going up the slope, %	Down-hill	Going across on plane (0%)	Uphill			
			0.5	1.0	1.5	2.0
The length of the transitory section behind the slope, m	150	200	250	300	350	400

Table 3 - The length of transition section following the slope of auxiliary lane for vehicles going up the slope

There must be connection of triangular style of 75m at the end of transitory section.

5.9.3. Cross section of freeway /expressway at the section with auxiliary lane for vehicles going up slope.

- At the slope section with the auxiliary lane the urgently stopping line is not required, therefore the outside of the auxiliary lane only needs the safe line of 0.50m (with pavement marking of 0.20m) and the grass-growing line of 0.75m is following.

- On the straight freeway/expressway, the cross gradient of auxiliary lane surface, of the safe line and of the shoulder are the same as the one of the section without auxiliary lane.

- When the freeway/expressway is on the curve the highest super-elevation in the area of auxiliary lane is 4% (correlative with the super-elevation specified for the main lanes from 4% to 8%); if the super-elevation of the main lane is less than 4% the one of auxiliary lane is equal to the one of the main lane.

5.10. The cross section of freeway/ expressway at the section of parallel speed-changing lane

- The width of speed-changing lane is 3.50m for one lane and 7.00m for two lane. This lane is separating with the main lane by a pavement marking of 0,20m width (this marking is in the area of speed-changing lane).

- The arrangement of the speed-changing lane should be put on the cross section of freeway/expressway shall be similar to that of sub-carriage way for vehicles to going up the slope in item 5.9.3; for the curve the super-elevation in the area of speed-changing lane should be linearly changed according the increase or decrease of speed in the scale of super-high gradient of main traffic and the one of the out/in-coming section to freeway/expressway.

5.11. Corridor for freeway/ expressway

5.11.1. Land corridor for freeway/expressway begins from the outside of gutter on the two side of the embankment (from the batter toe or supporting structure if there is no side gutter), or from the outside edge of the gutter on top of cut batter (if there is no top gutter, then calculated from the top of batter) according to Regulations on Road Management attached to an Decree 186/2004/NĐ-CP.

5.11.2. For the section of high embankment or deep excavation, embankment on weak soil the determination of land corridor must be based on the protection works such as counterweight beam, retaining wall etc.

5.11.3. We depend on the practical requirement and derailed design to define land corridor for the arrangement of equipment along the alignment, resorts, supporting works and toll stations on freeway/expressway in principle of saving land and using uncultivated land.

5.11.4. In the area of land corridor stipulated in item 5.11.1, plants are allowed to grow according to the current regulation, the non-road works such as canals, pipeline, cable and electric wire pole and other equipment are not allowed to build. For BOT expressway projects, the use of this corridor is regulated in the permit documents and investment agreements.

5.12. The cross section of the bridge on freeway/expressway

5.12.1 For all type of bridge, its cross section is arranged and follow the standards of the road cross section of the correlative grade in item 5.1. It requires the shoulder, surface, middle line with the dimension stipulated in table 1. The grass-growing pavement (from 0.75m to 1.0m, it depends on the grade of freeway/expressway) is replaced by the sub-line for servicing and parapet as shown in figure 4; it means that the width of the bridge (from the outside face of this bridge parapet to the outside face of that one) is equal to the width of road base at the correlative grade.

5.12.2 In complicated cases, the cross section of big and medium bridge can be narrowed in item 5.6 (including the stipulation of arrangement of the transitional section from the standard cross-section to narrowed cross section), accepted by investor.

On the small and medium bridge of 100m length or less the cross section shall not be narrowed (the length shall includes two abutments).

5.12.3 The cross section on freeway/expressway bridge shall be kept unchanged along to the length of bridge, including the length of two abutments. The structure of cross slope direction and cross grade of bridge on the straight or curve section is the same as the road (item 5.2).

5.12.4 On the cross section, the bridge of freeway/expressway is often divided into two bridges for two directions (figure 4), therefore there may be a free space with the

same width of separated line between two median parapet. This free line can be used for lightening the section below freeway/expressway or covered by light material which is able to resist pedestrian loading if narrow (for repair and maintenance)

5.12.1. The bridge cross section shall be arranged so that the width (between outside faces of two outmost parapets as shown in figure 4) shall be equal to that of road base as stipulated for cases in items 5.7, 5.8, 5.9.3, 5.10.

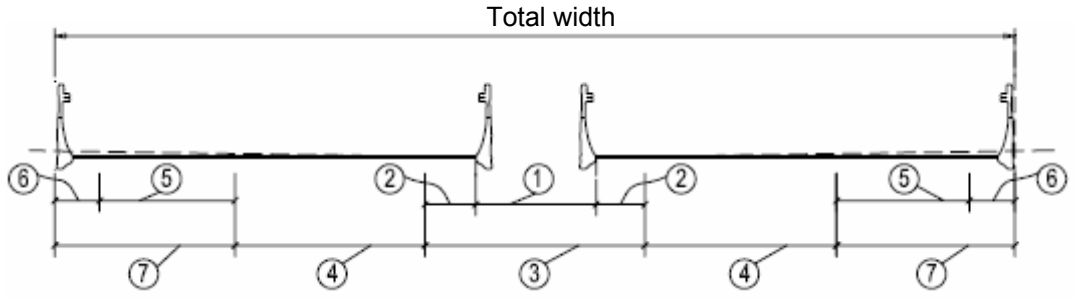


Figure 4-The cross section of bridge on freeway/expressway

Note:

1) The same as the width of median ,

2) The same as the width of safe line on the left.

3) The same as the width of the median

4) Freeway/expressway surface (carriage-way)

5) The same as the width of safe line on the right

6) The grass-growing line is replaced by the area of parapet and walkway for servicing staff of freeway/expressway staff.

7) Correlative with the width of the right pavement.

5.13. The cross section of tunnel on freeway/expressway

5.13.1. On freeway/expressway tunnel of length less than 1000m, the urgently stopping lane may not necessary, the arrangement of pedestrian lane is stipulated in item 4.7.1. In case the length of freeway/expressway tunnel is greater than 1000m, the urgently stopping lane with 30m length shall be placed at interval of 500m.

5.13.2. The separating freeway/expressway tunnel for different direction of lanes is recommended in design. For stabling the construction stratums, the minimum distance between crest line of two tunnel shall equal or greater than 10m - 15m.

5.13.3. The dimension of the elements on the cross section of one tunnel for one direction of freeway/expressway stipulated in item 4.7:

- The width of carriage way, B, in tunnel is correlative with the grades of freeway/expressway in table 1;

- The width of safe line (S in figure 1) depends on freeway/expressway grade (table 1);

- The width L (figure 1) is stipulated in 4.7.1 or 4.7.2;

- The pedestrian lane of 1.0m width shall higher than 0.4m above main lane;

- The grass-growing lane is not constructed;

- The clearance height of the freeway/expressway tunnel is stipulated in item 4.7

5.13.4. If the different direction of lanes is designed in one tunnel, the cross section of freeway/expressway in tunnel is stipulated in figure 1.

5.14. The cross section of the spur road of freeway/ expressway (also the extension road in the area of intersection on freeway/expressway) consists of one-way spur road and two-way one.

5.14.1. The width of the one-way spur road surface on the straight section is 4.0m, 7.0m for the two-way one; the extension width of curve section is stipulated in table 16. In case of heavy traffic, the width can be calculated by the number of necessary lanes (see TCVN 4054)

5.14.2 The cross section of the one-way spur road consists of road surface (as above), the safe line of 2.0m on the right and the grass-growing pavement of 1.0m on the left.

5.14.3 The cross section of the two-way extension road consists of road surface (as above), one safe line of 1.0m for each side and the grass-growing pavement of 0.75m.

6. Design of freeway/ expressway alignment on location map, longitudinal profile and coordinated design of alignment elements.

6.1. Main technical standard of alignment elements of freeway/expressway grades on location map and longitudinal profile is stipulated in table 4.

Items	The grade of freeway/ expressway			
1. Calculated speed Vtt Km/h	60	80	100	120
2. Highest super-grade (or one-wing grade) isc % not more than	7	7	7	7
3. The minimum radius Rmin correlative with isc = +7%,m	140	240	450	650

4. The minimum radius correlative with isc, = + 5%	250	450	650	1000
5. The radius correlative with isc =+ 2%m	700	1300	2000	3000
6. The radius with out the structure of one-wing grade isc = -2%, m grade i 2% m v	1200	2000	3000	4000
7- The length of the transitory curve correlative with Rmin, m	150	170	210	210
8. The length of transitory curve correlative with the minimum radius, m	90	140	150	150
9. The length of transitory curve correlative with the radius with the factor in bracket, m	50 (450)	75 (675)	100 (900)	125 (1125)
10. The length of braking section and the eyeshot of stopping vehicles, m	75	100	160	230
11. Maximum longitudinal gradient of going up, %	6	6	5	4
12. Maximum longitudinal gradient of going down, %	6	6	5.5	5.5
13. The minimum radius of convex radius, m	1500	3000	6000	12000
14. The minimum radius of concave radius, m	1000	1 2000	3000	5000

Table 4 - Main technical standard for freeway/expressway alignments

Note: The evaluated speed V_{tt} is understood as the speed for evaluating and defining limited standards of the geometrical elements at the special points of freeway/expressway.

6.2. Standards of the straight alignment section on the location map of freeway/expressway

- The length of straight alignment section shall not be exceed 4km on freeway/expressway

- The straight alignment section (measured by meter) which is not more than 20÷25 times of the evaluated speed (measured by km/h) shall be designed.

- The long straight section shall be replaced by the curve with the small angle of turning direction and big radius (5,000m to 15,000m) to avoid monotony and glaring (by headlight) at night.

6.3. Selecting the radius of the curve on freeway/expressway alignment

6.3.1. As usually, the curve with the radius less than the minimum popular radius in row 4 of table 4 shall not be used.

6.3.2. Using the minimum radius R_{min} in row 3 of table 4 must be accepted by investor.

6.3.3. The selection of the radius of the curve R should be based on the length of the straight section *l* following it as follows:

- If $l \leq$ 500m, then $R \geq l$

- If $l >$ 500m, then $R \geq$ 500m

6.3.4. The selection of the radius of the curve which the length of the curve is bigger than the minimum length K_{min}:

- K_{min}„ ensure that the driver must not turn direction of steering-wheel in 6 seconds:

$$K_{min} = 1.67 \times V_{tt}$$

of which

- V_{tt} is evaluated speed, measured by km/h.

- K_{min} is two times of the minimum length or the connected curve L (L in item 6.5), measured by m.

6.3.5. When deviation angle is less than 7^0 we must select the radius of the curve which distance p and the length of the curve K is large enough, p shall be greater than or equal 2.0m; 1.75m; 1.50m; 1.0m and K must be greater than 1,400/α; 1,200/α ; 1,000/α; 700/α (α is the angle of deviation, measured by degree; $\alpha \leq 2°$ is measured by 2^0) correlative with evaluation of 120, 100, 80 and 60km/h.

6.4. Super-elevation on the curve

6.4.1. The gradient of road surface on the curve shall be designed inward the belly of the curve for all curve with the radius less than the factor in 5 of table 4. The value of the gradient i_{sc} is defined by linearly interpolation of the values of correlative gradient at that line according to the reverse of the radius (1/R) and rounded to 0.5%.

6.4.2. Super-elevation can be applied to two sides of road surface (from the safe line of this side to the safe line of that side the gradient is, is the same) if the separated line has a topping, otherwise the two sides of road surface shall have tae grade increased separately in figure 3 (in this case the system of water intake must be put on the separated line).

