TCVN 5729 : 1997

FREEWAY / EXPRESSWAY

SPECIFICATION FOR DESIGN

HANOI - 1997

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Freeway / Expressway – Specification for design

1. Applied scale

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

2. Standards and reference document

Regulations for traffic road, Decision 203/HDBT dated 21, December 1982.

TCVN4054	Roadway Design Standards
TCVN4447	Earthwork – Specification for Construction and Acceptance
TCVN2737 - 90	Loads and Loading – Design Standards
TCVN4527 - 88	Tunnel Roadway and Railway Tunnel – Design Standards
TCVN5576 – 91	Water Supply and Drainage System – Technological Specification
TCVN25	Regulations of Traffic Sign System
TCVN221 – 93	Procedures of Design Specification for Soft Pavement
TCVN66 – 84	Testing Specification for Determining Roughness of Road Surface by Sand Scattering Method.

3. General regulations

3.1 Definition: The freeway / expressway is only used by car. It has the following specification: separating directions each of which requires a minimum of two lanes); each direction needs the lane for vehicles stopping in urgent condition. It requires equipment, supporting works to ensure the continuous and safe transport. The vehicles must be instructed to come in and out at the definite points.

3.2 Classification and gradation

The freeway / expressway is classified as follows:

3.2.1 Class of freeway / expressway

According to design of intersection, the freeway / expressway is divided into 2 classes:

- Class A (Freeway): locating elevated interchange at the in / out-going point on the freeway / expressway, at the intersection of freeway / expressway and railway, pipeline and other road (including public road).
- Class B (Expressway): locating on plane intersection at the same place as class A (except for the intersection of freeway / expressway and railway, pipeline) if the traffic at the intersection is not much and budget is limited. However, this location of intersection requires measures to ensure the priority of traffic on freeway / expressway and safe transport at the intersection.

3.2.2 Grade of freeway / expressway

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

Class-A freeway / expressway is only applied for the grades 80, 100 and 120; the grade 80 for the mountainous and rough topography, the grade 100 for hilly topography and grade 120 for plain topography.

Class-B freeway / expressway is only applied for the grades 60, 80 and 100; the grade 60 for the complicated topography (mountainous, rough area), the grade 80 for the hilly topography area and the grade 100 for the plain topography.

3.3 Design requirements for class-A and class-B freeway / expressway are the same and shall be followed according with this specification, excluding the different requirements of intersection in item 3.2.2.

3.4 Design of interchange or intersection (at some places on freeway / expressway) shall be also based on the current regulations of designing intersection.

In designing class-B freeway / expressway, it requires anticipated design of interchange at the location of intersection for future use in order to:

- Avoid the rehabilitation of freeway / expressway when replacing intersection by interchange, and making the best use of built intersecting alignment.
- Determine spare land for interchange.

3.5 In case of rehabilitating 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, the freeway / expressway should be newly designed and the old one should be used for local transport.

3.6 Freeway / expressway has to exist outside the planned area and 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.

3.7 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:

3.7.1 Study of defining the control point to establish alignment alternatives, comparing and selecting route and evaluate the economic and financial effectiveness of the selected route.

3.7.2 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.

3.7.3 Study of the necessity of arranging the sections for each direction at different elevation 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).

3.7.4 Study of defining the out / in points, study of selecting form and comparing the locations of intersections on freeway / expressway.

3.7.5 Studying and comparing the location of toll gate.

3.8 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.

3.9 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.

3.10 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 three-dimensional model to verify and evaluate the coordinated solutions.

4. Bases for designing freeway / expressway

4.1 All the kinds of vehicles on public highway network are allowed to run on freeway / expressway; 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 motors with cylinder volume of 70cm^3 or more can run on freeway / expressway but other kinds of vehicles are not allowed.

Traffic regulations on freeway / expressway

1. The vehicles must run on the right lane; the passing is allowed on the left lane; the sub-lane is only used by slow and heavy cars; if the car goes out from freeway / expressway, it must run on the lane of separating and decrease its speed; if it is coming in freeway / expressway, it must run on the lane of increased speed for joining the freeway / expressway.

2. The vehicles shall not be allowed to stop on freeway / expressway (except for the urgent situation, it can stop on the necessary sideway).

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

4.3 Except for the special case, construction of class-A freeway / expressway is only considered if the evaluated traffic is from 10.000 units /day-night to 15.000 units / day-night for each direction and class-B one if the evaluated traffic is from 5.000 units / day-night to 10.000 units / day-night for each direction. 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.

There may be some parts of different grades and this parts must be 10km-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 / 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

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

- N_{ix}, N_k 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_k, 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 (units / 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 follows:

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

of which:

- N_{ttmax} is the biggest practical traffic capacity of one lane in the standard condition (units/hour-lane) for freeway / expressway, applied $N_{ttmax} = 2.000$ units / 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.

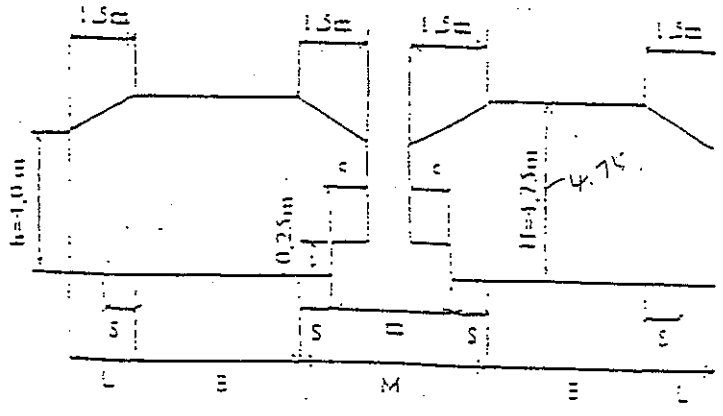


Figure 1 - Traffic Clearance

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 over space limitation of freeway / expressway tunnel is regulated as figure 1 (because we often construct one tunnel for each direction) with these 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 ($h = 0,40m$)
- 2,50 is the overhead space for pedestrian, measured by meter.

