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MINISTRY OF TRANSPORT
VIETNAM RAILWAY ADMINISTRATION
THE SOCIALIST REPUBLIC OF VIETNAM

THE STUDY ON BUILDING THE NATIONAL TECHNICAL REGULATION AND STANDARD SET FOR RAILWAY

FINAL REPORT

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Chapter 1 General Provisions

Article 2: Definitions （Terminological Description）

1. The terminological meaning showed the term used for a general railway.
   Terms in each field are explained in the detailed explanation of each field.
2. The meanings of terms relating to track are explained as the followings.

(1) “Curve incidental to turnout” means the curve in turnout and curves situated front or behind turnout.

(2)"Design speed" means the speed being defined in consideration of the future transportation system, and the train speed to be used as a design parameter to determine the curve radius, gradient and the width of formation level in a main line.

(3) "Derailment-coefficient" means the ratio of side force and vertical force generated between wheel and rail.

(4) "Estimated-derailment-coefficient" means the derailment coefficient determined by the calculation using parameter values of track and rolling stock.

(5) "Limit derailment coefficient" means the derailment coefficient theoretically computed from the geometry of wheel and the curve radius of track, when a wheel begins to lose touch with a rail.

(6) "Estimated-derailment-coefficient-ratio（Safety factor of derailment）" means the ratio of the limit derailment coefficient and the estimated derailment coefficient.

(7) “Design traction mass” means the traction mass being defined in consideration of the future transportation system, and the traction mass of a locomotive to be used as a design parameter to determine the gradient in a main line.

(8) “Equivalent appraisal gradient” means the steepest average gradient through a line section in the interval of train length.

(9) "Cant" means installing an outer rail higher than an inner rail to prevent turnover of vehicles toward outside by centrifugal force.

(10) “Slack” means expanding the distance between two rails in order to facilitate the running of rolling stock in a curve and a turnout.

(11) “Existing line” means the railway line currently under in-service condition (except for the section under suspended condition).

(12) “Elevated structure” means the structure such as a continuous bridge consist of concrete floor slab and a vertical retaining wall for an embankment, etc.

(13) “Design passing tonnage” means the passing tonnage being defined in consideration of a future transportation system, and an annual passing tonnage per track to be used as a design parameter to determine structures in a main line.

(14) “Long rail (continuous welded rail)” means the welded rail having total length of 200m or more.

(15) “Resistance to rail-creepage on a bridge” means the resistance force occurring between rail and rail fastening system when rail on a bridge tends to move in longitudinal direction.

(16) “Bridge without ballast floor” means the bridges without ballast bed which is consist of a track using fastenings directly fixed on steel girder and a track using bridge sleepers directly fixed on steel girder, except for a viaduct.

(17) “Buffer stop” means the equipment installed at the end of track in a main line, side line and storage line in order to prevent potential overrun of trains or vehicles.

(18) “Scotch block” means the equipment installed in side line to prevent potential rolling of cars under stopping condition.

(19) “Safety siding” means the side line provided to prevent potential accident such as collision due to overrun when two or more trains or cars run in or out simultaneously or run and occupy in a same line in a station.

(20) “Railroad comprehensive inspection” means the patrol and security check etc. for whole track in order to synthetically grasp the conditions of whole railroad structures such as embankment, cutting, bridges and track, and their maintenance conditions.

(21)“Individual inspection (regular period)” means the inspection carried out individually and periodically to check the track conditions such as a track irregularity and a train vibration, or deteriorating conditions and maintenance conditions of track materials.

(22) “Individual inspection (extraordinary)” means the inspection to be carried out when re-inspection will be necessary for the details of some items among the individual inspections (regular).

Chapter 3 Track

Article 14: Gauge

1. The gauge of ordinary railway shall be 1000 mm or 1435 mm to assure the running safety of vehicles by taking the vehicle structure including vehicle dimension such as width and conventional experience into account.

   The gauge of high speed railway shall be 1,435 mm.

   (1) The minimum distance between two rails is referred to as the gauge, which is defined by the spacing between the points of right and left rails guiding wheels where each wheel flange contacts.

   It is beneficial to standardize the gauge value in respect of forming a railway network and realizing through operation service.

   (2) In case of new device, the extent of a rail head contacts with a wheel flange is an upper zone from about 13mm below the rail head face.

   The measurement position of a gauge makes the minimum distance of two rails within 16mm below the rail head face in consideration of any wearing of rails and wheel flanges.

   In addition, the measurement points of gauge may be determined based on the wheel flange geometry to be used.

Article 15: Line Shape of the Track

1. The curve radius (except for a curve in turnout and the curves in front of and behind turnout (hereinafter referred to as “curve incidental to turnout”)) and the gradient in a main line shall be able to attain the design speed of the intended line section, in consideration of such as the performance of rolling stock, except for unavoidable case due to any reason including a topographical condition.

However, the gradient of a main line in a locomotive traction line shall allow the design traction mass in the intended line section to be pulled under the consideration of the factors such as locomotive performance.

2. The following formula which gives the relation between a train speed and a curve radius shall be used as foundations for the determination of an actual "curve radius", after sufficient examination about the suitable amount of maximum cant and cant deficiency, in consideration of the track structure in the intended line section, the situation of track preservation, the performance of the rolling stock, etc.

$$R = GV^2 / \{g \ (Cm + Cd)\}$$

Where,

R: Curve Radius (m)

G: Gauge or wheel support distance (m)

A wheel support point means a center of a rail.

V: Train speed (m/sec)

g: Acceleration of gravity (9.8 m/sec^2)

Cm: Setting cant (m)

Cd: Cant deficiency (m)

Article 16: Curve Radius

1. The curve radius of curves (except for curves along platforms) in a main line of ordinary railways usually shall be more than or equal to the values in the following table according to the classification of design speed.

Table 16-1

Line classification	Design speed (V), Others	Minimum curve radius (m)		
		Urban railway G1435 mm	National railway G1000 mm	National railway G1435 mm
1st class line	120km/h＜V≦150km/h			1200 m
	100 km/h＜V≦120km/h	800 m	800 m	
2nd class line	70km/h＜V≦120km/h			800 m
	60 ㎞/h＜V≦100 ㎞/h	400 m	600 m	
3rd class line	V≦70 ㎞/h			400 m
	V≦60 ㎞/h	300 m	300 m	
All class	unavoidable case due to a topographical condition or another	160 m	150 m	250 m
	A turnout curve and the curve in front or behind turnout (henceforth refers as a curve incidental to turnout)	160 m		

Note:

(1) Minimum curve radius of national railway are based on the railway technical grade (22TCN362-07, Decision of the Ministry of Transport, 34/2007/QD-BGTVT).