6.4.3. The super-elevation transition shall be applied on the whole transitional curve as stipulated in 6.5.2.

6.5. The transition curve

6.5.1. The transitional curve of the clothoid shape with $A = \sqrt{R.L}$ must be put between the straight alignment and the round curve on freeway/expressway in which:

- R is the radius of the round curve at the end point of the transitional curve, measured by meter.

- L is the length of transitional curve, measured by meter.

This rude shall be applied to all the round curve although the radius R is greater than the radius without the one-side slope structure in row 6 of table 4 (because the function of the transitional curve is to connect not only super-elevation but also carriage orbit).

6.5.2. The minimum length of the transitional curve L is defined as row 7, 8, 9 of table 4, correlative with the different radius. If the designed radius of curve R is within the values given in brackets (row 7, 8, 9 of table 4) the length of the transitional curve is defined by linearly interpolation according to the radius R and the length L correlative with among those lines (the less the radius R is, the more L is).

If the designed radius R is greater than the value in brackets in line 9 of table 4, the length of the transitional curve is defined as follows: L = R/9 (the more the radius R is, the more L is to ensure the harmonious coordination of the elements on the location map according to the viewpoint of optical design).

6.5.3. The parameter of the transitional curve with the clothoid shape A shall be selected as follows:

$$R \geq A \geq \frac{R}{2}$$

If the curve radius of is very large we should select A as follows:

$$R \geq A \geq \frac{R}{3}$$

6.6. Connection between the curve section

6.6.1. Two curve sections with the same or opposite direction will be directly connected to each other (the in-between straight section is not required) if each curve has the transitional curve of the clothoid shape meeting with the standard in item 6.5.2. This stipulation allows direct connection between the transitional curve of the clothoid shape on alignment. In this case the curve radius at the direct connecting point should be greater than 100m.

6.6.2. In the restrictive topography, between the continuous curve we have to place one straight alignment section which the minimum length (measured by meter) between the curve section of the same direction is defined as 6 times of evaluated speed (measured by km/h), between the curve of opposite direction is defined as 2 times of evaluated speed (measured by km/h)

6.6.3. In connecting the opposite curve of the S shape we should use two transitory curve having the same parameter A (or the parameter A is not 1.5-time uneven) and $R_1 \leq 3R_2$ (R_1, R_2 are the curve radius at the end of the transitory curve of the circle line 1 and 2).

In connecting two curves of the same direction, the parameter A should be selected from $0.5R_1 < A < R_2$.

6.7. Ensuring the sight distance on the curve

6.7.1. The obstacles in the inside of the curve on the location map must be destroyed to ensure the sight distance equal to the length of the sight-stopping distance stipulated in row 10 of table 4 and the height of the driver eye-level of 1.20m and the destroyed section is 0.30 lower than this eye-level.

6.7.2. In defining the area of destroying obstacles, the position of the driver's eyes on the cross section is put at the point 1.50m far from the inside edge of the safe line at the inside of the curve forward the carriage-way.

6.8. To increase the safety at the sections close to intersection point, the service station center or the toll station, it must ensure the minimum shot-eye of 200m, 270m, 350m and 400m correlative with the freeway/expressway of grades 60, 80, 100 and 120. Ensuring the sight distance on the horizontal and vertical curve must be checked to satisfy the minimum sight distance.

6.9. The position of finished grade on the vertical alignment.

The finished grade on longitudinal section shall be designed along the edge of road surface if separating line has no cover or along the centerline (centerline of separating line) if the separating line has cover (through the turning point increasing super-high gradient on the bending in figure 2 and 3).

6.10. Regulations on vertical alignment

6.10.1. The maximum longitudinal gradient for the freeway/expressway grades is stipulated in row 11 and 12 of table 4. Because the carriage-way on freeway/expressway is one-way the base of the opposite ways shall be designed separately from the longitudinal profile and the maximum grade of going down is bigger than one of going up.

6.10.2. The value of longitudinal gradient is only used in the most difficult case, the longitudinal gradient of 3% or less (to avoid putting sub-carriageway of going up the slope) is widely used. Particularly at the freeway/expressway sections before and after the intersections, a gradual slope should be designed (see item 7.6 and 7.8). The longitudinal grade on the bridge, which span is not less than 30m, and the its approach road should not exceed 4%, the longitudinal gradient across the tunnel of over 50m should not exceed 3%.

6.10.3. The minimum longitudinal gradient

- On the excavated sections, the minimum longitudinal gradient must be 0.5%.

- On the transitional sections with super-elevation of less than 1%, the minimum longitudinal gradient shall be 0.5%.

- In tunnel the minimum longitudinal grade must be 0.3%

6.11. The length of longitudinal slope

6.11.1. The minimum slope length of the freeway/expressway is 300m, 250m, 200m, 150m, correlative with the grades of 120, 100, 80, 60 and enough for the application of vertical curve.

6.11.2. The maximum slope length for the different grades on the freeway/expressway grade should be as follows:

unit: meter

The longitudinal gradient %	Grade 120	Grade 100	Grade 80	Grade 60
4	600	800	900	1000
5	-	600	700	800
6	-	-	500	600

Table 5 - The maximum slope length for the different grades on the freeway/expressway

Note:

1) The slope length is calculated as the total of ¼ the first vertical curve and the straight line between 2 curves and ¼ the following vertical curve.

2) If the slope is continuous by combining various slope section with different gradient, us the average slope gradient calculating method to restrict the slope length in that section.

6.12. The vertical curve

6.12.1. On freeway/expressway, at the changing point of vertical curve, the vertical curve of the arc, parabolic or clothoid shape is required.

6.12.2. The radius of the vertical curve on freeway/expressway grades and its minimum length is shown in Table 6 below:

unit: meter

Item		Grade 120	Grade 100	Grade 80	Grade 60
The radius of the crest vertical curve	Minimum	12,000	6,000	3,000	1,500
	Minimum normally	17,000 (20,000)	1,000 (16,000)	4,500 (12,000)	2,000 (9,000)
The radius of the sag vertical curve	Minimum	5,000	3,000	2,000	1,000
	Minimum normally	6,000 (12,000)	4,500 (10,000)	3,000 (8,000)	1,500 (6,000)
The minimum length of vertical curve		100	85	70	50

Table 6 - The radius and the minimum length of the vertical curve on freeway/expressway

The radius of greater than minimum value should be applied, the minimum value is used in the most difficult case. If the less the angle of changing slope is, the more radius it shall be selected.

The values in brackets in table 6 are the radius of the vertical curve meet with the requirements of vision and we should design the vertical curve of those radius if favorable.

6.12.3. Avoiding the short slope section between the vertical curves of the same direction (especially the same concave direction).

6.13. Designing co-ordination of alignment elements

6.13.1. To ensure traffic on freeway/expressway safely and economically, freeway l expressway alignment must be designed harmoniously to topography, landscaping, helping the driver have good vision and recognize alignment clearly. Therefore verification, evaluation of the. alignment coordination in space must be carried out by perspective photograph, firstly at the section with the simultaneously change of plan and longitudinal profile, then the sections across the intersections or the section with special topography and geophysics.

6.13.2. To make alignments continuous, smooth and clear in space, the regulations and instructions of designing the elements of plan and longitudinal profile 6.2, 6.3, 6.5, 6.6, 6.7, 6.12 shall be obeyed. The high levels should be applied to that elements which can provide guidance of direction to drivers naturally.

6.13.3. Coordination of vertical and horizontal curve

- The vertical and horizontal curve must be put coinciding with the length of horizontal curve greater than the length of the vertical curve and their peak distance is not larger than 1/4 of the shorter curve length.

- The radius of the vertical curve should be 6-time greater than the one of the horizontal curve.

- The end of the horizontal curve must not be connected with the beginning of the convex or concave vertical curve (the vertical curve on the straight section).

- The vertical curve with the small radius must not be placed in the transitory curve.

6.13.4. We should not place many slope-changing sections on one long straight long section, the convex vertical curve with the short length and the concave vertical curve with the small radius should not be placed on the straight section. The turning point is not coincide with the hard slope point.

6.13.5. Co-ordination of freeway/ expressway alignment and bridge and tunnel

- The location and the shape of the bridge is in attempt to satisfy the requirements of the coordination of alignment elements. The curve bridge, slope bridge, skew bridge are placed, if necessary, to ensure the continuity and smoothness of freeway/expressway alignment on bridge.

- We should design the straight alignment in tunnel; if the alignment in tunnel is on curve the radius without necessity of the one-side sloping structure must be used and this radius must meet with the requirement of traffic-stopping eye-shot on the bending (line 10 of table 4).

- The elements on plan and longitudinal profile at the two ends of bridge or tunnel need the minimum section of 10m with the same arrangement as that on the bridge or in tunnel.

6.14. The freeway/expressway design to be co-ordinated with landscaping

6.14.1. In selecting freeway/expressway alignment we should use natural scenery such as hills, mountains, lakes, plants and architectural works (dike, housing etc.) to avoid the monotonous feeling.

6.14.2. Destruction of topography shall be controlled, natural geomorphology and landscape: using alignment to emphasize the winding of natural topography; growing plants to landscaping excavation or embankment on the two sides of road.

6.14.3. The same plants shall not be grown: growing high plants to emphasize and show alignment direction, short plants to cover, group of plants to landscape etc.

6.14.4. If freeway/expressway goes through the forest, the forest shall not be separated by the straight alignment to avoid inflexible feeling. It shall be started by

the curve from the outside of the forest and group of plants with the increasing density on the transitory section to the forest.

6.14.5. Through hills, freeway/expressway alignment should have the curve with the big radius and the topographical winding. It is not much based on the partially small winding. Besides, we should limit embankment, deep excavation. The best way is to use the whole clothoid alignment to avoid break on longitudinal profile and location map which is caused by hilly topography.

For the topography of bald hills, we should grow plants at two sides of road.

6.14.6. For the plain topography, the selection of alignment must be followed item 5.2

6.14.7. Freeway/expressway alignment on mountain should have retaining walls, road of balcony style, viaduct, type of slope and strengthening measures that have decorative effects to make alignment continuous, smooth and clear.

Besides, the method of separating alignment of two carriage-way directions shall be applied to mountainous topography to be suitable for topography and high embankment and deep excavation.

7. Design of intersection on freeway/expressway and entry/exit point to freeway/expressway

7.1. Classification of intersection on freeway/expressway

Functionally, the intersections on freeway/expressway are divided into three types:

- The intersection without in-coming/out-going point at freeway/expressway (called grade-separated junction). These are the intersections between freeway/expressway with railway, pipeline, pedestrian walkway (under or over the freeway/expressway) or other public roads which we can not entry/exit the freeway/expressway.

- The intersection with in-coming/out-going point at freeway/expressway - (called grade-separated interchange). These are the intersections between freeway/expressway and highway which we can go entry/exit freeway/expressway and intersections between freeway/expressway and roads to airports, parts, railway station, cities, political and economical centers, industrial zones, mines, beauty spots, resorts, service centers along the freeway/expressway.

The connecting intersections on freeway/expressway are only placed at the roundabout of maximally 4 road extensions. That is to say just T-junction, or cross-road required.