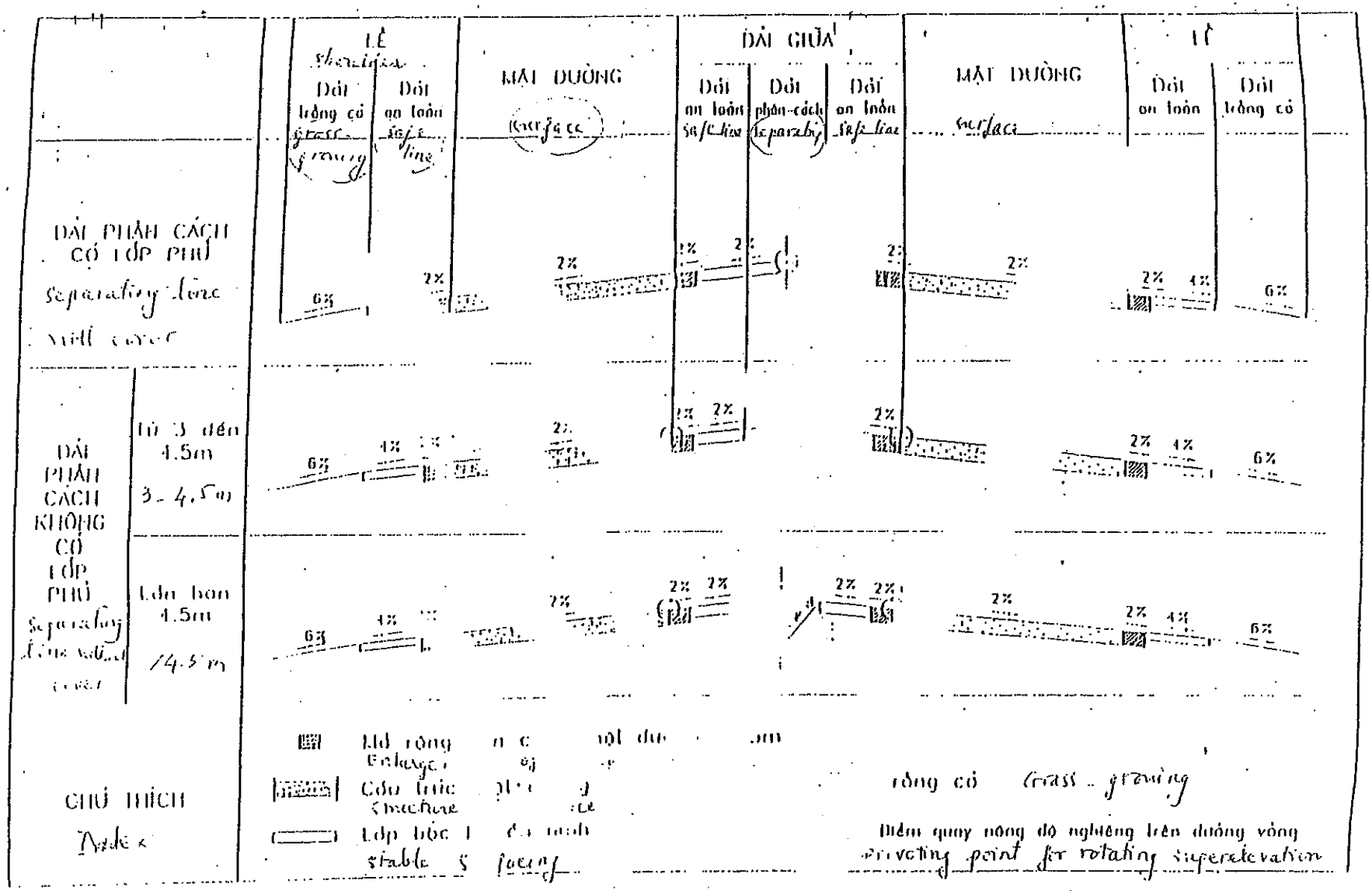
Note: the factor H should increase from 0,1m to 0,2m to spare in making the road surface in the tunnel higher in maintenance and modification .(H = 4,85 ÷ 4,95)

4.8. Clearance required underneath freeway / expressway

When freeway / expressway comes over the railway or other traffic road, under freeway / expressway 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 sectional arrangment of freeway / expressway

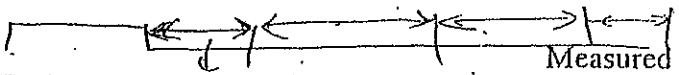
5.1 The elements of freeway / expressway cross-sectional arrangement is shown in figure 2.



Hình 2 - [illegible] Thành phần đường cao tốc

Cross section elements of freeway/ expressway

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

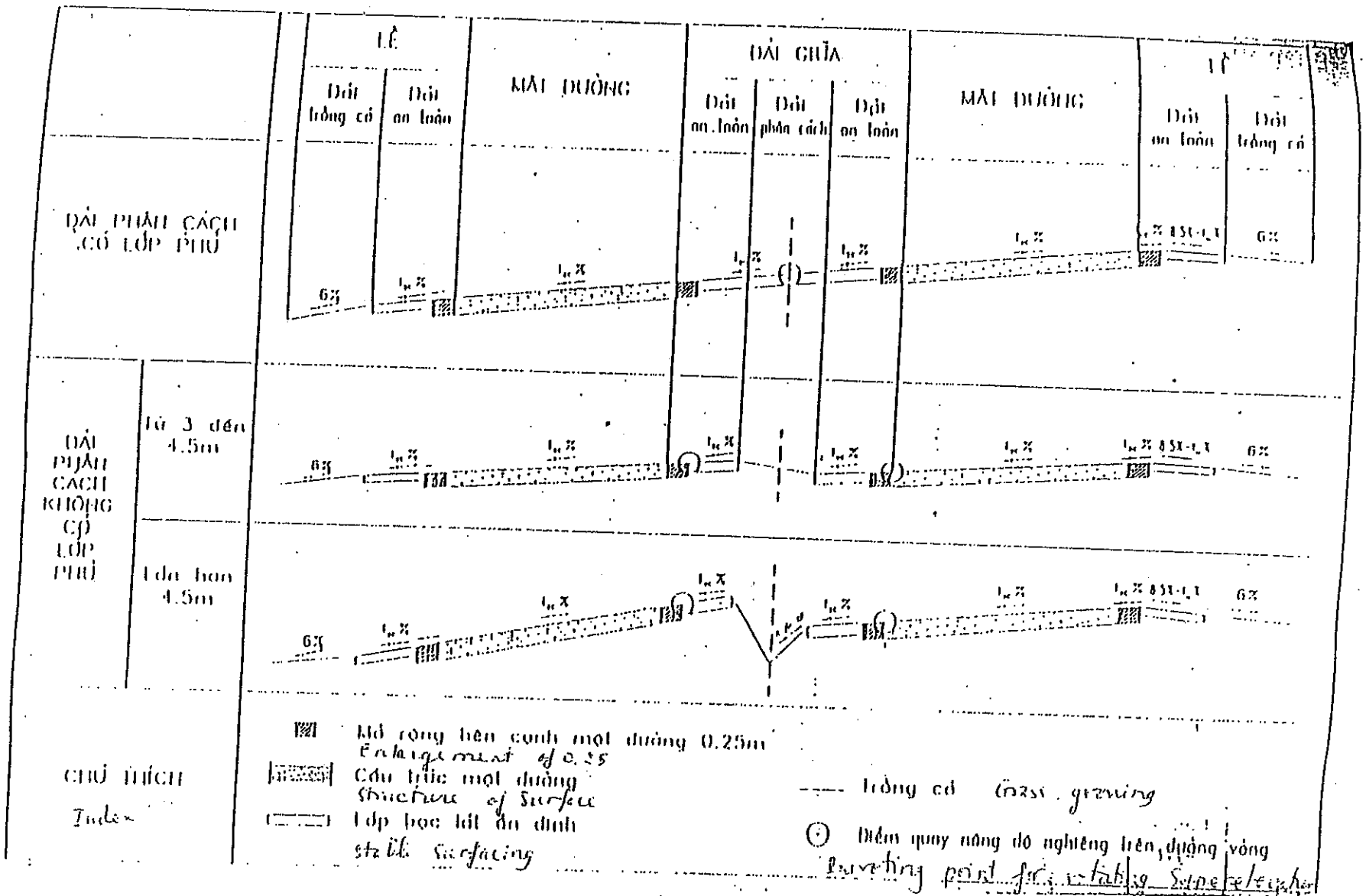


Measured by meter

Structure of separating line	Freeway/ expressway grades	Shoulder		Freeway/ expressway pavement	Middle line			Freeway/ expressway surface	Shoulder		Freeway expressway 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	0.75	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	0.75	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

Note:

1) *The column is arranged 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 pavements (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 for 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.*



Hình 3 - Độ dốc ngang của mặt đường;
Superelevation of freeway/expressway surface

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

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 8,5% - i_{sc}%.