(2) The values for urban railway are based on the representative values in Japanese electric railway.

1.1 The curve radius which might not be troubled to a safe operation of rolling stocks in a main line shall comply with the following standards under the consideration of the factors including cant and running speed.

1.2. The curve radius in ordinary railway must be as follows.

(1) The curve radius in urban railway (except for curves incidental to turnout、the same for next sentence (2)) shall be 160m or larger. Moreover, the radius for curves incidental to turnout shall be 100m or larger.

(2) The curve radius in national railway shall be 150 m or larger for gauge 1000mm and 250 m or larger for gauge 1435mm.

1.3. The curve radius in high speed railway shall be 400 m or larger.

The curve radius of a curve incidental to turnout in a line used only for the operation of deadhead trains shall be 200 m or larger.

1.4. The curve radius (except for the curves along platforms) in a main line of special railways shall be 100 m or larger.

2. The curve radius of ordinary railways and special railways may be made into the curve radius commensurate with the performance of curvilinear passage of the rolling stocks concerned under the condition of performing a speed limit in a particular case regardless of the requirements of above clause 1.1 to 1.4.

3. The minimum curve radius of a curve along platforms in railways (except for a high speed railway) must be larger than or equal to the values specified in below table.

However, at the end of a platform and in a case that passengers are few, the requirement may not apply.

"End of platform" means the range within a length of one car in the stopping train from the end edge of the platform and "a case that users are few" means a situation where there is no passenger stairway or ticket barrier at the end of platform, and users may not queue up.

Table 16-2

	Urban railway G1435mm	Special railway	National railway G1000 mm		National railway G1435 mm		High speed railway G1435 mm
			Classes 1-2	Class 3	Classes 1-2	Class 3	
Minimum curve radius at the end of platform (m)	400 m		500 (400)	500 (300)	1000 (600)	800 (500)	1000 m
Section where only vehicles of the length less than 18 m run.	300 m						

Note:

(1) The values in parentheses show unavoidable cases due to any reason including a topographical condition.

(2) The Values of national railway are based on article 41 of gauge1000 mm in design norms and article 2.3.15 of gauge1435 mm in design standard.

(3) The values of urban railway and the values of high speed railway are based on Japanese railway technical standards.

3.1 Radius of a curve along platform

In a case that the curve radius along a platform is small, the distance between car body and platform at car doors must be 20 cm or shorter

The distance between car body and platform is calculated by Formula (16.1) （Figure 16-1）.

$R = L2 / (8d)$ -------------------------------(16.1)

Where,

R: Curve radius (m)

L: Length of car body (m)

d: Distance between car body and platform (m)

In order to assure the safety of passengers when getting on and off, the distance from platform has been set at 20 cm or shorter from the past.

Here, if the margin against any contact between car end and platform is assumed as 5 cm (7 cm), “d” in above formula is 20－5(7) = 15 cm (13 cm).

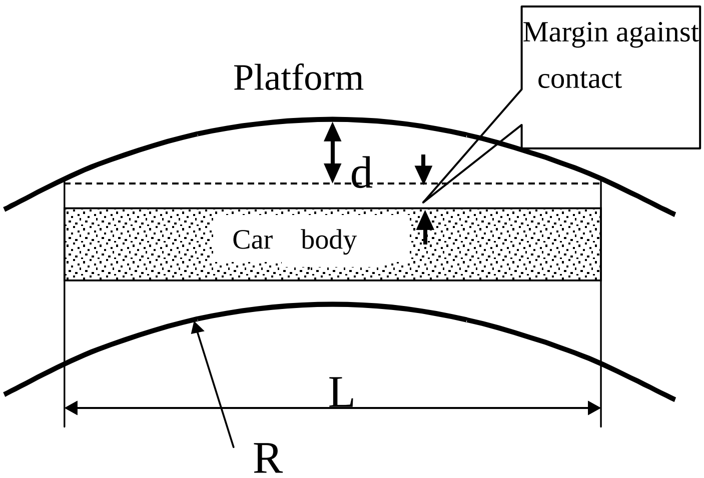


Figure 16-1 Relation between car and platform

Article 17: Cant (Super Elevation)

1. A cant shall be provided in the curve of a main line except for the case of a curve incidental to turnout. However, a cant may be provided correspond to its necessity in a side line.
2. A maximum cant and permissible cant deficiency for ordinary railways shall be smaller than or equal to the values specified in the table below.

However, when the height of center of gravity of a vehicle is lower considerably than 1900mm, or when the risk of overturning due to a wind is small considerably, and then an appropriate value corresponding to a line can be used, after the examination of safety has been done in consideration of the vehicle performance.	Urban railway G1435 mm	National railway G1000 mm	National railway G1435 mm
Maximum cant	180 mm	95 mm	150 mm
Permissible cant deficiency	90 mm	50 mm (1-2 class-line) 60 mm (3 class-line)	90 mm
Permissible cant deficiency when using car-body tilting/ inclination system	The value in consideration of the property of a car body tilting/ inclination system		

Note:

(1) The values of urban railways are applied to the line sections where only electric cars for passengers run.

(2) The maximum cant and permissible cant deficiency shall be set up as suitable for a line in consideration of the structure of rolling stock.

(3) The values for gauge 1000 mm of national railway are based on chapter 2 No. 11 of the explanation of Railway Technical Grade.

(4) While the values for gauge 1435mm of national railway are specified as125mm and 75mm in the explanation of Railway Technical Grade, the values of 150mm and 90mm are proposed in this specification.

3. The cant provided for a circular curve of railways should be an appropriate value under consideration of the centrifugal force which vehicles receive during running.
However, when the center of gravity of vehicle is high corresponding to a gauge, or when vehicles are lightweight, it must be verified the safety against overturning of vehicles due to wind effect under the condition of stopping of a vehicle, running at limited speed for a curve concerned.

3.1. The Cant for ordinary railways shall adopt the values acquired from the calculation of the below formula as a standard.
However, in a case of a curve incidental to turnout or like, and if it is confirmed that there is no risk of overturning of vehicles depend on measures such as limiting operation speed, this requirement may not apply.