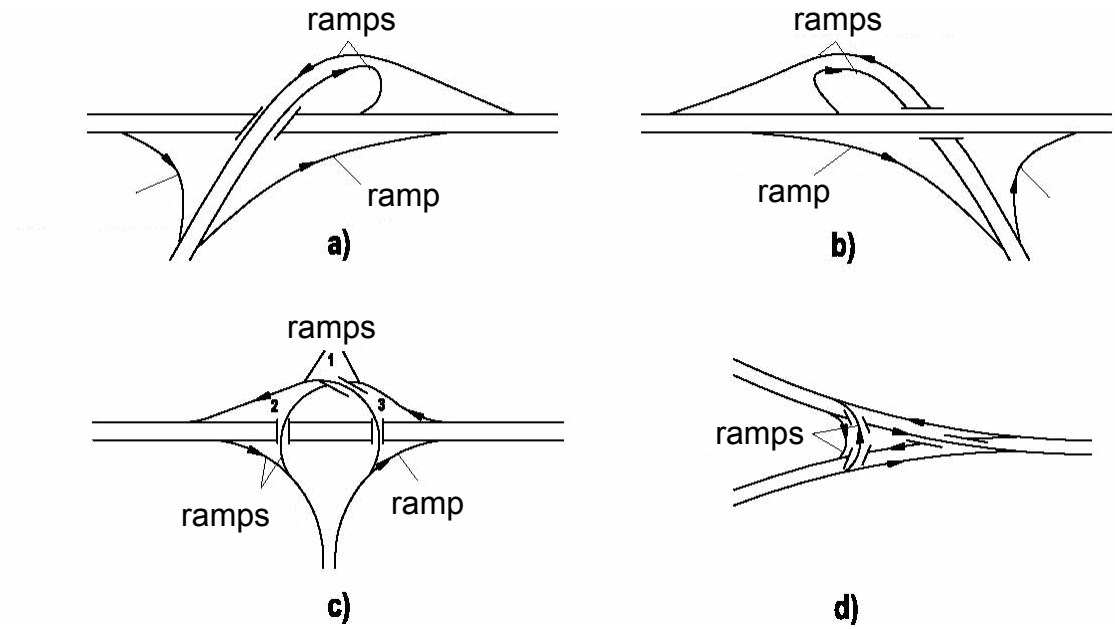
- The intersections on freeway/expressway is only the entry/exit point on the right side.

7.2. Freeway/expressway of both types of intersection (grade-separated junction and grade-separated interchange) in item 7.1 require intersection in principle of no at-grade intersection point on the whole freeway/expressway.

If intersection on freeway/expressway is the point of going entry/exit on the right, the design is following item 7.7.

7.3. Selection of grade-separated interchange types

7.3.1. At three arm intersection, the types of grade-separated interchange can be chosen in figure 5.



Note: a, b - Trumpet interchange, c - T shape interchange, d - Y shape interchange

Figure 5 - Basic types of three arm intersection interchange

The trumpet interchange in figure 5a and 5b have advantage as following: simple construction (only one flyover is needed), nice topology, driver can recognize direction way easily. But the disadvantage of this type is that the turning left stream getting long distance and need a large area to ensure the vertical slope for all ramp. This type of interchange is suitable for crossing over between two freeway/expressway or between freeway/expressway and highway of 4 lane (of which grade is I÷III).

The T and Y shape interchange in figure 5s and 5d have advantage as following: the length of ramps is shorter than trumpet one (especially Y shape), high traffic performance, not require large area for constructing. The disadvantage of this type is that the construction cost is high (constructing three flyover). However in case the freeway/expressway crossing over highway of low grade, the number of flyover can be reduced. For example, in figure 5c, we can merge flyover 2 and 3 and flyover 1 is

not necessary, or in figure 5d, a flyover connecting to low grade highway can be removed.

7.3.2. In three arm intersection area, only one toll plaza is needed and it can be located at the lower grade way or the way of lower traffic rate.

7.3.3. At four arm intersection, if toll plaza is not necessary, the types of grade-separated interchange can be chosen in figure 6. In figure 6a, 6b and 6e, if freeway/expressway crossing over a highway of 2 lanes (of which grade is lower than III), only two flyovers are necessary (at-grade intersection on low grade highway is acceptable). The remaining types are suitable for crossing over between two freeway/expressway, each one has at least 4 lanes and grade of which is I÷III.

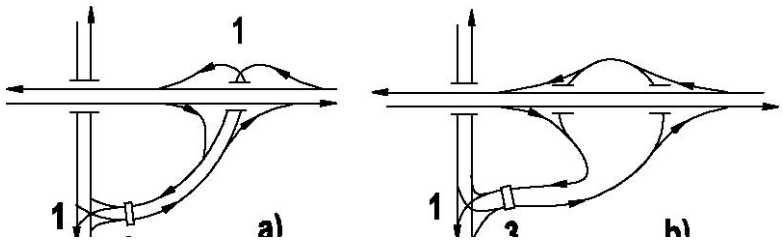
The advantage of each type of interchange can be seen by total flyover need to be constructed, the total length of interchange and the ability in helping the driver have recognize the traffic direction.

(this figure is not enough in VN version)

a- Lozenge interchange, b- half-asterisk interchange, c- spiral interchange, d: asterisk interchange, e- bracelet interchange, d- half-spiral interchange

Figure 6 - Basic types of four arm intersection interchange in which toll plaza is not constructed

7.3.4. At four arm intersection, if closed tolling is required, only one toll plaza shall be constructed with in intersection area. In this case, grade-separated interchange type in figure 7 can be applied; in which figure 7a, 7b, 7c and 7d, intersection with lower grade highway, is suitable for crossing over between freeway/expressway and highway of not over 2 lane (grade is I÷III). Figure 7e, 7f, 7g and 7h is suitable for crossing over between two freeway/expressway , each one has at least 4 lanes and grade of which is I÷III.



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Note:

1- at-grade intersection on ramp; 2- three layer interchange; 3- location of toll plaza.

Figure 7 - Basic types of four arm intersection interchange with constructing toll plaza

7.3.5. The type of selected interchange is depending on designer, the basic type as mention above is not obligatory. The designed interchange shall be taken based on traffic scale, topography condition. In proposal phase, the type of interchange shall be considered by the below analysis:

- Choosing turn direction in priority order: direct turn left for heavy traffic, half-direct or indirect turn left for medium or small traffic. The sort length of turn way for heavy traffic is also chosen.

- Three-layer intersection may be considered for the road way traffic of 6.000 converted cars/day-night to reduce the traffic length, travel time or to overcome the difficult topography.

- In all case, before giving a decision of interchange type, the traffic ability should be obeyed item 4.2.2 of standard TCVN 4054, the at-grade intersection with in grade-separated interchange should meet the technical requirement about geometrical elements (as mention in item 7.7 of this standard and in chapter 11 of standard TCVN 4054).

7.3.6. The design of intersection interchange should base on comparing general technique and economy as following:

1. Technical specification:

- Land area for right of way (ha);

- Total length (converted to one lane) of all branch in interchange area (km);

- Total length (converted to one lane) of main road in interchange area (km);

- Total surface area of all branch (m^2);

- Total surface area of main road (m^2);

- Total length (convert to one lane) of flyover and underpass in interchange area (m);

- Total quantity of earthwork(m^3).

2. Operating specification

- Travel time for turning left and right when using design speed (second). (travel time is the time for travelling between two fixed points in the through road for comparison of various options)

- Total time for passing interchange in all direction per day-night (unit/day-night). This criterion is calculated by product of time on straight going, turn left, turn right and number of converted cars on straight going, turn left, turn right, correlative with each travel being fixed by the same locations for all the comparison options.

3. Economy specification:

- Total construction cost (VND);

- Average maintenance cost in 1 year (VND)

- Average operation cost in 1 year (average in the entire operation period) (VND)

7.4. Stipulation of the distance among connecting interchanges

7.4.1. The minimum distance between not-at-grade interchange and the entry/exit point from the right-hand side is 4 km. However, it is necessary to consider the solution of mixing the close intersections into 1 such as 7.4.2.

7.4.2. The distance between not-at-grade interchanges (the distance between entry and exit points of freeway/expressway) should be from 15km to 25km by constructing auxiliary road to combine the close intersections into one point; for freeway/ expressway sections around major cities or important industrial zones, this distance can be from 5km to 10km.

7.4.3. If the distance between not-at-grade interchanges is more than 30km, we must locate the turning point at the break of the median at the special positions. At that location, signage or management personnel is required to instruct the wrong-direction vehicles, maintenance and emergency to U-turn.

7.4.4. The minimum distance between connecting interchange and public works or supporting works along the freeway/expressway alignment must be from 3km to 5km with the minimum tunnel portal of 1.5km÷4km.

7.5. The requirements for other highway tied with connecting interchange on freeway/expressway: this road must ensure traffic capacity of the whole intersection alignments. Besides, it can gather and distribute traffic for the neighbor road network or directly connect with the point of happening heavy traffic.

7.6. In the not-at-grade interchange, we must apply the technical standards in table 7 for freeway/expressway alignment (especially for the expressway running below) and just applying the radius larger than or the same as the normal value and the grade smaller than or the same as the normal value in table.

The grades of freeway/expressway		120	100	80	60
The minimum radius of the horizontal curve	Normally	2,000	1,500	1,100	500
	Limited	1,500	1,000	700	350

The minimum radius of the vertical curve	Convex	Normally	45,000	25,000	12,000	6,000
		Limited	23,000	15,000	6,000	3,000
	Concave	Normally	16,000	12,000	8,000	4,000
		Limited	12,000	8,000	4,000	2,000
The biggest longitudinal gradient, %		Normally	2	2	3	4.5
		Limited	2	2	4	5.5

Table 7 - Technical standards for freeway/expressway at the connecting elevated

7.7. Design requirements for the ramp in the area of the not-at-grade interchange and the entry/exit ramp on right side of freeway/expressway.

7.7.1. The cross section of these ramps must be arranged as item 5.14

7.7.2. Evaluated speed on the ramps is stipulated in table 8.

Measured by km/h

Character of connecting interchange	The grades of freeway I expressway			
	120	100	80	60
Transport connection between freeway/expressway and highway of grade I, II	80÷50	70÷40	60÷35	50÷35
Transport connection between freeway/expressway and other road	60÷35	50÷35	40÷30	35÷30

Table 8 - Evaluated speed on the extension road

Note:

1) For the right or left turning extension road, we should use the factor of evaluated speed from the middle distance of the factors in table or more.

2) For the extension roads of asterisk or spiral type, the low factor in table should be used.

4) For the extension road with heavy traffic and out going road, we must select high evaluated speed.

7.7.3. The calculated speed of ramp on the right side of freeway/expressway should follow its design grade and the geometrical specification of this ramp should follow

standard TCVN 4054. If design speed is same as table 8, the geometry specification is applied as branch road located with in area of grade-separated interchange (7.7.5).

7.7.4. The above-mentioned value of calculated speed is used to define the geometrical elements of extension road alignment on location map and vertical alignment according to TCVN 4054 - Highway Design Standards (the minimum radius, the length of transitional curve, the enlargement of bending, super-height, the biggest longitudinal grade. reduction of slope on the bending etc.) and current stipulations of intersection design. In design, we should apply the minimum and maximum factor to those elements and pay attention to the fact that traffic speed often change gradually on extension road.

7.7.5. Depend on the calculated speed of table 8, the geometrical elements of ramp should obey the specification in table 9 (about curve radius); table 10 (about parameters of transitional curve clothoid); table 11 (about vertical slope); table 12 (about vertical curve elements); table 13 (super-elevation); table 14, 15 (about transition of connecting super-elevation); table 16 (about expansion factor on curve); table 17 (about stopping sight distance).

Evaluated speed on interchange (km/h)		80	60	50	40	35	30
Minimum radius of curve (m)	Normal value	280	150	100	60	40	30
	Low limited value	230	120	80	45	35	25
Note: the normal value shall be used except other case the interchange is located in difficult topography.							