5.3 The safe lines have to ensure that the vehicles can run at the high speed. Besides the safe lines on the pavement is used for vehicles stopping if necessary (called the urgent stopping line).

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).

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 line 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).

The cross gradient of the safe lines in the area of hard pavement (the urgent stopping line) must be grade of 4% outside the road base, even on the right or curve part. If the curve part has i_{sc} more than 4% this cross gradient must be equal to i_{sc} of stopping line at the inside of the curve and 8,5% - i_{sc} at the outside of the curve (see figure 2 & 3).

5.4 The grass-growing part 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 lines 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 1 so that there is enough land for the mentioned works or widening the road in future if necessary.

5.5.1 If the width of the separated line 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 separating line 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 separating line is from 3.0 to 4.5m planting is only required on the cross grade of 0% to the straight part in figure 2. The surfacing layer is not required. For the curve 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, although the separating line is curbed or not there must be longitudinal drainage system over it (constructing opened ditch, ditch with cover and drainage crack, permeable drainage pipe or groove, etc.)

5.5.3 If the width of the separating line 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 separating band.

5.5.4 Along the separating line from 2 – 4km, in front of structures (bridge, tunnel), we have to set up one blank portion of 25 – 30m shall be provided so that the vehicles can turn its direction if necessary (the management and barrier 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 traverse 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.

- 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 0,50m.

The length of the narrowed section as mentioned above must not be from 05 km – 1 km and more than 2km, also not less than 0.5 – 1km. The transitional section from the standard section to narrowed section must be 1^0 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 $i_{sc} = + 2\%$ (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 Slope sub-lane

Consideration shall be taken for the construction of slope sub-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-up side (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).

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

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

- 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 100m 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 sub-lane for the 6-lane freeway / 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 sub-lane to be constructed or not shall base on economic and financial study. The study must 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 sub-lane of going up slope

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

- The sub-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 slope sub-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:

Table 3 – The length of transitory section behind the slope of sub-carriage way for vehicles going up the slope.

Longitudinal slope after going up the slope, %	Going down	Going across on plane (0%)	Going up			
			0,5	1,0	1,5	2,0
The length of the transitory section behind the slope, m	150	200	250	300	350	400

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 sub-carriage way for vehicles going up slope.

- At the slope section with the sub-lane the urgently stopping line is not required, therefore the outside of the sub-lane only needs the safe line of 0,50m (with the drawing line of 0,20m) and the empty line of 07,5m is following.

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

- When the freeway / expressway is on the curve the highest grade in the area of sub-lane is 4% (correlative with the super-elevation specified for the main lanes from 4%

to 7%); if the super-high gradient of the main lane is less than 4% the one of sub-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 speed-changing lane of 3,50m width is put close to the outside of main carriage way with the drawing line of 0,20m (this line 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 Land corridor for freeway / expressway

Land corridor for freeway / expressway begins from the outside of gutter on the two side of the embankment (from the foot of talus or supporting structure if no outside gutter), or the outside edge of gutter on talus outside (if no top gutter from the peak of talus) according to Regulations on Road Management attached to and Decision 203/HDBT dated 21/12/1982.

5.11.2 For the section of high or embankment or deep excavation, embankment on weak soil the determination of land corridor must be based on the protective works such as counter presser bern, retaining wall etc.

5.11.3 We depend on the practical requirement and detailed 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 stipulation, the works such as canals, pipeline, cable and electric wire pole and other equipment are not allowed to build.

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), if 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).

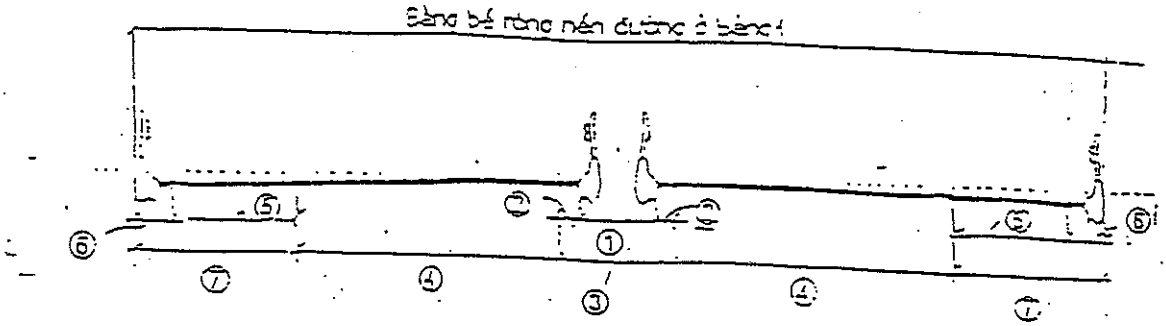


Figure 4 – The cross section of bridge on freeway / expressway

1) *The same as the width of separating line*
2) *The same as the width of safe line on the left.*
3) *The same as the width of the middle line*
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.*

5.12.4 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 insinuating section below freeway / expressway or covered by light material which is able to resist pedestrian loading if narrow (for repair and maintenance).

5.12.5 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.

5.13 The cross section of tunnel on freeway / expressway

On freeway / expressway there is always the separated tunnel for each direction of carriage way; on the cross section of these tunnels there shall be the narrowest section between the outside of two tunnel covers of 10m – 15m.

Note: in the first stage, one or two lanes for both directions shall be built (one lane for each direction), if accepted by the investor.

5.13.2 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 in tunnel is correlative with the grades of freeway / expressway in table 1.
- The width of safe line (s in figure 1) is 0,50m.
- Way for pedestrian is put on the right of the tunnel. Its width L-S is 1,0m for the tunnel on freeway / expressway of grade 60 and 1,25m for the tunnel on freeway / expressway of grade 80 or more (symbol L-S in figure 1); in the area L-S way for pedestrian is 0,50m (correlative with L-S = 1,0m) and 0,75 (correlative with L-S = 1,25), the rest section is the free line for more safety. Way for pedestrian is 0,40m higher than the surface of the safe line).
- The overhead space length of the tunnel on freeway / expressway stipulated in item 4.7

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; if R is less than 100m on the curve, it requires the enlargement of 50/R (R is the radius of the curve, measured by meter).