$Co = GVo^2 / (127R)$

In this formula, Co, G, V and R represent the following values.

Co: Cant (unit: mm)

G: Gauge (unit: mm)

Vo: Average speed of trains running through the curve concerned (unit: km/h)

R: Radius (unit: m)

In this case, the cant shall be smaller than or equal to the value calculated by below formula.

$Cmax = G^2 / (6H)$

In this formula, Cmax, G and H represent the following values.

Cmax: Maximum cant (mm)

G: Gauge (unit: mm)

H: Height of center of gravity in car from rail face (unit: mm)

Here, if H = 1900 mm, G = 1435 mm are assumed, Cmax = 180 mm is obtained.

3.2. The cant for special railway must be as follows.

3.2.1. The rate of cant reduction for suspended railway, straddled type monorail and guided rail type railway shall adopt the value obtained by below formula as a standard. However, the value must be 12% or lower.

$i = V^2 / (1.27R)$

In this formula, i, V and R represent the following values.

i: Rate of cant reduction (unit: %)

V: Average speed of trains running through the curve (unit: km/h)

R: Curve radius (unit: m)

3.2.2. The cant angle for levitated transportation system shall adopt the value obtained by below formula as a standard, except for a case of a curve incidental to turnout. However, the value must be 8 degrees or smaller.

$\theta = \tan - 1 (V^2 / (127R))$

In this formula, θ, V and R represent the following values.

θ: Cant angle (unit: deg)

V: Design speed passing through a curve (unit: km/h)

R: Curve radius (unit: m)

4. The cant of ordinary railways shall be gradually diminished according to the following criteria.

4.1. In a case that a transition curve is provided, the cant shall be gradually diminished over its entire length.

4.2. In a case that no transition curves are provided (except for a case of connection with two curves of same direction), and then the following requirements shall apply.

(1) Gradual diminishing length for cant when using linear gradual diminishing:

If maximum wheel base of car is 2.5 m or shorter, the length shall be 300 times or longer of cant.

If maximum wheel base of car is longer than 2.5 m, the length shall be 400 times or longer of cant.

(2) Steepest gradient of cant when using curve gradual diminishing:

If maximum wheel base of car is 2.5 m or shorter, the gradient shall be 1/300.

If maximum wheel base of car is longer than 2.5 m, the gradient shall be 1/400.

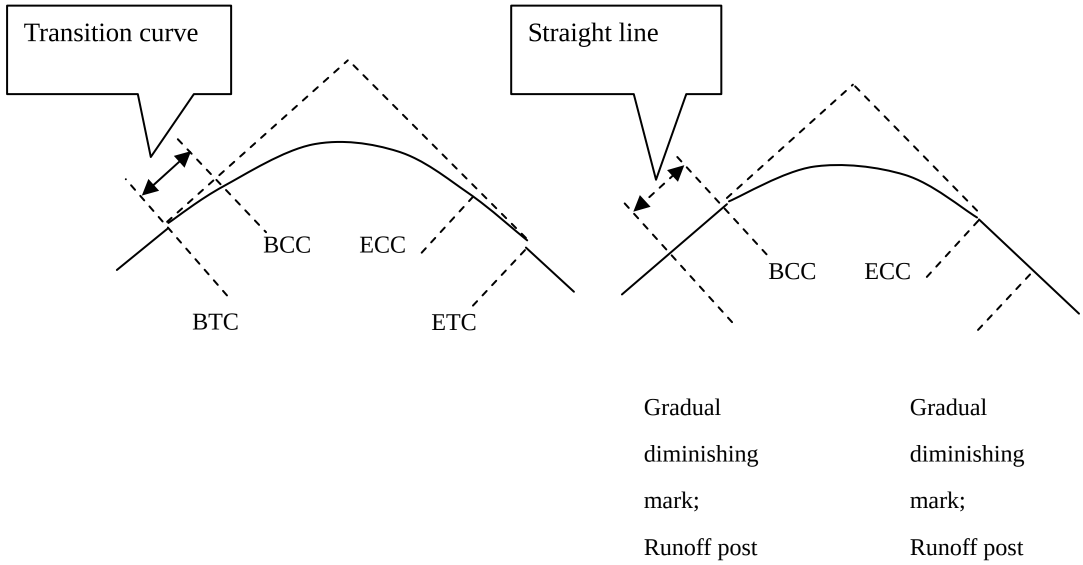


Figure 17-1 Distance of cant gradual diminishing

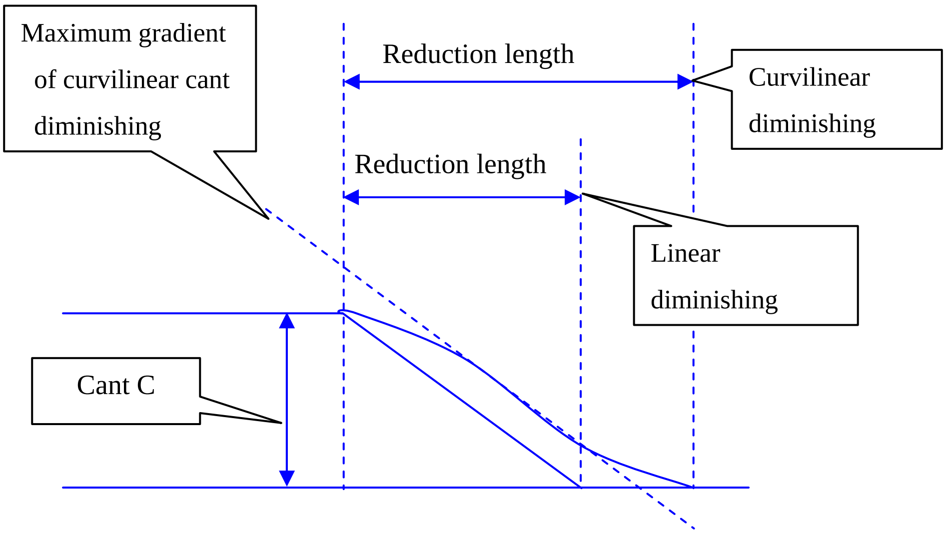


Figure 17-2 Concept of cant gradual diminishing

4.3. In a case that two curves of the same direction connect with each other and no transition curve is provided, the difference of cant values of two circular curves shall be gradually diminished in a circular curve of large radius through the length longer than or equal to 400 times of the difference value. In this case, when the gradual diminishing of cant is carried out by a curve diminishing type, the steepest gradient of cant transition shall be 1/400 or smaller.