Table 9- Minimum curve radius of branch road in grade-separated interchange

Evaluated speed on branch road (km/h)	80	60	50	40	35	30
A parameters (m)	140	70	50	35	30	20
Note: 1) The length transitional clothoid should also following the requirements of super-elevation connection; 2) parameters A shall be chosen as $A \geq 1.5R$ (R - radius of designed curve); 3) the transition of different direction curve shall have same r their ratio is less than 1.5.						

Figure 10- Clothoid parameters on branch road (for calculating the length of transitional clothoid)

Evaluated speed of ramp at the intersection (km/h)	Maximum vertical slope (%)
80	4,0
60	5,0
50	5,5
≤ 40	6,0

Table 11- Maximum vertical slope in interchange

Evaluated speed on branch road (km/h)			80	60	50	40	35	30
Minimum radius of vertical curve (m)	crest	normal	4500	2000	1600	900	700	500
		low limited	3000	1400	800	450	350	250
	sag	limited	3000	1500	1400	900	700	400
		low limited	2000	1000	700	450	350	300
Minimum length of vertical curve (m)		normal	100	70	60	40	35	30
		low limited	70	50	40	35	30	25
Note: Except for special case, the normal value or above shall be used.								

Table 12- Minimum radius and length of vertical curve in interchange

Evaluated speed on branch road (km/h)	80	60	50	40	35	30	super-elevation (%)
	230 ~ 330	120 ~ 180	80 ~ 120	45 ~ 70	35 ~ 50	< 30	8
	330 ~ 380	180 ~ 220	120 ~ 160	70 ~ 90	50 ~ 60	30 ~ 40	7 ~ 8

	380 ~ 450	220 ~ 270	160 ~ 200	90 ~ 130	90 ~ 110	40 ~ 60	6 ~ 7
	450 ~ 540	270 ~ 330	200 ~ 240	130 ~ 160	90 ~ 110	60 ~ 80	5 ~ 6
	540 ~ 670	330 ~ 420	240 ~ 310	160 ~ 210	110 ~ 140	80 ~ 110	4 ~ 5
	670 ~ 870	420 ~ 560	310 ~ 410	210 ~ 280	140 ~ 220	110 ~ 150	4
	870 ~ 1240	560 ~ 800	410 ~ 590	280 ~ 400	220 ~ 280	150 ~ 220	3
	> 1240	> 800	> 500	> 400	> 280	> 220	2
Radius without super-elevation	2500	1500	1000	600	500	350	keep no change

Table 13- Super-elevation on curve branch road

Pavement type and location of super-elevation axis	One-way single lane		One-way double lanes and two-way double lanes	
Evaluated speed on branch road (km/h)	Shoulder	Centerline	Shoulder	Centerline
80	1/200	1/250	1/150	1/200
60	1/200	1/225	1/125	1/175
50	1/200	1/200	1/100	1/175
$\leq$ 40	1/100	1/150	1/100	1/150
Note: the location of super-elevation should be overlapped the transitional clothoid. The length shall be chosen in middle range of table 10 and table 14.				

Table 14- The changing rate of super-elevation on branch road of interchange (for determining the transitional length)

Type of branch road cross section		One-way single lane	One-way double lanes and two-way double lanes
Location of super-elevation axis	Centerline	1/800	1/500
	Shoulder	1/500	1/300

Table 15- The minimum changing rate of super-elevation to determine the super-elevation length of branch road of which the horizontal slope is 0%

Branch road of one-way single lane		Branch road of one-way double lane or two-way double lanes	
Radius of curve (m)	Extension parameter (m)	Radius of curve (m))	Extension parameter (m)
25 ~ < 27	2,00	25 ~ < 26	2,25
27 ~ < 29	1,75	26 ~ < 27	2,00
29 ~ < 32	1,50	27 ~ < 29	1,75
32 ~ < 36	1,25	29 ~ < 31	1,50
36 ~ < 42	1,00	31 ~ < 33	1,25
42 ~ < 48	0,75	33 ~ < 36	1,00
48 ~ < 58	0,50	36 ~ < 39	0,75
58 ~ < 72	0,25	39 ~ < 43	0,50
≥ 72	0	43 ~ < 47	0,25
-	-	≥ 47	0,00
Note: The extension of main branch road is not including the extension of safe line as mention in 5.14.2 and 5.14.3			

Table 16- Extension parameter of curve branch road

Evaluated speed on branch road (km/h)	80	60	50	40	35	30

eye-shot	110	75	65	45	35	30

Table 17- Eye-shot of branch road

When applying the parameters in tables 9÷17, the primary interpolate between the ranges of evaluated speed is acceptable.

7.7.6. In asterisk interchange (figure 6e), the minimum radius should be 55÷60m, 40÷50m, 30÷35m for correlative calculated speed on ramp of 40km/h, 35km/h, 30km/h.

7.8. Locate the connection between the ramp and freeway/expressway (the entry/exit point to freeway/expressway) in the area of grade-separated interchange and the entry/exit in the right-hand side.

7.8.1. This joint is always located on the right of carriage way at the favorable direction. The out-going point from freeway /expressway must be visible, often located in the front of man-made' works (like viaduct etc.). If it must be behind the works it should be more 150m far from the viaduct. Besides the out-going point should be located on the section of going up slope on freeway/expressway to reduce speed easily.

7.8.2. From the auxiliary lane to freeway/expressway, on the section of going down slope (for increasing speed easily) we should place an free triangle section between them so that vehicles on both of them can recognize together at the same time. This triangle has its peak as the intersection between the edge of the right freeway/expressway base and the one of the left extension road. It is 100m along the edge of the edge of the right base of freeway/expressway and 60m along the one of the left base of extension road (figure 8).

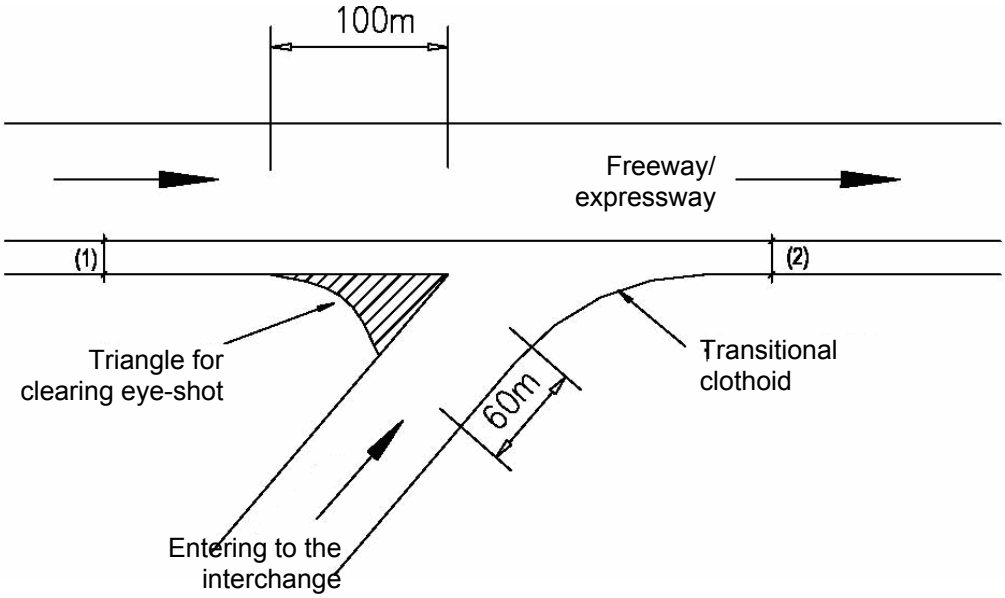


Figure 8 - The triangle for eye-shot at entry/exit point of interchange

7.8.3. We should ensure chat eye-shot on freeway/expressway at the section before the current-separating point at the out-going point is more than 1.25 times of the stopping eye-shot in table I and we should follow the standard eye-shot in item 6.8, if favorable.

7.8. ding to two

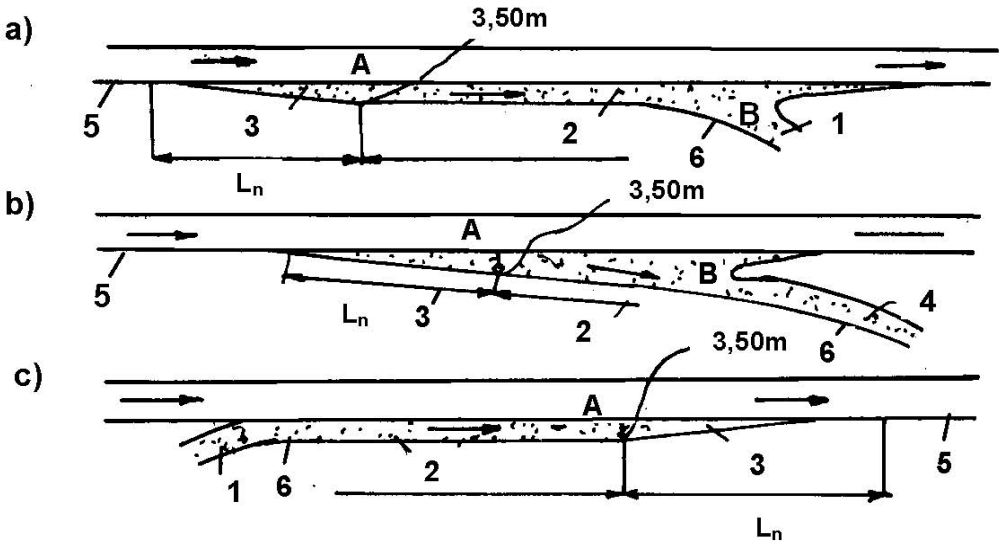


Figure 9 - The ways of locating out-going and in-coming section

a) The out-going section with the parallel style

b) The out-going section with the style of direct connection

c) The in-coming section with the parallel style

Curve radius at B: r = 0.60m – 1.00m

1 . The auxiliary lane

2. The speed-changing section (reducing speed in figure a and b; increasing speed in figure c).

3. The triangle lane-changing section (refer definition in 7.8.6)

4. The extension road with the function of changing lane and speed.

5. Edge of traffic lane (excluding shoulder) of the expressway.

6. Clotoid transition section, as 7.8.1

Ln : lane-changing section in triangle shape.

7.8.5. For the entry to freeway/expressway (merging location) we must follow the parallel style (figure 9c) with the whole length of the speed-increasing section next to

the carriage-way on freeway/expressway; if the speed-increasing section is too long, at least 100m of the section must be placed next to the carriage-way on freeway/expressway. In the case there is two traffic lanes in the entry road, it is possible to have the entry as direct connection.

7.8.6. The width of speed-changing lane in all cases is stipulated as 3.50m. The length of triangle lane-changing section including the enlarged carriage-way is 3.50m (if the speed-changing section has 1 lane) and 7.0m (if 2 lanes). 2-lane speed-changing section occurs when the expressway has 6 traffic lanes.

7.8.7. The minimum length of the triangle lane-changing section (including the case of going out/in to freeway/expressway) is defined basing on the grades of freeway/expressway like table 18; in case the lane-changing section has two lanes, the minimum length of the triangle should 1.3÷1.4 time of the value L_n in table 18

Grades of freeway/ expressway	120	100	80	60
L_n	75	60	50	40

Table 18 - the minimum length of the triangle lane-changing section (current separating or joining)

7.8.8. The speed-increasing/reducing section is counted from the point A in figure 9 and its length S (measured by meter) is defined according to this formula:

$$S = \frac{V_A^2 - V_B^2}{26.a}$$

of which

- V_A is the speed at the point A (at the beginning or end of the lane-changing section with triangular style) in figure 9, measured by km/h;

The value A is based on the grades of freeway/ expressway in table 19.