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 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.

Table 4 – Main technical standard for freeway / expressway alignments

Items	The grade of freeway / expressway			
1. Evaluated speed V_{tt}. Km/h	60	80	100	120
2. Highest super-grade (or one-wing grade) i_{sc} %, not more than	7	7	7	7
3. The minimum radius R_{min}, correlative with i_{sc} = +7%, m	140	240	450	650
4. The minimum radius correlative with i_{sc} = + 5%	250	450	650	1000
5. The radius correlative with i_{sc} = + 2%m	700	1300	2000	3000
6. The radius without the structure of one-wing grade i_{sc} = - 2%, m	1200	2000	3000	4000
7. The length of the transitory curve correlative with R_{min}, 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	2000	3000	5000

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 (5000m to 15000m) 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 line 4 of table 4 shall not be used.

6.3.2 Using the minimum radius R_{min} in line 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 $l \leq 500m$, 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 70 we must select the radius of the curve which distance p and the length of the curve K is large enough, p shall not be less than 2.0m; 1.75m; 1.50m;

1,0m or more and K must be greater than $\frac{1400}{\alpha}; \frac{1200}{\alpha}; \frac{1000}{\alpha} \frac{700}{\alpha}$ (α is the angle of deviation, measured by degree; $\alpha \leq 2^0$ is measured by 2^0) correlative with evaluation of 120, 100, 80 and 60km/h.

6.4 Superelevation 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) B rounded at 0.5%.

6.4.2 Superelevation 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 i_{sc} is the same) if the separated line has a topping, otherwise the two sides of road surface shall have the 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 transitional curve

The transitional curve of the clotoit 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 line 6 of table (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 line 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 (line 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 clotoit shape A shall be selected as follows:

$$R \geq A \geq \frac{R}{2} \quad (1)$$

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

$$R \geq A \geq \frac{R}{3} \quad (1)$$

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 clotoit shape meeting with the standard in item 6.5.2. This stipulation allows direct connection between the transitional curve of the clotoit 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 shape S 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 traffic-braking section stipulated in line 10 of table 4 and the height of the driver eye-shot of 1.20m and the destroyed section is 0.30 lower than this eye-shot.

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 the red line on the longitudinal profile.

The red line 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 longitudinal gradient

6.10.1 The maximum longitudinal gradient for the freeway / expressway grades is stipulated in line 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 big, medium bridge and the access road at the beginning of the bridge 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 1%.
- 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, 200m 150mm, 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:

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

Measured by meter

The longitudinal gradient %	Grade 120	Grade 100	Grade 80	Grade 60
2	1500	-	-	-
3	800	1000	-	-
4	600	800	900	1000
5	-	600	700	800
6	-	-	500	600

6.12 The vertical curve

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

6.12.3 The radius of the vertical curve on freeway / expressway grades and its minimum length is as follows

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

Measured by meter

Item		Grade 120	Grade 100	Grade 80	Grade 60
The radius of the Convex longitudinal curve	Minimum	12000	6000	3000	1500
	Minimum normally	17000 (20000)	1000 (16000)	4500 (12000)	2000 (9000)
The radius of the concave vertical curve	Minimum	5000	3000	2000	1000

	Minimum normally	6000 (12000)	4500 (10000)	3000 (8000)	1500 (6000)
The minimum length of vertical curve		100	85	70	50

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 coordination of alignment elements

6.13.1 To ensure traffic on freeway / expressway safely and economically, freeway / 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 sp... ...ust be carried out by perspective photograph, firstly at the section with the simultaneo... ...ge of plan and longitudinal profile, then the sections across the intersections or the sect... with special topography and geophysics.

6.13.2 To make alignments continuous, smooth and clear in space, ...ulations and instructions of designing the elements of plan and longitudinal profile i. ...2, 6.3, 6.5, 6.6, 6.7, 6.12 shall be obeyed. The high levels should be applied to th... ...nts 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 h... curve greater than the length of the vertical curve and their pea... ...ed differently uneven more than ¼ of the shorter curve leng...
- 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 beginnir... ...he convex and concave vertical curve (the vertical curve on the straight section).
- The vertical curve with the small radius must not be placed in the transitory cu...

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 Coordination 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, sken 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 coordinated 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.

The same plants shall be grown, growing high plants to emphasize and show alignment direction, short plants to cover, group of plants to landscape etc.

6.14.3 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.

6.14.4 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 clotoit 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.

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

6.14.6 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 limit embankment and deep excavation.

7. Design of intersection on freeway/expressway and in/out point to freeway / expressway

7.1 Classification of intersection on freeway / expressway
Functionally, the intersections on freeway / expressway are divided into two types:

- The intersection without going in/out freeway / expressway (called non-connecting intersection). 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 go in/out freeway / expressway.

- The intersection with going in/out freeway/expressway (called connecting intersection). These are the intersections between freeway / expressway and highway which we can we go in/out freeway / expressway and intersections between freeway / expressway and roads to airports, ports, 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.

7.2 On freeway / expressway of class A, both types of intersection in item 7.1 require interchanges in principle of no intersection point on freeway / expressway.

7.3 On freeway / expressway of class B, interchanges must be placed at the non-connecting intersections and interchanges should also be placed at the connecting intersections; the interchange is just placed at the connecting intersection under these conditions:

- It is far from urban traffic and in the thinly populated areas.

- The distance between two continuous connecting interchanges is more than 40km. In this distance, in/out point required.

- In the 8 –10 year duration of using the evaluated traffic on freeway / expressway is less than 1000 units and the average traffic all day and night on the crossed section is not more than 100 units.

- The amount of pedestrians is not considerable (or pedestrians go through the road by interchange).

- The intended location of the intersection must be at least 10km far from its closest connecting interchange

7.4 Stipulation of the distance among connecting interchanges

7.4.1 The minimum distance among connecting elevated interchanges is 4 km to ensure the requirements of mixing traffic flows, changing traffic speed (increasing or decreasing) and putting signage.

7.4.2 The distance among connecting elevated interchanges (the distance of the in/out point of freeway / expressway) should be from 15km to 25km by constructing sub-road to gather the close intersections into one point; for freeway / expressway sections around big cities or important industrial zones this distance can be from 5km to 10km.

7.4.3 If the distance among connecting interchanges is more than 30km we must locate the turning point through pausing sections of the separated line at the special positions. At that place signage or management required to show the missing vehicles, life-vehicles turning their direction.

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 connecting interchange, we must apply the technical standards in table 7 for freeway / expressway alignment and just applying the radius bigger than or the same as the normal factor and the grade smaller than or the same as the normal factor in table.

Table 7 – Technical standards for freeway / expressway at the connecting elevated interchange.