4.4. In a case that two curves of opposite direction connect with each other, the cant shall be gradually diminished as next figure.

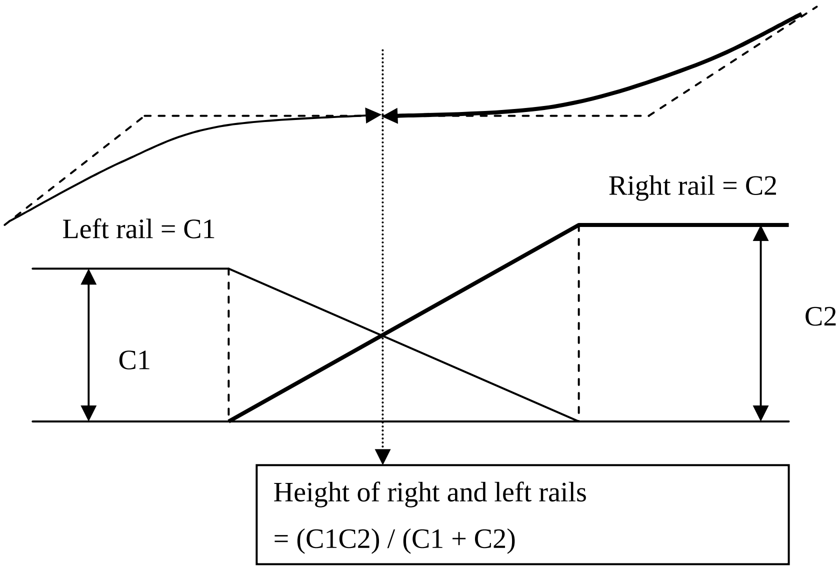


Figure 17-3 Connection of two curves of opposite direction and cant gradual diminishing

Article 18: Slack (Increasing of the distance between two rails)

1. The slack of ordinary railways must be as follows by taking the parameters including the curve radius, the wheel base and the number of axles of car running through the curve into account.

1.1. The slack must be smaller than or equal to the value obtained by below formula.

(1) For the section where solely two-axle/ four wheeled cars run:

$$S_{max} = 1000 (B^2 / (2R)) - \eta$$

(2) For the section other than above (1):

$$S_{max} = 1000 (9B^2 / (32R)) - \eta$$

In this formula, Smax, B, R and η represent the following values.

Smax: Upper value of slack (unit: mm)

B: Maximum wheel base of a car running through the curve (unit: m)

R: Curve radius (unit: m)

η: movable margin value (unit: mm)

"η" in general track may be used either the value of 7 mm or 9 mm.

(3) Regardless of the requirements of (1) and (2), maximum slack must be as below table.

Slack (mm)	Urban railway G1435 mm	National railway G1000 mm	National railway G1435 mm
Maximum (main line, side line)	15 mm	20 mm	15 mm
Unavoidable case	25 mm		

1.2. Slack shall be gradually diminished according to the following criteria.

(1) In a case that transition curve is provided, gradual diminishing shall be carried out over its entire length.

(2) In a case that no transition curve is provided, slack shall be gradually diminished in the section of the length longer than or equal to the maximum wheel base of a car running through the curve from the end of circular curve. However, in a case of a curve in turnout, the requirement may not apply.

Article 19: Transition curve

1. The length of transition curve in ordinary railways shall be longer than or equal to the largest one among the values calculated by the below table corresponded to the classification of design speed.
However, in the section where operating full speed is lower than or equal to 70 km/h, L2 and L3 could be apply the value in parenthesis of the lower line.

Length of transition curve \ Maximum train speed		150 km/h ≥V_{max} ＞ 110 km/h	110 km/h ≥ V_{max} ＞ 90 ㎞/h	90 km/h ≥ V_{max} ＞ 70 ㎞/h	70 ㎞/h ≥ V_{max}
L1	wheel base is 2.5m or less	300C			
	wheel base is more than2.5m	400C			
L2		10CKV	10CKV	8CKV	8CKV (7CKV)
L3		9CdKV	9CdKV	9CdKV	9CdKV (7CdKV)

Note:

(1) L1, L2, L3 means a transition curve length (mm) -- C shows an actual cant (mm), Cd shows a cant deficiency (mm), and V shows the highest train speed in the curve (km/h).

(2) K is 1.07 for 1000mm gauge and 0.75 for 1435 mm gauge.

(3) The value in parenthesis shows an unavoidable case due to any reason including a topographical condition.

2. The length of transition curve in an unavoidable case due to a topographical condition shall comply with the following criteria according to the parameters including wheel base of a car running through the transition curve.

2.1 The length of transition curve must be as follows and be determined by taking the operation speed of train into account. However, in a case of a curve incidental to turnout, a circular curve with small cant, etc., and when it is confirmed that the running safety of a car can be assured by limiting the operation speed, this requirement may not apply.

2.1.1 The length of transition curve for ordinary railways shall be longer than or equal to the value obtained by below formulas.

(1) For the section that maximum wheel base of a car running through the curve is longer than 2.5 m:

$$L = 400C$$

(2) For the section that maximum wheel base of a car running through the curve is shorter than or equal

to 2.5 m:

$L = 300C$

In these formulas, L and C represent the following values.

L: Length of transition curve (unit: mm)

C: Actual cant

(When inserting a transition curve between two circular curves, it is the difference between respective actual cants. Unit: mm)

In this case, if the gradual diminishing is provided by a curve gradual diminishing, the gradual diminishing curve shall be such shape that the steepest gradient of a cant is 1/400 for a section where maximum wheel base of a car running through the curve is longer than 2.5 m, and that the steepest gradient of a cant is 1/300 for other section.

2.1.2. The length of transition curve for high speed railway shall be longer than or equal to the value obtained by below formulas.

(1) For the section that maximum speed of a train running through the curve is lower than 200 km/h.

$L = 300C$

(2) For the section that maximum speed of a train running through the curve is higher than or equal to 200 km/h.

$L = 450C$

In these formulas, L and C represent the following values.