Measured by km/h

Grades of freeway/expressway	1 120	1 100	1 80	1 60
VA .	130	170	160	150

Table 19 - The value of the speed V_A at the beginning of the speed-reducing section or the end of the speed-increasing section.

- a is the accelerate of increasing or reducing speed, measured by m/sec'

When defining the length of the speed-reducing, we use a = 2.5m/sec^2, for the length of the speed-increasing, a= 1.0 m

V_B is the speed at the end of the speed-reducing section or the beginning of tile speed increasing section, measured by km/h.

The value V_B is based on the evaluated speed of extension road (item 7.7.2 and 7.7.3) or based on the practical geometrical elements applied to extension roads in detailed design after the speed-reducing section or before the speed-increasing section.

7.8.9. If the triangle lane-changing section with the speed-reducing section are on the section of going down slope and the lane-changing section with the speed-increasing section are on the section of going up slope, their length is defined as table 18 and item 7.8.8 and multiple with an adjustment factor in table 20:

The average grade of the speed-changing lane, %	≤ 2	>2÷3	> 3÷4	> 4÷6
The factor to the speed-reducing lane of going	1.0	1.1	1.2	1.3
The factor to the speed-increasing lane of going up	1.0	1.2	1.3	1.4

Table 20 - Adjustment factor of the speed-changing lane length on the slope

7.8.10. The total length of the lane-changing (triangle) with the length of the speed-changing section (reducing or increasing speed) should be more than the value in table 21 multiple with adjustment factor in table 20.

Grades of freeway/expressway	120	100	80	60
The minimum length of out-going point (reducing speed) of one lane, m	100 (150)	90 (130)	80 (110)	70 (90)
The minimum length at in-coming point (increasing speed) of one lane, m	200 (300)	180 (260)	160 (220)	120 (160)
Note: the value in brackets is correlative with speed-changing of two lanes				

Table 21 - The minimum value applied to the total length-of the lane-changing section and the speed-changing section.

7.8.11. The geometry design standard which is mentioned in 7.7.5, correlative with speed V_A depending on the expressway grade as in Table 19 in all cases of calculated speed in the auxiliary road should be applied to the speed-reducing section directly connected (section 2 or 6 in figure 9b) or out-going section (section 6 in figure 9a) and in-coming section (section 6 in figure 9c). The clothoid curve should be placed as mention in figure 9.

7.8.12. Crossfall and Super-elevation arrangement at entry/exit of freeway/expressway

1. If the entry/exit point is on the straight section of freeway/expressway and the lane-changing is also on straight section (figure 10a), the super-elevation on the whole section (1) and (2) is normal super-elevation value of freeway/expressway. From point ZH, the super-elevation should obey the branch road standard (table 14, 15).

2. If the entry/exit point is parallel with freeway/expressway straight section (figure 10b), the section from (1) and (2) to point A (the branch road start going out the freeway/expressway) have normal super-elevation value of freeway/expressway. From point A, the super-elevation should obey the branch road standard.

3. If the entry/exit point is direct or parallel connected on the curve which has same direction with freeway/expressway curve (figure 10c, 10d), the super-elevation on section (1) and (2) is normal super-elevation value of freeway/expressway.

4. If the entry/exit point is direct connected on the curve which has opposite direction with freeway/expressway curve (figure 10e), the super-elevation value on section (1) is same as super-elevation value of freeway/expressway. The super-elevation on section (2) is transitory to the value of less than 2% and having opposite direction with freeway/expressway super-elevation. The different super-elevation value at point A is not larger than 5% and then the super-elevation of section (3) is transitory to the super-elevation of branch road.

5. If the entry/exit point is parallel connected on the curve which has opposite direction with freeway/expressway curve (figure 10g), the super-elevation from section (1) and a part of section (2) to the point ZH is same value and direction with freeway/expressway super-elevation. The super-elevation at point A is transitory to the value of less than 2% (opposite direction with freeway/expressway super-elevation). The different super-elevation value at point A is not larger than 5%. The super-elevation on section (3) is transitory to the super-elevation of branch roach.

The transitory super-elevation shall be ensured the requirement in table 14 and 15.

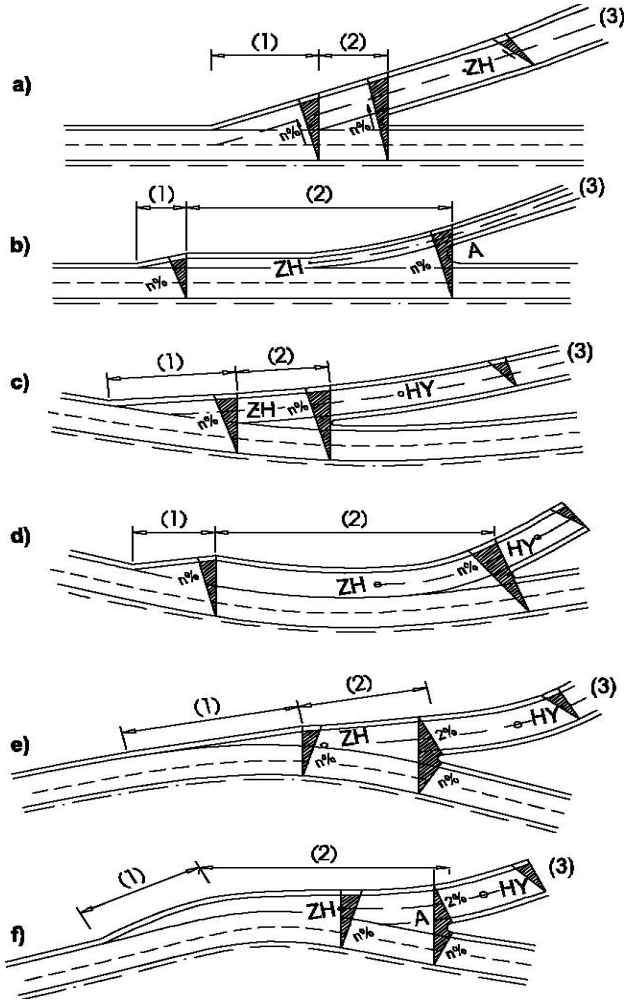


Figure 10 - Super-elevation at out-going, in-coming point

Note:

1. Triangle lane-changing; ZH: beginning point of curve;

2. Speed-changing lane; HY: ending point of curve;

3. Curve branch; A: start point of out-going from freeway/expressway

7.8.13. Balancing the number of lanes and arranging auxiliary lane at out-going/in-coming point of freeway/expressway

1. On the whole length or section length of freeway/expressway, the number of basic lanes should be ensured.

The increasing or decreasing of basic lanes in the same direction of two closed road should not larger 1 lane, the lane-changing should be in the location of distance not less than 0.5÷1.0km from intersection interchange.

The lane number at out-going/in-coming point should be calculated by the formula below to ensure the balancing lanes

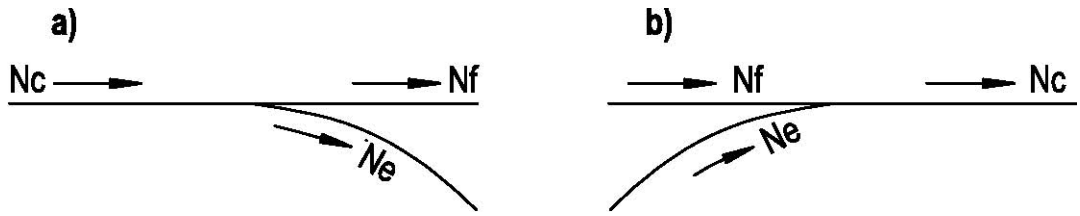
$$N_c \geq N_f + N_e - 1$$

in which:

N_c: Number of main lanes before out-going or after in-coming;

N_f: Number of main lanes after out-going or before in-coming;

N_e: Lane number of branch road



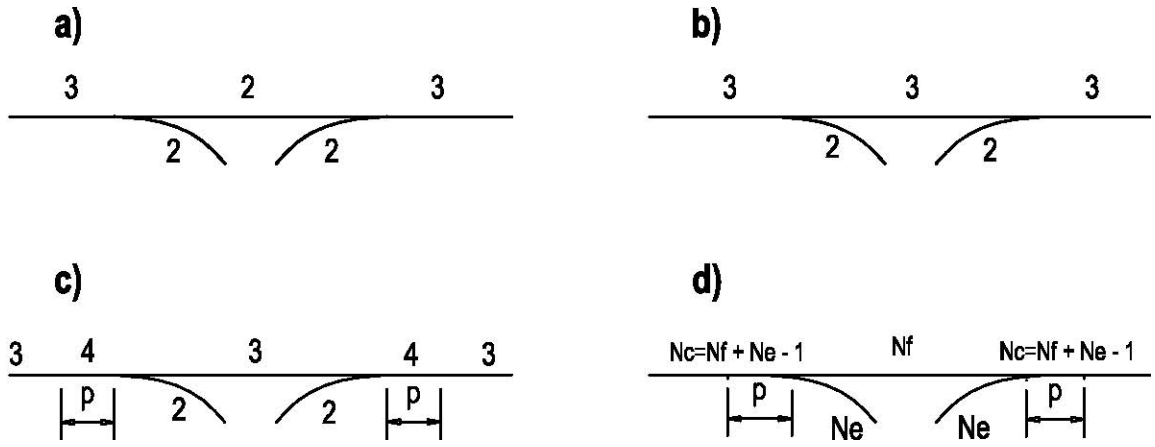
Note:

a) Out-going point of freeway/expressway, b) in-coming point of freeway/expressway;

Figure 11 - Balancing lanes checking scheme

2. Arranging auxiliary lane

The number of basic lanes should be kept continuously at out-going and in-coming point. The balancing lanes also should be kept, if necessary, the auxiliary lane is added as showing in figure 12



Note:

a) Balancing lanes number but the continuation of basic lane number is not ensured;

b) Continuous basic lanes but not balancing lanes;

c) Balancing lanes and ensuring continuous basic lanes

d) Condition of continuous basic lanes;

p: Section needed additional auxiliary lane

Figure 12 - Checking scheme about balancing lanes and continuous basic lanes

For smooth traffic, the length of auxiliary lane at out-going section shall be 1000m (minimum 600m); at in-coming section shall be 600m.

When the distance between ending point of speed-increasing lane of front interchange and beginning point of speed-decreasing lane of rear interchange is less than 500m, the auxiliary lane should be added to connect them together. If the traffic is quite heavy, the mixing rate of two lanes is quite high, the auxiliary lane is required even the above distance is larger than 2000m. For this reason if there are two interchange of distance less than 2000m, the auxiliary lanes shall be added to connect them together. The arrangement of auxiliary lane is mentioned in item 5.9.

7.9. Designing of landscape, tree and drainage system in the area of grade-separated interchange

7.9.1. Inundated water should not be allowed within the area of curve branch road.

7.9.2. Designing of embankment landscape

The fill talus on branch road should have gentle slope to the existing ground

7.9.3. The various trees should be grown in the area of interchange: at the in-going/out-going section, growing the directional trees. At one side of out-going point growing the low tree to guide driver decreasing speed indirectly.