The grades of freeway / expressway		120	100	80	60
The minimum radius of the horizontal curve	Normally	2000	1500	1100	500
	Limited	1500	1000	700	350

The minimum radius of the vertical curve	Convex	Normally	45000	25000	12000	6000
		Limited	23000	15000	6000	3000
	concave	Normally	16000	12000	8000	4000
		Limited	12000	8000	4000	2000
The biggest longitudinal gradient, %		Normally	2	2	3	4.5
		Limited	2	2	4	5.5

Besides, we must verify the traffic capacity of spur roads, the sections of mixing traffic current and intersections in the scale of connecting interchange according to methods stipulated in TCVN4054 – Highway Design Standards – Main Technical Design Standards of Intersections (Crossings).

7.7 Design requirements for the extension roads in the scale of the connecting interchange (the out/in extension road of freeway / expressway too).

7.7.1 The cross section of these extension roads must be arranged as item 5.14

7.7.2 Evaluated speed on the extension roads is stipulated in table 8.

Table 8 - Evaluated speed on the extension road

Measured by km/h

Character of connecting interchange	The grades of freeway / expressway			
	120	100	80	60
- Transport connection between freeway / expressway class A and B	80 ÷ 50	70 ÷ 40	60 ÷ 35	50 ÷ 35
- Transport connection between freeway / expressway class A and B	70 ÷ 40	60 ÷ 35	50 ÷ 30	40 ÷ 30
- Transport connection between freeway / expressway class A or B and other road	60 ÷ 35	50 ÷ 35	45 ÷ 30	35 ÷ 30

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.*
3) *Not applied to extension road directly connected with freeway / expressway (that is to say the transitory section at the in/out point to freeway / expressway).*
4) *For the extension road with heavy traffic, we must select high evaluated speed.*

7.7.3 The above factor of evaluated 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 transitory 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.

7.8 Locating the joint between the extension road and freeway / expressway (the in/out point to freeway / expressway) in the scale of connecting interchange.

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 extension road 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.

7.8.3 We should ensure that 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 1 and we should follow the standard eye-shot in item 6.8, if favorable.

7.8.4 The out-going section from freeway / expressway can be arranged according to two parallel ways or connecting directly as figures 5a and 5b.

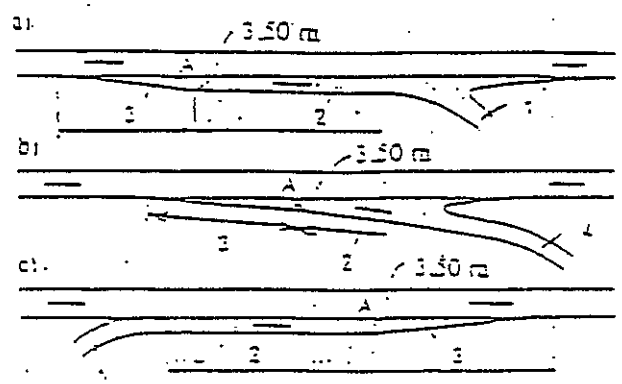


Figure 5 – the ways of locating out-going and in-coming section

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
1. The extension road

2. The speed-changing section (reducing speed in figure a and b; increasing speed in figure c).
3. The triangle lane-changing section
4. The extension road with the function of changing lane and speed.

7.8.5 For the in-coming point to freeway / expressway we must follow the parallel style (figure 5c) with the whole length of the speed-increasing section next to the carriage-way on freeway/expressway; if the necessary speed-increasing section is too long, its minimum part of 100m must be placed next to the carriage-way on freeway / expressway.

7.8.6 The width of speed-changing lane is stipulated as 3.50m. The length of triangle lane-changing section including the enlarged carriage-way is 3.50m.

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 9:

Table 9 – the minimum length of the triangle lane-changing section (current-separating or joining).

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

The speed-increasing/reducing section is counted from the point A in figure 5 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 end of the lane-changing section with triangular style) in figure 5, measured by km/h;
  The value A is based on the grades of freeway / expressway in table 10.

Table 10 – The value of the speed V_A at the beginning of the speed-reducing section or the end of the speed-increasing section.
Measured by km/h

Grades of freeway / expressway	120	100	80	60
V_A	80	70	60	50

- a is the accelerate of increasing or reducing speed, measured by m/sec^2

  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 the speed-increasing section, measured by km/h.

  The value V_B is based on the evaluated speed of extension road (item 7.7.2) 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 and the speed-reducing section are on the section of going down the slope and the .....lane-changing section and the speed-increasing section are on the section of going up the slope, their length is defined as table 9 and item 7.8.8 and multiple with one adjustment factor in table 11:

Table 11 – Adjustment factor of the speed-changing lane length on the slope

The average grade of the speed-changing lane, %	≤ 2	> 2 ÷ 3	> 3 ÷ 4	> 4 ÷ 5
The factor to the speed-reducing lane of going down	1.0	1.1	1.2	1.3
The factor to the speed-increasing lane of going up slope	1.0	1.2	1.3	1.4

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 12 multiple with adjustment factor in table 11.

Table 12 – The minimum value applied to the total length of the lane-changing section and the speed-changing section.

Grades of freeway / expressway	120	100	80	60
The minimum length of out-going point (reducing speed) of one lane, m	100	90	80	70
The minimum length at in-coming point (increasing speed) of one lane, m	200	180	160	120

7.8 The radius of the horizontal and vertical curve (if existing) on the speed-reducing section directly connected and on the rest of the speed-increasing section out of the area next to the carriage-way of freeway / expressway must ensure the stipulated speed depending on the grades of freeway / expressway in table 10.

Because the traffic speed continuously changes on the speed-changing section of going out/in the freeway / expressway, we must pay attention to the suitable geometrical elements and the alignment must be continuously placed at the point that the speed-changing section or extension road separated from the freeway / expressway by the clotoit bending with the parameter A = 160, 120, 90, 60, correlative with the freeway / expressway grades 120, 100; 80, 60.

7.9 When selecting the arrangement of position for the connecting interchange we must carefully analyze the traffic every direction (especially the traffic turning left), coordinated with topographical and ground conditions to determine and follow the stipulations of intersection design. Besides, it is necessary to analyze and prove the rationale when placing the intersection on the sub-road or extension roads in the scale of the connecting interchange, and the verification of traffic capacity as mentioned in item 7.6 must be paid attention.

7.10 Location of non-connecting interchange

7.10.1 Design of non-connecting interchange as mentioned in item 7.1, 7.3 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, the 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 2,70m and only lane required.

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

7.10.3 The elevated interchange between freeway / expressway and railway must not be in the area of railway station or switch location.

7.11 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 owner.

7.12 Stipulations of arrangement and design of intersection on freeway / expressway class B.

7.12.1 The control by signal light at the intersection on freeway / expressway is not applied, but the measures of signing to give priority to the vehicles on freeway / expressway (especially the signal STOP on the sub-road across freeway / expressway).

7.12.2 At the intersection, the evaluated speed of every direction on freeway / expressway and the crossing road must be the same as the evaluated speed outside the intersection of that road; depending on the traffic of the straight, left-turning and right-turning currents the signals can be placed to limit speed or stop the currents from the roads going into or across freeway/expressway. If necessary, we can give the signal of reducing speed to the traffic currents on freeway / expressway to ensure safety at the intersection. This limited speed is defined depending on the left-turning radius after reducing speed, stop to turn left or defined depending on the right-turning radius.