L: Length of transition curve (unit: mm)

C: Actual cant (When inserting a transition curve between two circular curves, it is the difference between respective actual cants. Unit: mm)

2.1.3. Regardless of the requirements of above 2.1.2 and 2.1.2, only for the transition curve in exit side of a curve in ordinary railway, in a case that there is no risk of a derailment or where the L shape derailment preventive guard or another type guard are installed in the transition curve, the length of transition curve may be based on the performance of curvilinear passage of the car.

The examination about the risk of a derailment could be done by the formula of the estimated derailment coefficient ratio shown below or other empirical formula.

Estimated derailment coefficient ratio(safety factor) = a limit derailment coefficient/ estimated derailment coefficient

2.1.4. The length of transition curve for suspended type monorail must be longer than or equal to the value obtained by below formula.

$L = V^3 / (28R)$

2.1.5. The length of transition curve for straddled type monorail and guide rail type railway must be longer than or equal to the value obtained by below formulas.

$L = V^3 / (14R)$

In an unavoidable case due to any reason including a topographical condition, using next formula.

$L = V^3 / (17R)$

In these formulas, L, V and R represent the following values.

L: Length of transition curve (unit: m)

V: Maximum speed of a train running through the curve (unit: km/h)

R: Radius (unit: m)

3. The shape of a transition curve must be any one of a cubic parabola, half sin wave shape transition curve, or clothoid curve.

Article 20: Gradient

1. The steepest gradient in running area and stopping area of train (including area where cars are stored or coupled/decoupled) shall be determined under the consideration of the factors including the performance of power unit, braking device and the running speed of car.

1.1 The steepest gradient in a running area of train for ordinary railways must be lower or equivalent values in below table.

Line classification	Design speed (V)	Maximum gradient (‰)		
		Urban railway G1435mm	National railway G1000mm	National railway G1435mm
1st class	120km/h＜V≤150 km/h			12 (18)
	100 km/h＜V≤120km/h	10 (35)	12 (18)	
2nd class	70km/h＜V≤120km/h			18 (25)
	60 km/h＜V≤100 km/h	20 (35)	18 (25)	
3rd class	V≤70 km/h			25 (30)
	V≤60 km/h	35	25 (30)	

Note:

(a) The value in parenthesis shows an unavoidable case due to any reason including a topographical condition.

(b) Steepest gradients of national railway are based on the railway technical grade (22TCN362-07, Decision of the Ministry of Transport, 34/2007/QD-BGTVT)

(c) The values of steepest gradient for urban railway refer to Japanese Regulations.

1.2 In a line where train pulled by locomotive is operated (limited to a section where freight car is operated), it is 25/1000 (including a case that equivalent assessed gradient is determined as 25/1000).

1.3 In a line other than the case of above 1.2, it is 35/1000.

1.4 Regardless of the requirements of preceding clauses 1.1、1.2 and 1.3, in a line where only train of linear induction motor type is operated, it is 60/1000.

1.5 The steepest gradient for a turnout in ordinary railways shall be 25/1000 or less.

1.6 The steepest gradient in a running section of freight trains shall be the value allowing freight trains to be operated.

1.7 The steepest gradient in a running section where train pulled by locomotive is operated shall be the value allowing such the train pulled by locomotive to be operated.

1.8 The steepest gradient must be as the below table as standard according to the classification of the design traction mass of locomotive.

Design traction mass	Maximum gradient
Traction mass greater than or equal to 1200 t.	15/1000
Traction mass greater than or equal to 1000 t and less than 1200 t.	20/1000
Traction mass less than 1000 t.	25/1000

1.9 In a case that there is an unavoidable reason due to a topographical condition not allowing the requirements of above clause 1.1 to 1.5 to be complied with, or in a side line (limited to a line where cars are not stored or not coupled/decoupled), the steepest gradient shall be determined under the consideration of the running capability of train in a gradient, the rescue method for failed train and the running capability of maintenance car in a gradient.

1.10 Steepest gradient for ordinary railways in an area where train stops shall be as below table.

Area where train stops.	Steepest gradient (‰)		
	Urban railway G1435mm	National railway G1000mm	National railway G1435mm
Station premises	5	1.5	1.5
Unavoidable case in station premises		2.5	2.5
Area where cars are not stored or not coupled/decoupled.	10	6	6

(Note) Area where cars are not stored or not coupled/decoupled is limited to the case that there will be no trouble for the arrival/departure of train.

2. Standard steepest gradient for high speed railway must be as follows.

2.1. Steepest gradient in a running area of train must be as follows.

2.1.1. It is 25/1000.

2.1.2. In a section where it may be difficult to obey above requirement because of the reason due to any reason including a topographical condition, steepest gradient may be 35/1000 under the consideration of the performance of power unit, power transmission device, running device and braking device of train.

2.2. Steepest gradient in an area where train stops shall be 3/1000.

3. Steepest gradient for suspended type monorail, straddled type monorail and guide rail type railway must be as follows.

3.1. Steepest gradient in a running area of train shall be 60/1000. However, in a case that there is a proper reason including an unavoidable case due to any reason including a topographical condition, this requirement may not apply.

3.2. Steepest gradient in an area where train stops shall be 5/1000. However, in an area where cars are not stored or not coupled/decoupled, steepest gradient may be 10/1000 only in the case that there will be no trouble for the arrival/departure of train.

Article 21: Vertical curve

1. Vertical curve radius must be larger than or equal to the values specified in below table. However, in a case that it has been verified that the running safety of cars will be assured depending on the parameters such as the design speed and the length of car, these requirements may not apply.

Horizontal curve radius (m)	Vertical curve radius (m)		
	Urban railway G1435 mm	National railway G1000 mm	National railway G1435 mm
Including straight line R > 800 m	3000 m (2000 m)	5000 m (3000 m)	Class 1 line: 10000 m Class 2 line: 10000 m Class 3 line: 5000 m (3000 m)
800 m ≥ R > 600 m	4000 m (2000 m)		
R ≤ 600 m	4000 m (3000 m)		
Gradient change not requiring to insert a vertical curve (Δi)	Less than 10 ‰	4 ‰ or below	3 ‰ or lower

Note:

(1) The values in parentheses show unavoidable cases due to any reason including a topographical condition.

(2) The value "3000m" in national railway is applied correspondingly from Japanese specification.

1.1. For urban railway, the vertical curve radius shall be larger than or equal to 2,000 m (3,000 m at the curve location where the radius is shorter than or equal to 600m). However, the vertical curve may not be inserted at a location where the change of gradient is less than 10/1000.