At triangle of out-going point, growing flowers, grass. When growing the low trees on inner side of curve section, the eye-shot should be ensured (figure 13)

7.9.4. The drainage system in interchange area should be appropriate to the freeway/expressway drainage system.

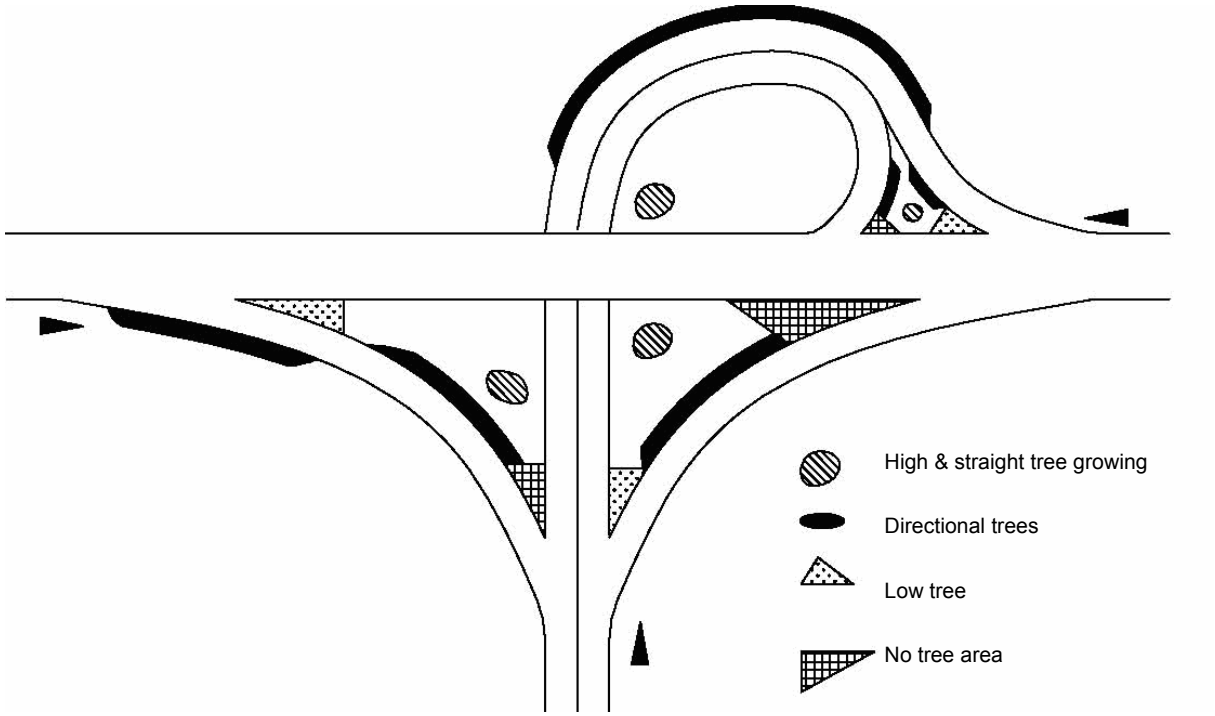


Figure 13 – Tree planting

7.10. Designing of at-grade intersection on low grade highway within area of grade-separated interchange (as mention in item 7.2)

This design should obey chapter 11 of standard TCVN 4054 and other related standards for selecting intersection type, design speed, geometric factor and sight-distance, island, speed-change lane and traffic sign arrangement.

7.11. Arrangement of grade-separated intersection

7.11.1. Design of grade-separated junction as mentioned in item 7.1, 7.2 must follow the stipulation of overhead space limit over and under the freeway/expressway in item 4.7 and 4.9. If the freeway/expressway is going over the public roads, the determination of overhead space limit must be based on the practically traffic-situation. In case the traffic is not much, overhead space height of the public roads can be reduced to 3.20m. If the public road is just for tractor, the overhead space limit can be reduced to 2.70 and only lane required.

7.11.2. It is necessary to have study of comparing the projects of freeway/expressway over or under. In every case, the arrangement of viaduct span (including the location of abutment and pier) must ensure the eye-shot of the traffic on the road under the viaduct.

7.11.3. The drainage system and the luminance under grade-separated junction should be ensured.

7.11.4. The angle between grade-separated junction and under road should large than 45^0.

7.11.5. The grade-separated junction between freeway/expressway and railway must not be in the area of railway station or switch location.

7.12. The intersection between freeway/expressway and pipeline, other line (power, communication line etc.) and the reciprocal position among them outside or inside the scale of intersection should follow standards in TCVN 4054 - Highway Design Standard and other requirements of the Authorities.

8. Design of freeway/expressway pavement and drainage system

8.1. General requirements

8.1.1. In order to ensure the performance, safety of traffic, the base of freeway/expressway must be strong and stable to avoid the bad effect of environment (especially the destruction from underground water). The surface of freeway/expressway must have enough roughness and good drainage system.

8.1.2. Except the additional specification in this standard, the design of base and drainage system should obey the standard TCVN 4054.

8.1.3. The structure of base and surface should obey the standard TCVN 4054 and 22TCN 211 (soft pavement) and 22TCN 223 (hard pavement).

8.1.4. The subsidence of the pavement after construction on soft soil area should obey standard 22TCN 211 and 22TCN 262.

8.1.5. The structure of pavement should not be implemented in staged investment. In special case, the freeway/expressway is located in soft soil area which have high subsidence, the staged investment shall consider to reduce amount of construction cost. The proposal of this staged investment must be approved by the owner.

8.2. Design of pavement

8.2.1. The design of freeway/expressway base should follow the investigation of geology, hydrology to ensure the stableness of road base in the below case:

- High embankment and deep excavation with batter height of over 12.0m;

- Excavation in the rock area, erosion area, rock rolling area, and the area of difficult geology (hillside, weathered soil condition, swamp, soft ground with underground water, hillside with steep crossfal)

- Pavement close to river, creek with high possibility of erosion.

8.2.2. The design of talus

1. To ensure the requirements of safety, speed, avoiding erosion, landscape, the talus of freeway/expressway should obey the slope angle in Table 22. If land area is limited, the retaining wall or rock filling can be use to replace fill embankment. The design of talus on the mountain area which have high slope angle, the talus slope can be obeyed standard TCVN 4054.

Embankment high or excavation depth	Embankment slope	Excavation slope
to 1.2m	1 : 4 (1 : 3)	1 : 3.0
≥1.2m ÷ 3.0m	1 : 3 (1 : 2)	1 : 2.5 (1 : 2)
≥ 3.0m ÷ 4.5m	1 : 2.5 (1 : 1.75)	1 : 2.0 (1 : 1.5)
≥ 4.5m ÷ 6.0m	1 : 2 (1 : 1.5)	1 : 1.75 (1 : 1.5)
over 6.0 m	1 : 2 (1 : 1.5)	1 : 1.5
Note: - The value in bracket is correlative to the case of difficult topography or limited land area; - the design slope gradient of the embankment varies within the embankment height values in Table 22 (the type of embankment that is gentle slope at toe, steep slope on top)		

Table 22 - Slope angle of freeway/expressway talus (soil talus)

2. The top of embankment slope is filleted with the radius of R = 2.5m, the foot R = 8.0m; the top of edge of digging base R = 2.5m, the top of the slope on digging base R = 2H (H is the height of talus, measured by meter).

3. For the coordination between the shape of embankment and landscape, at the changing between excavation section and embankment section, talus angle of excavation section should be steeply changed from the middle of the out-going section to the embankment section (for example, the slope 1 : 2 in the middle is change into 1 : 3 then 1: 5).

8.2.3. Compaction requirements of foundation

1. The compaction index of 30cm top embankment at the bottom of road surface cover must be K = 1.0 (standard compaction of 22TCN 332) or enhanced compaction K=0.98 . This requirement must be applied to embankment, non-embanking and non-excavating base and excavation base (if natural base has not got enough compaction index).

2. The land section of embankment base below 30cm mentioned must be compacted with K = 0.98 (standard compaction) or enhanced compaction K = 0.95. The land section of excavation base below 30cm to upper 1.0m depth must be compacted with K = 0.95 (standard compaction).

3. The base of freeway/expressway must be designed depending on the standard of structure of road surface class 1 in annex B of 22TCN 221, correlative with the value of evaluated elastic module 400daN/cm^2 or more.

4. The surface of embankment talus on freeway/expressway must be supported by measures suitable for geological and hydrological conditions to avoid the erosion of surface by rainy water, underground water, wave etc. and surface weathering causing rock and soil falling.

8.2.4. Soil for embanking freeway/expressway base shall be taken from borrow-pit. We should not take soil from excavation on the road sides because it cannot ensure the consistency of soil, makes water stagnant and destroys landscape. If fine sand is used for embanking, we must select cohesive covering soil capable of avoiding erosion on surface, simultaneously selecting the method of embanking ensuring the quality of compressing cover, specially on talus cover. The top layer of sand embankment should be covered by 30 cm thickness clay sand or clayish with compaction is stipulated in item 8.2.3.

8.2.5. The appropriated soil should follow the stipulation in item 7.4 of standard TCVN 4054. The compaction should be K=1.0 for embankment behind bridge abutment, both side of residential and drainage culverts.

8.2.6. Design standards for freeway /expressway base at soft soil or peat soil.

1. There must be the measures ensuring the stability of the whole embankment in the process of embanking and after reaching the designed elevation and coming into use.

2. Before constructing the finished road surface structure, it requires the measures to ensure subsidence of embankment following item 1.3.5 of standard 22TCN 211.

3. The size of fill embankment on soft soil must be designed correlatively with the value of settlement allowance and it should be noted that due to the large width of of freeway/expressway, the settlement at centerline must be paid attention to avoid the inundated water.

4. For the fill embankment section on the soft soil at the end of bridge, culvert, underpass, to avoid the unpredicted damage of abutment base, wing wall, etc. by the negative friction between embankment and abutment when base is subsiding, the base must be designed with subsidence reaching 90% of consolidation index before constructing these parts of abutment. If not, the base and other their parts must be designed in considering negative friction and propulsive forces from behind abutment when base is subsiding. These section shall be constructed as sooner as better to ensure the pre-subsidence. At the underpass, small culvert section, before excavating to construct base and culvert, it can be preloaded until the subsidence reaching the mentioned consolidation index. The minimum time for surcharge is 6 month. If possible, this surcharge time is as longer as better. The construction of embankment on soft soil area shall be taken as soon as possible to avoid the subsidence after opening traffic.

5. For the general fill embankment sections of the expressway through soft soil areas and the section mentioned in Item 4 in particular, the settlement survey and lateral movement of the soil during the filling and waiting periods prior to the construction of road pavement is essential. It must be carried out in accordance with the accurate survey value. The consolidation level of soft soil under fill loading (including the surcharge) can be evaluated through the settlement curve through actual survey if the survey result is trustable (it is possible to compare with the settlement forecasting result with time)

6. If the freeway/expressway project has many soft soil sections, the owner shall hire the consultant and constructor in order to experiment some embankment section before constructing the embankment on the whole project. On the experiment embankment section, the necessary observation equipment should be installed. The observation time for this experimental embankment is at least 12÷18 months. The soft soil treatment method shall be implemented base on this experimental results to ensure the best economic and technical performance.

8.3. Design of drainage system

8.3.1. Drainage system on freeway/expressway must drain water from road surface quickly to avoid soakage of water to road structure and erosion of embankment at shoulder or talus. Due to the freeway/expressway has may lanes, the its design is not only obeyed standard TCVN 4054 and item 2.6 of 22TCN 211 but also considered to item 15 of standard TCXDVN104 (Urban Road - Design Criteria).

8.3.2. In any case, at out-going/in-coming section, curve section and section with vertical slope is less than 1%, the elevation (at profile) of freeway/expressway must be designed in scope of the whole width.