7.12.3 The angle of intersection should be 90^0 by changing alignment direction of the road intersected by freeway / expressway (no change of alignment direction of freeway / expressway).

7.12.4 The master design and improvement of the intersection into interchange in future must be considered.

7.12.5 The design of vertical plan with the slanting from 5cm to 10cm must be applied to solve the drainage and make good surface at the intersection on freeway / expressway.

7.13 The main geometrical standards at the intersection on freeway /expressway class B.

7.13.1 Straight alignment must be designed for every direction at the intersection or bending alignment with the radius from the radius value without the one-wing slope structure or more.

7.13.2 In the scale of intersection the biggest longitudinal gradient on freeway / expressway alignment should be applied as table 7: on other alignment the biggest longitudinal gradient should be from 3% to 5%. The slope length should be symmetrical to two sides from the center of intersection. The vertical curve and the slope length in the scale of intersection on freeway / expressway is stipulated in table 6 (item 6.12.2) and on the road intersected by freeway / expressway in TCVN 4054 – Highway Design Standard.

It is necessary to have the eye-shot angle at the intersection which the side is as long as the braking section (stopping eye-shot) correlative with the grade of intersecting road. In favorable topography, the side of angle on freeway / expressway should be the same as the eye-shot value in item 6.8.

7.13.4 Selecting intersection form, defining turning radius, bending radius connecting with the outside edge, defining scale, shape, position and dimension of isles, other detailed design and computation in the area of intersection must follow the stipulations of current intersection design.

7.14 At the connecting intersection on freeway / expressway class B (vehicles are allowed to go out / in freeway / expressway), the left-turning and right-turning lanes with the width of 3,50 required for vehicles going out from freeway / expressway. The length of left-turning lane includes the angle lane-changing section L_n then the speed-reducing section to stop (S) and waiting section to turn (L_{ch}). The length of right-turning lane just consist of the angle lane-changing and current-separating section and speed-reducing section correlative with the right-turning radius (or the speed on the road intersected by freeway / expressway).

Depending on the traffic of the straight current and the current turning to freeway / expressway, there may be turning lane on the intersecting road or not like item 6.14, the

vehicles must stop to observe before coming into freeway / expressway. On the freeway / expressway there must be the speed-increasing section S and the angle lane-changing and current-joining section Ln so that the vehicles turn left or right from the stopping point after crossing intersection, to join the current on freeway / expressway.

7.15 The minimum length of the angle lane-changing and current-separating or joining section and the length of speed-reducing or increasing section S in every case of item 7.14 are defined as table 9 and formula of item 7.8.8. When defining S as formula of item 7.8.8 the value V_A must follow table 10, and the value V_B is defined correlatively with each case like item 7.14.

7.16 The length of the waiting section to turning left L_{ch} is measured by meter and the minimum is not smaller than 30m, defined as follows:

$$L_{ch} = 2l_x.N_{tr}$$

In which

- l_x is the average distance between two ends of vehicle waiting to turn, measured by meter.
- N_{tr} is the average quantity of vehicles turning left per minute.

8. Design of freeway / expressway base and drainage system

8.1 Design of embankment elevation

8.1.1 The elevation of the outside edge of embanking base at the end sections of big, medium bridge, at the section with small bridges or culverts or crossing valleys, flooded fields must be higher than the evaluation flood level (considering emerging water level and the wave height on talus) with the minimum of 50cm.

The frequency of evaluating flood water level in every case is stipulated as 1%.

8.1.2 The minimum height from evaluated underground water level, regularly stagnant water level and from the ground without regularly stagnant water to the bottom of road surface cover are based on type of base soil as specified in TCVN 4054 – Highway Design Standards

8.2 Soil for embanking freeway/expressway base must be selected like the one for highway according to current stipulations and should be taken from mines. 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 upper layer of sand base require the sandy-clay soil or gravel of 30cm width with the tightness stipulated in item 8.7.1, (the layer of road surface cover with the incoherent material is not directly put on the sand base).

8.3 Evaluation and design must be based on the full and reliable survey data of geology and meteorology to ensure the stability of freeway / expressway base under the following conditions:

- Highly embankment and deep excavation with the talus height of over 12.0m.
- Excavation through rock, erosive, or falling stone areas and the areas with complicated topographical and meteorological conditions (deluvi, eluvi, weathered rock, slope-sliding, drifting mud and stone, swamp, soft soil, underground water, steepest slope areas).
- Erosive embankment adjacent to river, stream.

8.4 To help vehicles safely and advantageously running at the high speed, to avoid erosive soil at the dug section, the freeway / expressway embankment should be designed as slope like standards in table 3. If the square is limited, the stopping walls or embanking stone replacing the slope. For the talus on the slope of mountain with the big horizontal gradient, the difficult topography, we can design talus gradient like TCVN 4054 – Highway Design Standard.

Table 13 – Talus gradient of freeway / expressway embankment (soil talus)

The height of embankment or the depth of excavation	The slope of embankment	The slope of excavation
To 1.20m	1 : 4 (1 : 3)	1 : 3.0
1.2m 3.0m	1 : 4 (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 : 7.5 (1 : 1.5)
over 6.0m	1 : 2 (1 : 1.5)	1 : 1.5

Note:

- *the values in brackets applied to the case of difficult topography or limited land square.*
- *Talus must be changed in the scale of talus height in table 13 (the shape of talus is steep at the top and gradually slope at the foot.*

8.5 The top of embankment slope is made round 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).

8.6 For the coordination between the shape of embankment and landscape, at the digging section into embankment, talus should be designed steeply from the middle of the out-

going section to the section of beginning digging (for example, the slope 1 : 2 in the middle is change into 1 : 3 then 1 : 5).

8.7 Requirements of compaction index and bearing capacity of embankment

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

8.7.2 The land section of embankment below 30cm mentioned must be compacted with K = 0.95 (standard compaction). This section with 1.2m depth from the carriage-way surface must be compacted K = 0.9 0.95 (standard compaction).

8.7.3 The freeway / expressway must be designed depending on the standard of structure of road surface class 1 in index II 22 TCN 221 – 93 – Procedures of designing soft road surface cover, correlative with the value of evaluated elastic module 400da N/cm2 or more.

8.8 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.

8.9 We must not use soil on the natural slope with the horizontal gradient of 50% or more to embank. In this case, the supporting works to embankment (stopping walls, laying rock etc.) required. If the horizontal gradient of 20% - 50%, the steps must be designed before embanking.

8.10 Design standards for freeway /expressway base weak soil or peat soil.

8.10.1 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.

8.10.2 Before constructing the finished road surface structure, it requires the measures to ensure settlement of embankment with a consolidating rate of 90% and /or time dependent settlement as estimated shall be less than 2cm/year.