1.2. For high speed railway, the vertical curve radius shall be larger than or equal to 10,000 m (5,000 m at the location where train is operated at the speed lower than or equal to 250 km/h).

1.3. For straddled type monorail, suspended type monorail and guide rail type railway, the vertical curve radius shall be 1,000 m. However, the vertical curve may not be inserted at a location where the change of gradient is less than 10/1000.

1.4. For levitated transportation system, the vertical curve radius shall be 1,500 m. However, the vertical curve may not be inserted at a location where the change of gradient is less than 10/1000.

2. Whenever feasible, it should be avoid any conflict between vertical curve and transition curve in railways.

Article 24: Distance between centers of track

Distance between centers of tracks must not endanger the train operation, the safety of passengers and person in charge, and shall comply with the following requirements.

1. Distance between centers of tracks for ordinary railway (except for high speed railway) and special railway must be as follows.

1.1. Distance between centers of tracks in a straight section of a main line (limited to one where train speed is lower than or equal to 160 km/h) shall be larger than or equal to the value obtained by adding 600 mm to the maximum width of the basic limit of rolling stock gauge.

However, for the section where only the cars having the structure not allowing passenger to extrude own body from window run, the distance shall be larger than or equal to the value obtained by adding 400 mm to the maximum width of the basic limit of rolling stock gauge.

1.2. In a case that the refuge space is necessary between tracks, it must be enlarged the distance between centers of tracks specified in above 1.1 by additional space of 700 mm or more.

Table 24-1 Minimum values of the distance between centers of tracks in ordinary railways

	Distance between centers of tracks (m)			
	Urban railway G1435 mm	National railway G1000 mm		National railway G1435 mm
		Classes 1 and 2	Class 3	Classes 1, 2 and 3
One of spaces where 3 or more tracks have been constructed.	B + 1.5 m (B + 1.0 m)			
Main line (ordinary section including a station)	B + 0.6 m	4.0 m	3.8 m	4.2 m
Section where only the cars of which structure not allow passenger to extrude own body from window are operated.	B + 0.4 m			
Yard-work zone inside a station	B + 1.0 m	4.4 m		5.0 m
Section without yard-work inside a station	B + 0.8 m			
Side track or storage track	B + 0.4 m			

Note:

(1) “B” indicates the maximum width of rolling stock gauge (basic limit except an indicator, an indicating lamp, and a car side lamp).
When “B” is assumed 3.0m in an urban railway, it is result as B+0.6m=3.6m.

(2) The values in parentheses show unavoidable cases due to a topographical condition or another.

(3) The values for 1000 mm gauge in national railway are based on the design norms for 1 m gauge in the railway technical grade, Article 7.5.1

(4) While the values for 1435 mm gauge in national railway are specified as 4.0 m in Article 5.5.1 of the railway technical grade, and specified as 5.0 m for 1435 mm Gauge in the design standard 8.4.1, in this case it was specified that 3.6 m of rolling stock gauge + 0.6 m = 4.2 m.

1.3. The distance between centers of tracks in a curve shall be determined by adding the value obtained from below formula based on the car-body displacement to the distance between centers of tracks specified in the requirements of above clause 1.1 or 1.2.

However, if such the value is sufficiently smaller than the spacing between the structure gauge and the basic limit of rolling stock gauge, the enlargement based on car-body displacement can be omitted.

The calculation formulas for car-body displacement in curve shall be the same as the formulas to calculate the enlargement based on the structure gauge and car-body displacement in curve specified in Article 22, clause 3 of the explanatory material for the technical regulation.

W = A + W1 + W2

In this formula, W, A, W1 and W2 represent the following values.

W: Enlargement dimension

A: Car-body displacement based on cant difference

W1: Car-body displacement based on curve in the line

W2: Car-body displacement based on curve in the adjacent line

$$W_1 = R - \sqrt{\{(R-d)^2 - (L_1/2)^2\}}$$

$$d = R - \sqrt{\{R^2 - (L_0/2)^2\}}$$

L0: Rigid wheel base (mm)

L1: Distance between the bogie centers (mm)

$$W_2 = \sqrt{\{(R + B/2 - W_1)^2 + (L_2/2)^2\}} - R - B/2$$

L: Car-body length (mm)

B: Car-body width (mm)

R: Curve Radius (mm)

2. The distance between centers of tracks in high speed railway must be as follows.

2.1. The distance between centers of tracks in the straight section in main line of high speed railway (limited to the line where train speed is 300 km/h or lower) shall be larger than or equal to the length determined by adding 800 mm (600 mm at the location where train is operated at the speed lower than or equal to 160 km/h) to the maximum width of the basic limit of rolling stock gauge. The distance shall be further enlarged if required for implementing work.

The distance between centers of tracks in a curve shall be determined by adding the enlargement value obtained from the formula of preceding clause 1.3 based on the car-body displacement to the distance between centers of tracks specified in straight line.

However, if the curve radius is larger than or equal to 2,500 m, the enlargement based on car-body displacement can be omitted.

Table 24-2 Minimum values of the distance between centers of tracks in high speed railway

Speed in the line section；（Ｖ)	Distance between centers of tracks (m)	
	Outside of a station	Inside of a station
300km/h<Ｖ<=350km/h	5.0m	
210 km/h<Ｖ<=300km/h	4.3m Ｂ＋0.9m	
160km/h<Ｖ<=210km/h	4.2m Ｂ＋0.8m	
Ｖ<=160 ㎞/h	4.0m Ｂ＋0.6m	
Side track	4.0m Ｂ＋0.6m	
Section for yard work in a station		4.6m
Section without a yard work		4.3m
Storage track		4.3m

Note:

(1) “B” indicates the maximum width of rolling stock gauge.

(2) Values for the cases of 350 km/h or lower are based on Article 5.5.1 of the railway technical grades.

(3) Values for the cases of 300 km/h or lower are based on Japanese technical standards.

(4) The length of 4.0 m as the distance between centers of tracks is based on the standard values for ordinary railway in Japanese technical standards.

Article 25: Track

The track of ordinary railway must have the track structure specified in the following standards to assure the safety of running vehicles and the railway operator must consider the installation conditions of turnouts and guard rails as follows.

1. The structure of track of ordinary railway (including turnouts) must be reviewed for the following items to secure its safety.