8.3.3. In the low embanking and digging base, there can be narrow side ditch of 0.50m with covers, or gutters of 0.4m÷0.5m depth and 2m - 2.5m width, the slope top and bottom of gutter is made slope and bending, supported by thick grass.

8.3.4. On the curve with one-wing horizontal grade, the side ditch with cover or underground pipeline must be placed next to separating line and pipeline system required to lead water out of embankment; if using side ditch with cover, it can be encroach the safe line and its cover can bear traffic loading capacity.

8.3.5. We should located the underground side ditch in grass-growing line on the slope top of embankment and in the neighbourhood of the slope top of embankment to lead and receive water to avoid erosion of the slope top. We can make a barrier by asphalt concrete at the outside edge of the hard line (the urgently stopping line) so that the hard line can stop and receive water and water from carriage-way surface cannot directly flow to talus but slope exit to go out of road foundation area. The distance between the flow and flow area must be determined depending on the catchment area of each flow.

8.3.6. Every side ditch must be supported. The underground pipeline must be located on a reliable base to avoid water soakage causing sinking or erosion.

8.3.7. The section of leading water out of embankment or from the top side ditch to the foot of the slope require step, slope and support at the downstream.

8.3.8. The evaluated frequency of hydrology for the drainage gutter is 4%, for bridge and culvert is 1%.

8.3.9. It require the measure solving the underground water section and exposures of underground water capable of effecting the stability of the whole embankment.

8.4. Pavement design

8.4.1. The freeway /expressway surface must be designed with the structure of asphalt concrete or cement concrete road cover and following the standards of the intensity, durability, especially the roughness and smoothness index (as mentioned in item 1.3.3 and 1.3.4 of 22TCN 211). For this purpose, designing structure and evaluating intensity must follow principle and method in current procedures of designing road surface cover in which for the soft road surface it is necessary to study and design the rough-making layer suitable for the conditions of climate and executing reality. We should use the material with organic or inorganic conjunction for the upper foundation of the plastic concrete road surface structure and soil, rock, sand with inorganic conjunction for the cement road surface structure.

8.4.2. The pavement structure of shoulders, separate lines, safe lines, auxiliary lanes, toll gate should obey standard 22TCN 211.

8.4.3. At abutment, pavement should be located on transition slab to ensure good connecting between road and bridge. The expansion join is also chosen properly for smooth joining at abutment.

9. Designing and locating toll gate on freeway/expressway

9.1. The location of toll gate depends on the toll collection method:

- If applying "the close system", the toll gate must be located on all the exit/entry ramps and toll is collected according to the length of real journey on freeway/expressway (refer 7.3.2, 7.3.2 and Figure 7 of this standard).

- If applying "the open system" the toll gate is located at some certain locations on the freeway/expressway; toll is collected based on the acceptable average distance for every vehicle.

- If applying "the lump sum collection", the toll gate must be located at the ends of freeway/expressway. Design consultant must depend on practical situation to select the toll collection method and study the location of toll gate, especially "the open system" to avoid too many toll stations that may cause negative effects to the social

activities (in particular with BOT project). The distance between toll gate of "the open system" is stipulated in circular 90/204/TT-BTC dated Sept 07-2004.

9.2. The area of the toll gate requires the following works:

- The island of separating lane and classifying vehicles.

- Control booth, toll booth, ticket booth.

- Car parking for police work.

- Toll plaza (management, accounting, data storage, money box, transport control, electrical and communication system).

9.3. Alignment of the section having toll gate.

9.3.1. If toll gate is located on freeway/expressway, the alignment of this section is the same as the one of other sections on freeway/expressway. If it is on the branch road the radius of the curve there must not be less than 200m.

9.3.2. Vertical slope in the scale of toll gate should be less than 2.0%.

9.3.3. Crossfall at toll gate area is 2%.

9.4. The number of traffic lanes is defined in formula in 4.5.1; in which N_k in item 4.5.2 but the evaluated duration is 10 years, then N_{tk} is defined as follows:

- For toll gate on entry ramp, no collection of money, only collect the number: from 500 units/hour-lane to 650 units/hour-lane.

- For toll gate on exit ramp, collection of money: from 300 units/hour-lane to 350 units/hour-lane.

We must depend on the forecasting of the traffic component to define the number of lanes and waiting length necessary for every vehicle class with the same toll amount. Besides, one lane for over-sized vehicles should be located on the outer right-hand side on either side.

The number of traffic lanes at toll gate should be 1.5 time more than the one on freeway/expressway.

9.5. The width of lane at toll gate is from 3.0m to 3.2m. The width of lanes for over-sized vehicle is from 3.5m to 4.0m.

9.6. The overhead clearance in the area of one lane at toll gate is stipulated as figure 14.

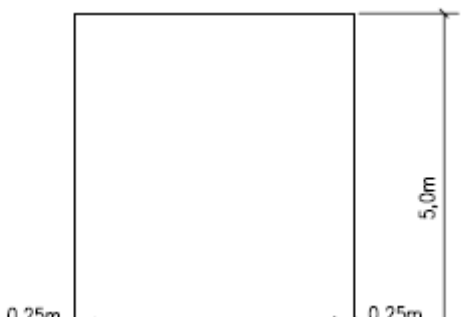


Figure 14 - the overhead space limit for one toll gate

9.7. The structure of lane-separating island at toll gate.

The width of island is from 1.50m to 2.20m (depending on the toll collection method); the surface of island is 0.25m higher than carriage-way (figure 14); the length of island along the road is from 25m to 30m if toll gate is located on branch road and from 30m to 45m if it is on freeway/expressway. On the island, outside the clearance limit in Figure 14, can arrange the toll booths. On the surface, two ends of toll gate island have one narrowed section as boat shape which is away from the island end with the length of 1/5 - 1/6 of island and it is filleted, increasing elevation and having line marking.

The roof of toll booth is 5 - 6m large every side from the center of toll booth and over the height of overhead space limit in figure 14.

9.8. Cross sections at the center of toll gate (this center is in the middle of toll island according the along the alignment).

These cross sections consist of toll lanes (the number of lanes is determined in accordance with 9.4), the lane-separating islands, the normal pavement next to the lane for over-size vehicle on the right (hard pavement and over-size lane need not isle). The total width of pavement at toll gate (B_{tr}) is the total width of all mentioned sections.

9.9. The width transition from main road to the center of toll gate.

9.9.1. The width B_{tr} in item 9.8 must remain the same in the scale of the length of lane separating island and enlarged the minimum of 20m - 25m every side from each end of island (if toll gate is on freeway/ expressway) and 10m -15m (if toll gate is on the entry/exit ramp to freeway/expressway).

9.9.2. Outside the above mentioned constant width (B_{tr}), the width of pavement is gradually narrowed. The width of main road outside toll gate reduced 1/3 (every 3m of the length, 1m of the width is reduced) symmetrical with centerline. At the point the width reduced the bending connecting the edge of pavement with the radius of 5m - 15m required.

9.9.3. The length of toll gate consists of the total length of constant width (B_{tr}) and the length of reduced width sections (as mentioned in 9.9.2). This length should be designed in considering the queue of vehicle on both ends of toll gate (the queuing length is recommended not longer than 500m).

9.10. In item 9.9.1 and 9.9.2, the construction of cement concrete road pavement should be considered (recommended to be continuous steel reinforced cement concrete pavement)

9.11. In front of each toll lane the barrier must be placed to stop vehicles if necessary (except lane for over-size vehicle). Around toll booth, protective balcony is required. The room of toll booth requires enough equipment for toll staff, installing communicative system and necessary devices. For toll gate with heavy traffic which having many gates and large traffic flows, it needs underpass for staff accessing the toll booths.

10. Safety measures, facilities and environmental protection on freeway/expressway

10.1. Safety measures, transport safety must follow the below stipulations:

10.1.1. On the median there must be two safety barriers (made of steel or cable) with back to each other (figure 15) or double protective barriers of shaped steel in these cases:

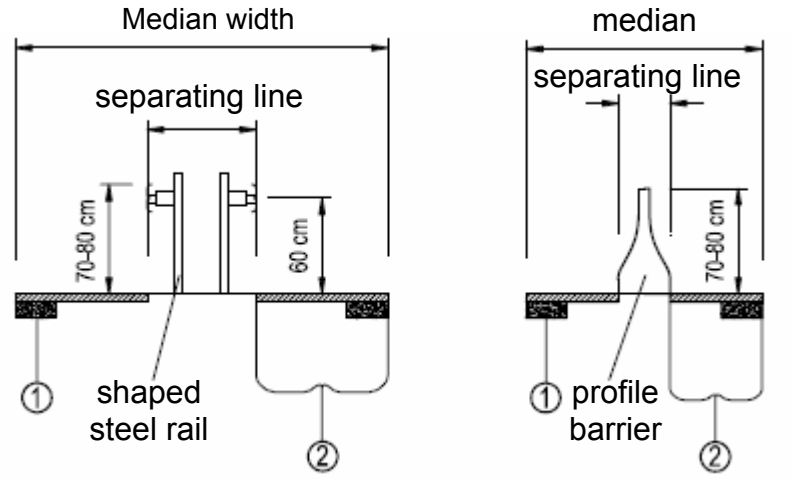
- The width of median is less than 4.50m.

- The width of median is from 4.5m to 10.0m but anticipated traffic after 5 years (from the time of opening traffic) will reach 4,000 unit/day-night/lane. If the width of median is over 10.0m, protective is not needed.

- At the curve with the radius less than the normal smallest radius, along the length of curve.

- On the right hand side and entire length of the signal pole or abutment foundation of the road crossing.

- At opening median, the mobile barrier should be located (can be opened for car turning back in emergency cases).



1) Enlargement section 0.25m

2) The minimum distance to the edge of free way /expressway is the width of safe lane (table 1)

Figure 15 - Protective balconies of shaped steel or profile barrier wall at separating line

10.1.2. On the median there is a cover of 0.5÷0.75m width and barrier wall should be made of concrete (figure 15), the wall must be foot-buried or connected with steel pin with 20mm diameter to stick into cover.

10.1.3. On the grass-growing pavement there must be a row of protective barriers of shaped steel or cable in these cases:

- Along the length of curve with the radius less than the normal smallest radius, excluding the case that this curve is on the low cut and fill embankment with the gentle batter slope and the side table-drain having cover;

- The fill embankment height is more than 2.0m;

- The fill embankment height is over 1.0m without batter slope but replaced with retaining wall or abutment;

- In the area of signal panel pole or abutment for crossing bridge;

- Within 1.0m from the batter toe in the area river, pond;

- When using bridge, entry/exit the tunnel, overpass bridge at the non-connected not-at-grade intersections;

- In entry/exit section of freeway/expressway, speed-changing lane, changing width.

- In the section that has railway or other highway running parallel with the freeway/expressway.

10.1.4. There must be hard protective wall (concrete) along the length of high embankment section or sections having elevation higher than existing ground over 5.0m. The structure of protective wall must obey standard 22TCN 237.

10.1.5. In cases of item 10.1.1 to 10.1.4, the edge side of balcony or protective wall should be at least same width of safe line (table 1), 1.0m from the pillar surface or the column foot of signal panels, 0.30m from the edge of road base, their height is 0.75m - 0.8m (the height of cable balcony is 1.05m).

In case using the hard protective wall with dazzling resist for median line, the elevation above road surface is 1.2m and hence the minimum height of the wall is 1.0m.