If the measures of increasing consolidation speed is so expensive and the time of execution is limited, design consultant must submit the proposal to make the structure of imperfect road surface to use timely in the case of base remaining to sink. It requires the feasibility study (considering the use of road early and the damage of transport expense, exploitation and the damage due to the road base repaired after finish sinking) to define the suitable consolidation index before executing road surface (imperfect).

8.10.3 The size of embankment on weak soil must be designed correlatively with the value of sinking.

8.10.4 For the embankment section on the soft land at the end of bridge, to avoid the unpredicted damage of abutment (its foundation, wing wall etc.) by the negative friction between embankment and abutment because of embankment sinking, we must make embankment sinking 90% of consolidation index before executing the parts of abutment. If not, sub-loading by negative friction and earth pressure behind abutment due to embankment sinking must be considered in computing and designing abutment foundation and other parts of abutment.

8.11 Drainage system on freeway / expressway must drain water from road surface quickly to avoid erosion of embankment.

8.11.1 In the low embanking and digging base, there can be narrow ditches 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.

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

8.11.3 We should located the underground vertical gutter in grass-growing line on the slope top of embankment and in the neighbourhood of the slope top of embankment to stop and receive water to avoid erosion of the slope top. We can make stopping ramp by plastic 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 base.

8.11.4 Every gutter must be supported. The underground pipeline with cover must be located on valid embankment to avoid water absorption causing sinking.

8.11.5 The section of leading water out of embankment, water from the top gutter, stopping gutter to the foot of the slope top require step, slope and support at the downstream.

8.11.6 The evaluated frequency of hydrology for the drainage gutter is 4%, for small culvert 1%.

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

8.12 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. 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.

8.13 Design must ensure adhesion index according to the method of experimenting traffic braking as follows:

- Equal to or more than 0.5 for freeway / expressway of grade 100, 120.
- Equal to or more than 0.45 for freeway / expressway of grade 60, 80.

Note: the road surface must be humid before experiment.

At the same time we must verify and compare the geometrical roughness index according to 22 TCN 65 – 84

Experiment by other methods is only decided by the office of jurisdiction.

The smoothness index is measured by the rule of 3.0m, the acceptable maximum value of ditch is 5mm for plastic road surface and 3mm for cement one.

8.14. In the scale of abutment, the structure of freeway / expressway surface must be located on transitory table of hardness index to ensure good connection between freeway / expressway and bridge, especially the selection of the suitable connecting ditch for traffic from freeway / expressway coming into bridge easily.

9. Designing and locating toll station on freeway / expressway

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

- If applying "the close system", the toll gate must be located on the branch of going out / in freeway / expressway and toll is collected according to the length of real journey on freeway / expressway (giving ticket when entering, collecting money when exiting).

- If applying "the open system" the toll gate is located somewhere on 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 method and study the location of toll gate, especially "the open system".

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

- The isle of separating lane and classifying vehicles.
- Control hut, toll hut, ticket hut.
- Some neighbor parking lots for police work.
- Building for office (management, accounting, data storage, money box, transport control, electrical and communicative system).

9.3 Alignment of 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 gradient in the scale of toll gate must not be more than 1.5% - 2.0%.

9.3.3 Horizontal gradient in the scale of toll gate is 2%.

9.3.4 The quantity of traffic lanes is defined as formula in item 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 in-coming branch road, vehicles get ticket, no collection of money: from 500 units / hour-lane to 650 units / hour-lane.
- For toll gate on out-going branch road, collection of money carried out: from 300 units / hour-lane to 350 units / hour-lane.
- For toll gate on freeway / expressway, collection of money carried out: from 450 units / hour-lane to 500 units / hour-lane.

We must depend on the evaluation of the vehicle current class to define the number of lanes necessary for every vehicle class with the same toll. Besides one lane for over-size vehicles should be located on the right outside of every side.

The number of 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 over-size lane is from 3.5m to 4.0m.

9.6 The overhead space limit in the scale of one lane at toll gate is stipulated as figure 6.

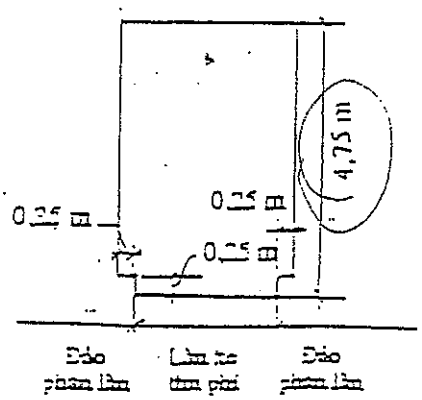


Figure 6. Clearance on toll gate

Figure 6 - the overhead space limit for one toll gate

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

The width of isle is from 1.50m to 2.20m (depending on the toll method); the surface of isle is 0,25m higher than carriage-way (figure 6); the length of isle 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 surface, two ends of toll isle have one narrowed section as boat shape which is far from the isle end with the length of 1/5 – 1/6 of isle and it is made round, increasing elevation and having signal line.

The root of toll gate is 5 – 6m large every side from the center of toll gate and over the height of overhead space limit in figure 6.

9.8 The group of cross sections at the center of toll gate (this center is in the middle of toll isle according the longitude of alignment.

This group consists of toll lanes (the quantity of lane determined as item 9.4), the lane-separating isles, the normal pavement next to the over-size lane on the right (hard pavement and over-size lane need not isle). The total width of road base at toll gate B_{tr}) is the total width of all mentioned sections.

9.9 The width transition of road base is passed into 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 isle and enlarged the minimum of 20m – 25m every side from each end of isle (if toll gate is on freeway / expressway) and 10m –15m (if toll gate is on the out/in branch road to freeway / expressway).

9.9.2 Outside the above remained width, the width of road base is gradually narrowed. The width of road base outside toll gate reduced 1/3 (every 3m of the length, 1m of the width is reduce) symmetrical with centerline. At the point the width reduced the bending connecting the edge of pavement with the radius of 5m – 15m required.

9.10 In item 9.9.1 and 9.9.2, the construction of cement concrete road base should be considered, at least designing the structure of the asphalt concrete road base with the foundation of material and organic conjunction.

9.11 In front of each toll lane the barrier must be placed to stop vehicles if necessary (excluding over-size traffic lane). Around toll hut, protective balcony required. The office of toll hut requires enough equipment for toll staff, installing communicative

system and necessary devices. For multi-door toll gate with heavy traffic, it needs underground ditch for toll staff.

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

10.1 Protective measures, transport safety must follow this standard:

10.1.1 On separating line there must be 2 protective balconies (made of steel or cable) with back to each other (figure 7) or one steel double balcony in these cases:

- The width of separating line is less than 4.50m.
- The width of separating line is from 4.5m to 6.0m but anticipated traffic after 5 years (from the time of using) reaching at 4000 unit /day-night / lane.
- At the curve with the radius less than the normal smallest radius, along the length of curve.
- On the right and from this end to that end of pooctich or the column foot of the road-crossing works.