1.1. Review for the stress in the structural members and the deformation of track panel.

The fatigue and fracture strength of structural members must be reviewed from the viewpoint of running safety by evaluating the stress in each structural members of track caused by significantly large load and repeated load due to the running of trains, in the process take the factors such as track structure conditions, the conditions of vehicles and their operation, and track conditions, as well as the design speed and the design load into account.

In addition, for the concern of significant displacement in lateral direction, the safety against plastic deformation must be reviewed by assessing the lateral sleeper pressure due to significantly large load and the ballast resistance provided by sleepers under the consideration of any difference from track structure and load conditions.

1.2. Review for long-term stability of track

For the increase in vertical and lateral displacement due to repetitive passage of trains, the increase in the vertical and lateral displacement must be estimated based on the track structure and load conditions caused by trains. Then, such the estimated values must be compared with the allowable increase in vertical and lateral displacement determined from the factors including the conditions of trains and their operation, the conditions for implementing maintenance activities, and the maintenance level required for running safety.

1.3. Review for buckling stability of track

The buckling stability of track must be reviewed against the increase in the axial force of rails due to temperature rise.

2. The structure of track for special railway must be as follows.

2.1. The track beams and runway for special railway must be able to withstand significantly large load and cyclic load due to the running of trains with sufficient margin.

2.2. The expansion joint must be installed for the junction between track beams for special railway.

3. The railway turnout must be compatible with the structure of running device of vehicles, must have the linearity and structure allowing vehicles to be smoothly guided and passed into reference side or turnout side, and must be so constructed that the stress occurring in its structural members when vehicles pass is less than or equal to the allowable stress intensity for the materials.

When installing turnout, the turnout must comply with the following standards.

3.1. The turnout shall not be installed in transition curve and vertical curve. However, in a case that a transition curve is gradually diminished with a curve, if operation speed is low and the curvature of transition curve and cant do not significantly change in the section; the railway operator may install a part of turnout.

3.2. The turnout shall not be installed in a bridge without ballast floor (bridge sleeper track). However, in an unavoidable case because of any reason such as topography and that the required measures have been taken to assure the safe operation of trains, this requirement may not apply.

3.3 The turnout shall not be installed in a section behind an abutment. However, in an unavoidable case because of any reason such as topography and that the required measures to reinforce roadbed have been taken, this requirement may not apply.

4. The guardrails installation in a main line of ordinary railway shall be as follows.

4.1. For the section with large lateral rail force and other location with any potential of derailment, derailment preventive guard rail or L shape guard must be installed.

The safety rail shall be installed for a location where the installation of guard rail or L shape guard may be inappropriate such as a location with frequent rock-fall events (hereinafter, referred to as “location with rock-fall, etc.”)).

For examination of the location with large lateral rail force, the formula of the estimated derailment coefficient ratio shown below or other empirical equation may be used.

Estimated derailment coefficient ratio (Safety factor of flange climbing)

= limit derailment coefficient / estimated derailment coefficient

4.2. For bridges without ballast floor (bridge sleeper track), derailment preventive guard rails, L shape guards or inner bridge guardrails (inner bridge guardrails for location with rock-fall, etc.) must be installed.

4.3. For high embankment, derailment preventive guard rails, L shape guards or safety rails (safety rails for location with rock-fall, etc.) must be installed.

4.4. For all level crossings, crossing guard rails must be installed.

Table: Installation range of guardrails, etc. (Explanation of 4.1, 4.2 and 4.3 of above clause 4

	Structure	Installation range
Over river	Bridge that bridge sleepers are directly fixed on steel beams (bridge without ballast floor).	1) Steel bridge girder section including straight section. 2) A section with large lateral force in a transition curve of radius less than or equal to 400 m in the side where train runs out.
Other than river	Viaduct, concrete bridge, steel bridge (except for bridge without ballast floor). Tunnel. Cutting, embankment.	1) A section of radius less than or equal to 150 m (including transition curve). 2) A section with large lateral force in a curve of radius less than or equal to 400 m and in a transition curve in the side where train runs out.
Hazardous location	・ A section with potentially significant consequence if derailment occurs. ・ A section with hazardous substances, etc. in its wayside.	・A section with large lateral force in a curve of radius less than or equal to 400 m and its transition curve.

Note:

(1) Guardrails, etc. refer to derailment preventive guard rails, L shape guards, safety rails or inner-bridge guardrails.

(2) A section with large lateral force (a section of estimated derailment coefficient ratio (safety factor of flange climbing) less than 1.2) corresponds to the section of radius less than or equal to 300 m. Therefore, in a case that the calculation of estimated derailment coefficient ratio (safety factor of flange climbing) is omitted, it was specified that the radius is less than or equal to 400 m by adding some safety margin.

(3) The areas of installation such as a preventive guard may remove the next line sections.

(a) The line section which has a curve radius exceeds 150m and below 400m and does not have fear of a derailment by the formula of a derailment coefficient ratio, or other empirical equations.

(b) The part where it is difficult to install the guard on a turnout curve etc.

5. Ground facilities for the railway of linear induction motor type must comply with the following standards.

5.1. Primary side device and secondary side device (reaction plate) of linear induction motor must maintain a distance required for safe operation.

5.2. Reaction plate must have sufficiently safe structure against the factors including attraction force and must be fixed with specified force.

5.3. Ground facilities must be able to form the electric and magnetic circuits, which can produce stable driving power by electromagnetic interaction between on-vehicle equipment of the power plant and them.

5.4. The driving power of above 5.3 shall be sufficiently large commensurate with the conditions such as the weight of vehicle.

6. The structure of the track for ordinary railway (limited to the cases of design maximum speed lower than or equal to 130 km/h) requires the safety review for each review item specified in this article clause 1. But, in a case that axle load is less than or equal to 16 t, the items greater than or equal to the values shown in below table can be regarded as that these reviews have been completed.

Standard ballast depth is 200 – 250 mm. Below table shows the lower limit values.