Steel for barrier must be 4mm thick and galvanized, its section of teeth style (2 teeth) is 300mm - 350mm high. Shaped steel balcony is unchangeably connected with supporting column through wedging block. The steel supporting column with the diameter of 110mm - 150mm or U shape steel of 100÷125mm is buried of 70÷120mm depth. The beginning sections of protective balcony must ensure the longitudinal attachment capacity of the whole row by gradually lowering the beginning section to the ground in the area of 12m. The distance between the column of balcony is from 2m to 4m (or less on the curve section).

The cable barrier requires cable diameter of 16÷20mm, longitudinally connected with supporting column by 4÷5 strings, the upper string is 10÷25cm far from the top of column, the lower string is 45cm above existing ground. The structure of column, the distance among column and the longitudinally connecting way are the same as shaped steel balcony.

10.1.6. The barrier of steel net (or other materials) with its minimum height of 1.50m must be built at the section where people or animals can suddenly cross road. This barrier is placed at the edge of land for freeway/expressway. The specification of these protective equipment should obey standard 22TCN 237.

10.2. Direction-guidance design

Beside the line marking at the edge of road surface, one direction-guidance line mentioned in item 5.3.2 need some guide post (to show direction at night or under rainy condition when direction-guidance line is hardly visible), coordinated with safety barriers and plants.

10.2.1. Guide post can be made of round, square, triangle section with the diameter or side of 12÷15cm which placed symmetrically on both sides of road, 25cm away from the road shoulder, 1.05m higher than road shoulder and 35÷40cm buried underground.

Guide post must be placed on the entire alignment (including ramps at interchanges), excluding the section with safety barriers and safety walls. The distance between guide posts is depending on curve radius (table 23).

Curve radius(m)	<30	30÷89	90÷179	180÷274	275÷374	375÷999	1000÷1999	≥2000 and on low embankment
Guide post distance(m)	4	8	12	16	20	30	40	50

Table 23 - Guide post distance (also applying to branch road)

On the curve section, there are at least 5 guide posts each side.

At the section with protective balconies, guide posts can be coordinated with supporting column at the same height (higher than balcony) or connecting one part of guide post on the top of supporting column,

In any case, guide post must be painted luminously (a yellow line of 4cm width, 18cm height at the body of guide post at the side towards carriage way, the position of luminous paint is 25cm far from the top of column.

10.2.2. Growing plants to show directions

We should grow the high plants with straight body, straight and long root at median or in the area of safety corridor so that drivers can recognize direction from far distance (detailed design and verification by 3D image is required).

10.3. Signals panels on freeway/expressway

10.3.1. Design of signal panels must aim for these purposes:

- Contributing to stipulations of vehicle class allowed to run (item 4.1) and transport regulations on freeway/expressway (see 4.2).

- Give information about related road network, journey (distance, km) directions and intersections, accident precautions, service system along freeway/expressway.

To fulfill the above requirements, it is necessary to repeat the information by combining the sign boards (both sign board on post and gantry) with the line marking, signs and writings on pavement. The combination must be consistent, and not conflict with each other.

10.3.2. The position, structure (material, size, font, color etc.) of signal panels, drawing lines (horizontal, vertical, font, signs) must follow stipulations in "Regulations of highway signal" 22TCN 237.

10.3.3. In any cases, signal works must not encroach safe line including encroaching in vertical direction if signage is placed on road-crossing panes, the height of vertical overhead sign board is at least 5.2m.

10.3.4. The signal panels on freeway/expressway must be made of reflection glass or reflected materials.

10.3.5. For intersection interchange, signal panels is put at place driver can see it before 10 seconds (the panels shows directions according to the chart of interchange).

10.4. Preventing glaring due to opposite headlight at night

10.4.1. If freeway/express way has large separating line (having spare land) so that the distance between two orbits of opposite traffic is more than 12m, it need not anti-glaring measure.

10.4.2. Anti-glaring measures must be arranged on the sections of heavy traffic (especially heavy truck) at night time, radius of curve section smaller than the normal value, vertical curve section, long straight section, mountain area with continuous variations, long bridge, flyover without lighting, connected interchange, entry/exit to rest area and service area.

10.4.3. Anti-glaring method: arranging anti-glaring plate on separate line of freeway/expressway or growing herbs or placing light-stopping wall of 1.60m height.

If choosing the growing herbs method, the herbs should have green leaf all the year round; each herb width is 0.4÷0.6m and distance between them is 2.0÷3.0m.

If using light-stopping wall, it consisting of plates. The material of this plate is steel or plastic of 1.5÷4.0cm thick, 8.0÷10.0cm width (at normal sections) or 8.0÷25.0cm (at curve sections), and 80.0cm height. Each plate is mounted to the square shaped steel (section size is 40x40mm or 65x65mm) and connected to the top of hard protective (as mentioned in item 10.1.2). The height from the top of this wall to separated line is 1.6m. This wall is rotated 45^0 with direction of carriage way and located at every 50cm along the anti-glared section.

10.4.4. The sight-stopping distance must be checked when using anti-glaring methods on curve sections.

10.5. Lighting design

10.5.1. Lighting must be placed at the following section:

- At toll gate area;

- In tunnel.

Besides, there should be lighting at:

- The area of connected intersection on freeway/expressway;

- The section where the vehicle just exit from freeway/expressway and approach one lit section (such as industrial zone, airport).

- On the right side of technical service center.

- At the important signal panels (when it is not possible to install signs with automatic lighting).

10.5.2. Light index which is measured by the average light on freeway/expressway is from 1cd/m^2 to 2cd/m^2 (candela/m^2).

The equal light on carriage-way showed by the luminous ratio between the darkest place and tightest place shall not more than 1:1.3 according to the vertical alignment and 1:2.5 according to the horizontal alignment of carriage-way.

10.5.3. From the light section to the non-light section, light must be gradually reduced by the decrease of the average illumination index from 2cd/m^2 to 0cd/m^2 in the minimum section area of 250m. If the section requiring light is less 250m far from each other, the light should be continuously kept at the section between them.

10.5.4. The height of lighting pole is 12÷15m and arranged in the horizontal line at the separating line or on the freeway/expressway pavement or on both the separating line and the pavement (horizontally straight or uneven). The distance between the lighting pole must be computed suitably for item 10.5.2 and 10.5.3.

10.6. The service works on freeway/expressway

10.6.1. Along the freeway/ expressway there should be the following service works:

- Every 15km -25km there is one parking lot outside the area freeway/expressway base. Here passer-by can stop to relax, do maintenance. This area can be tens of mere. to hundreds of meters far from freeway/expressway.

- Every 50km - 60km there should be a technical service center (capable of supplying petrol, prepairing) and facilities such as restaurant, toiler, hotels.

- Every 120km to 200km there should a big service center (capable of repairing, supplying and receiving tourists etc.) basing on the quantity and class of guests. It also requires a long-term parking area.

10.6.2. Coordination with the cities along freeway/expressway in building the service works. The out-going/in-coming section to parking station or service works must obey the requirements in item 7.8.

10.6.3. The parking station along freeway /expressway should be at the good scenery:

- Parking lot for a short-term: for 1 - 3 units of vehicle with a relaxing hut and tourist map.

- Parking lot for long term: many vehicles with restaurant and post office etc.

10.6.4. The service works must be located at the favorable place, not stopping eye-shot to the slope or bending and far from intersection; the out-going way must be more than 6m and the maximum speed of 40km/h.

These service works should be put regularly and symmetrically (nearly opposite, it can see each other if uneven) and have the same advantage. The restaurant, hotels can be arranged at the same side and viaduct or tunnel under freeway/expressway for passenger required. Parking lots can be at two sides of freeway/expressway.

The scale of service works must be based on traffic, traffic current, number of passenger for each kind of service.

10.6.5. The emergency telephone (to urgently noticed to road management centre, traffic police, car reparing centre, emergency service…) should be installed along the freeway/expressway with the distance of 2÷3km and at two ends of major structures (bridge, tunnel).

They are located on the grass-growing pavement, behind balconies or protective walls and symmetrically each other at two sides. There should not be only one emergency telephone located in the area of median. The phone booth must be painted for easy recognition and consistent in the entire expressway.

10.7. The requirements must be considered in designing freeway/expressway to protect environment along freeway/expressway:

- Protective measures to agriculture, forestry, and water source.

- Landscaping improvement

- Preventing noise, dust and sewer by traffic.

- Traveling of residents at both side along freeway/expressway.

10.7.1. To protect agriculture, forestry, and water source there must be measure of restoration of excavated location for cultivated land; consideration of the effects of service works to surrounding water sources; control of deforestation around freeway/expressway and anti-erosive measures. For the bridge it is necessary to compare and select viaduct instead of embankment to save cultivated land.

10.7.2. The method of flooding prevention on the upstream end is basically to provide sufficient bridge navigation, drainage capacity and when necessary, lower the height of design road level as referred Clause 7.3.2 of standard TCVN 4054.

10.7.3. To improve environmental pollution by dust and sewer the following measures must be paid attention to:

- The main solution is that there is no traffic jam on freeway I expressway (the lower vehicles run, the more dust and sewer emit), therefore computation of traffic capacity must be considered (item 4.5), it is necessary to consider design auxiliary lane of going tip slope near residential area and focus on transport administration measures.

- At the branch road of coming to freeway/expressway there should be the section to wash vehicles or the transitory section Qf the minimum length 30m with the high-grade surface to limit dirty vehicles into freeway/expressway.

10.7.4. The acceptable noise index for the residential area along freeway/expressway is from 45 dB/A to 55 dB/A (A: the value of the biggest noise index measured outside the house towards freeway/expressway 2.0m).

At the edge of freeway/expressway base, the noise index by traffic is defined as follows:

$$L_0 = 24 + 20 \log N \qquad (1)$$

of which:

- L_0 is the noise index, measured by dB

- N is the traffic in one hour, measured by unit/hour.

The noise factor L_n is far from noise-causing position (centerline of freeway/expressway) with the horizontal distance, R_n, measured by meter, is defined by the formula:

$$L_n = L_0 - 25 \log \frac{R_n}{R_0} \quad . (2)$$

of which:

- L_0 is the noise index at the edge of freeway/expressway base, measured by dB.

- R_0 is the distance from the centerline to the edge of freeway/expressway base, measured by meter.

After coordinating formula (1) and (2), we can anticipate the noise factor for the residential area R_n, measured by meter.

10.7.5. If the residential area is too close to the freeway/expressway, the anti-noise measures can be applied:

- Building the noise-stopping wall of 3÷3.5m height close to the edge of freeway/expressway base (enlarging base), the wall is made of sound-stopping cement or installed concrete slab

- Sound-stopping embankment with the width of top of 2.0m, high enough to create the sound-stopping area (from the center of carriage-way to the edge of embankment top).

- Growing grove of plants outside the area of freeway/expressway.

10.7.6. To ensure traveling of local residents, since feasibility study stage the favorable and economic system of gathering road, viaduct, underpass must be considered. Besides, designer must pay attention to planning, construction management for residential areas on both sides of the freeway/expressway.

10.7.7. The position of alignment and technical standard of gathering road depend on transport requirement at present and in future from 5÷10 years (kind of vehicles, traffic, etc.) predominantly for public use. It is not obliged to design the road on any certain road grade (including the overpass width on the expressway). For the residential culvert under the expressway, there should be at least 1 traffic lane with 3.5m width (see 7.11.1).

To ensure the function of freeway/expressway, the gathering road is completely separated from freeway/expressway (if it is in the area of freeway/expressway in item 5.11 there must be stopping barrier as item 10.1.6).

10.8. The arrangement and construction of maintenance and service works for freeway/expressway must be included in the expressway design project as other road design and follow the regulations of Vietnam Road Authority (VRA).