10.1.2 On the separating line there is a cover of o.5m – 0.75 width and hard protective –wall is made of concrete (figure 7), the wall must be foot-buried or connected with steel pin to stick into cover.

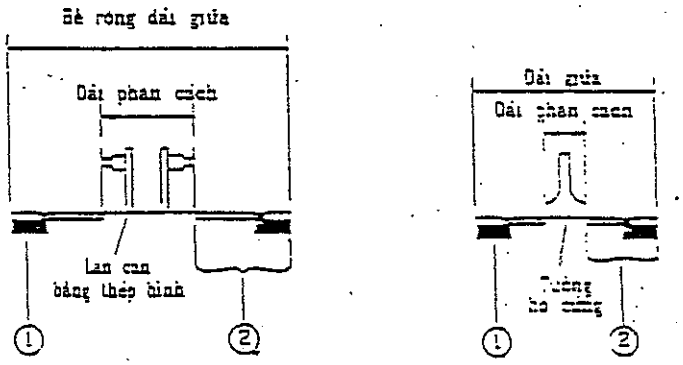


Figure 7 – protective balcony of shaped steel or hard protective wall at separating line
1) Enlargement section 0.25m
2) The minimum distance to the edge of freeway / expressway is 1.0m

10.1.3 On the grass-growing pavement there must be a row of protective balcony of 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 dug, embanked section with the gradual slope roof and the edge ditch having cover.
- The embankment height is more than 4.0m.
- The embankment height is more than 1.0m but there is no the slope roof but stopping wall or abutment wing.

- In the area the column foot of signal panel or abutment of road-crossing bridge.

10.1.4 There must be hard protective wall (concrete) along the length of embanked section or sections uneven with the below 5.0m or more.

10.1.5 In cases of item 10.1.1 to 10.1.4, the edge side of balcony or protective wall must be at least 1.0m far from the edge of road surface, 1.0m from the pillar surface or the column foot of signal panels, 0.30m from the edge of road base, their height is from 0.75m – 0.85m from.

Steel for balcony must be 4mm thick and plated, its section of teeth style (2 teeth) is 300mm – 350mm high. Steel balcony is unchangeably connected with supporting column through wedging block. The steel supporting column with the diameter of 110mm – 210mm or steel of U style from 100mm – 125mm is buried from 70mm – 120mm. 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 in the bending section).

The balcony of cable style requires cable diameter of 19mm – 20mm, longitudinally-connected with supporting column by 2 – 4 strings, the upper string is 10cm – 25cm far from the top of column, the distance among column and the longitudinally connecting way are the same as 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.

10.2 Direction-showing design

Beside the drawing line at the edge of road surface, one direction-showing line mentioned in item 5.3.2 need some marker pin (to show direction at night or under rainy condition when direction-showing drawing line is hardly visible), coordinated with protective balconies and plants.

10.2.1 Marker pin can be made of ellipse, square, round concrete with the diameter or side of 12cm – 15cm which placed symmetrically on two road sides 25cm 30cm far from road edge, 1.00m – 1.05m higher than road edge and 35cm – 4cm underground.

Marker pin must be placed on the whole alignment, excluding the section with protective balconies mentioned in item 10.1. The distance between marker pin is:

- 50m on the straight section and the curve with the radius R of 500m or more.
- 15m on the curve with the radius of 140m – 200m (each curve has at least 5 marker pins).

the section with protective balconies, marker pins can be coordinated with supporting umn at the same height (higher than balcony) or connecting one part of marker pin on .e top of supporting column.

any case, marker pin must be painted luminously (a yellow line of 4cm width, 18cm .eight at the body of marker pin at the side towards carriage way on drawing line according to "Regulation of Highway Signals"), the position of luminous paint is 30cm – 35 :n far from the top of column.

.2 Growing plants to show directions

We should grow the high plants with straight body, straight and long root at separating ine or in the area of 3.0m in item 5.11.1 so that driver can recognize direction from far distance (detailed design and verification by perspective photos required).

10.3 Signals panels on freeway / expressway

10.3.1. Design of signal panels must aim at these purpose:

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

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

he necessary information must be repeated by signal panels (on the column or on the octich) and drawing line, symbols and signs. This coordination must be identical.

3.2 The position, structure (material, size, font, color etc.) of signal panels, drawing s (horizontal, vertical, font, signs) must follow stipulations in "Regulations of way signage" and correlative with "Multi-lane road or traffic at high speed".

.3 In any cases, signal works must not encroach safe line including encroaching e, if signage is placed on road-crossing panes, the vertical overhead space limit must w item 4.7.

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

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

Preventing glaring by opposite headlight at night

10.4.1 If freeway / express way has large separating line (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 arrange on separating line of freeway / expressway, or growing herbs, placing light-stopping wall of 1.50m. Herb should have leaves all the year round, each herb is from 2.6m – 3.0m.

10.5 Light must be placed at the following section:
- Where there is toll gate.
- In tunnel

Besides, there should be light at:

- The area of intersection on freeway / expressway.
- The section vehicle just going out from freeway and seeing one light section (such as industrial zone, airport).
- On the right of technical service center.
- At the important signal panels.

10.5.2 Light index is measured by the average light on freeway, expressway 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 lightest 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 lamp should be put on the column of 12m – 15m height 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 column 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 meter to hundreds of meters far from freeway / expressway.

- Every 50km – 60km there should be a technical service center (capable of supplying petroi, repairing) and facilities such as restaurant, toilet, 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 real parking lot.

10.6.2 Coordination with the cities along freeway / expressway in building the service works

The out/in-coming section to parking station or service works requires speed-increasing/decreasing lane with the elements as stipulated in item 7.15.

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

- Parking lot for a while: for 1 – 3 units of vehicle with a relaxing hut and tourist map.
- Parking lot for long time: many vehicles with restaurant and post office etc.

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.

The spare post office should be put along freeway / expressway with the distance of 2 – 5km and at two ends of big works (bridge, tunnel). They are located on the grass-growing pavement, behind balconies or protective walls and symmetrically each other at two sides. One post office must not be located in the area of separating line.

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.
- Travelling of residents 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 measures of protecting and improving landscaping must follow stipulations in item 6.14.1.

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 / expressway (the lower vehicles run, the more dust and sewer emit), therefore computation of traffic capacity must be considered (item 4.6), it is necessary to consider design sub-lane of going up-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 of 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 55dB/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:

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

Of which

- L_0 is the noise index, measured by dB
- N is the traffic in one hour, measured by unit/hour.

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

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

Of which

- L_0 is the noise index at the edge of freeway / expressway base, measured dB.
- R_o 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 index for the residential area R_n, measured by meter.

10.7.5 If the housing area is too near freeway / expressway the anti-noise measures can be applied:

- Building the sound-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.

To ensure travelling of local residents, since feasibility study stage the favorable and economic system of gathering road, viaduct must be considered. Besides, designer must pay attention to plan, constructive management around 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.) for public use (see item 7.10.1).

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 construction of maintenance and service works for freeway / expressway must be in design of project and follow the regulations of Vietnam Highway Department.