Design maximum speed, V	Rail weight, number of sleepers and ballast depth	Design passing tonnage											
		Over 20 million t / yr			Over 10 million t /yr to 20 million t / yr inclusive			Over 5 million t / yr to 10 million t / yr inclusive			5 million t / yr or less		
110 km/h < V ≤ 130 km/h.	Rail weight	50	60	50	50	60	50	50	60	50	50	60	50
	Number of sleepers	39	39	42	37	37	40	37	37	40	37	37	40
	Ballast depth	250	200	200	200	150	150	200	150	150	200	150	150
90 km/h < V ≤ 110 km/h.	Rail weight	50	60	50	50	60	50	37	40	37	37	40	37
	Number of sleepers	39	39	42	37	37	40	37	37	40	37	37	40
	Ballast depth	200	150	150	200	150	150	200	150	150	200	150	150
70 km/h < V ≤ 90 km/h.	Rail weight	50	60	50	50	60	50	37	40	37	30	37	30
	Number of sleepers	39	39	42	37	37	40	37	37	39	34	34	36
	Ballast depth	200	150	150	200	150	150	150	120	120	150	120	120
V ≤ 70 km/h.	Rail weight	50	60	50	50	60	50	37	40	37	30	37	30
	Number of sleepers	39	39	42	37	37	40	37	37	39	34	34	36
	Ballast depth	200	150	150	200	150	150	120	100	100	120	100	100

Note:

(1) Unit

Rail weight: kg; ballast depth: mm; number of sleepers: sleepers / 25 m.

(2) In a case using a continuous welded rail, the number of sleepers can be applied such value reduced 1 from each value in this table.

(3) In a case of paved track, among above requirements, the number of sleepers may be reduced from the values in this table.

(4) Roadbed in a section of embankment and cutting must have the roadbed thickness allowing

the stability of formation level to be assured and must use the roadbed materials, which can provide sufficient strength.

(5) The thickness of ballast shows the case where a road bed is a soil roadbed.

The ballast depth in this table can be reduced, when a rail weight or sleeper numbers is increased proportionally from above requirements, and when the roadbed is what has a bearing capacity as a concrete slab or more than equivalent material.

7. In a case that axle load is less than or equal to 16 t, the standard track structure with ballast track in ordinary railway may be determined as follows.

Design maximum speed V	Rail weight, number of sleepers and ballast depth	Design passing tonnage			
		Over 20 million t / yr	Over 10 million t /yr to 20 million t / yr inclusive	Over 5 million t / yr to 10 million t / yr inclusive	5 million t / yr or less
110 km/h < V ≤ 130 km/h.	Rail weight	50	50	50	50
	Number of sleepers	39	37	37	37
	Ballast depth	300	250	250	250
90 km/h < V ≤ 110 km/h.	Rail weight	50	50	43	43
	Number of sleepers	39	37	37	37
	Ballast depth	250	250	250	250
70 km/h < V ≤ 90 km/h.	Rail weight	50	50	43	43
	Number of sleepers	39	37	37	34
	Ballast depth	250	250	200	200
70 km/h or lower	Rail weight	50	50	43	43
	Number of sleepers	39	37	37	34
	Ballast depth	250	250	200	200

Note:

(1) Unit

Rail weight: kg; ballast depth: mm; number of sleepers: sleepers / 25 m.

(2) In a case using a continuous welded rail, the number of sleepers can be applied such value reduced 1 from each value in this table.

(3) The thickness of ballast shows the case where a road bed is a soil roadbed.

The ballast depth in this table can be reduced, when a rail weight or sleeper numbers is increased proportionally from above requirements, and when the roadbed is what has a bearing capacity as a concrete slab or more than equivalent material.

8. Track structure of high speed railway can be determined by referring to the following examples.

Design maximum speed	Rail weight, number of sleepers and ballast depth	High speed railway (an example that axle load is 17 t). Tokaido Shinkansen, Sanyo Shinkansen and Tohoku Shinkansen
300 km/h or lower	Rail weight (kg)	60
	Number of sleepers	43
	Ballast depth in earthwork section (mm)	300
	Ballast depth in tunnel section (mm)	250
	Ballast depth in viaduct and structures section (mm) Ballast mat (mm)	200 25

9. The verification that the stress occurring in the structural members of turnout is lower than the allowable stress intensity in Clause 3 of this Article will be carried out only for the turnout newly designed from now on.

Article 26: Roadbed and earth structure

For the sub grade and roadbed, the applicable items corresponds in the following list must be appropriately examined so as to ensure a safety.

Item group 1 to be examined for roadbed
(1) Survey for the ground supporting embankment: standard penetration test, boring, soil quality, flat plate loading test. (2) Assessment of the ground supporting embankment: stability assessment, subsidence assessment. (3) Materials for embankment: For general work: earth and sand complying with standards, high-quality in-situ earth and sand. For rapid work: crashed stones (macadam), crashed stones having adjusted grain size, styrene foam, coal ash, foaming mortar. (4) Compacting control: layer thickness control during compaction, reinforcing soil, stabilization treatment work, etc. (5) Embankment on weak ground: stabilization treatment work, measure against subsidence of embankment, improvement work for weak ground. (6) Water drainage work for embankment: vertical sewerage, water drainage blanket, water drainage layer (sand layer). (Figures 26-1, 26-2, 26-3 and 26-4) (7) Slope protection work of embankment: planting work, reinforcement work for slope face. (8) Roadbed and sub grade: soil roadbed, reinforced roadbed (macadam roadbed, slag roadbed). Roadbed materials: crashed stones (macadam), crashed stones having adjusted grain size, styrene foam, coal ash, and foaming mortar. (9) Roadbed by cutting, raw surface, and embankment: in-situ roadbed, improvement range for roadbed. (10) Reinforced embankment: Terre Armee method, reinforcing earthwork using geo-textile.

Item group 2 to be examined for roadbed
(1) For road floor, in-situ bed will be utilized, replaced, or improved (Figures 26-1 and 26-2). (2) The thickness of roadbed supporting a track shall be 30 cm as a standard (Figure 26-2). (3) In a case that groundwater or a layer with water permeability may be present, the railway operator must consider the water drainage layer or water drainage blanket (Figures 26-1, 26-2, 26-3 and 26-4) . (4) The railway operator must investigate any effects of groundwater leading to decrease in the strength of road floor and roadbed and must take appropriate measure against them. (5) For a location with spring water, the railway operator must assure excellent water drainage (Figures 26-1 and 26-2) . (6) For a location with any potential of mud pumping due to viscous soil, the railway operator must use water drainage blanket (Figures 26-1, 26-2, 26-3 and 26-4) . (7) For a location where embankment may block surface water drainage, the railway operator must install a transverse water drainage facility to prevent any weakening of the lower part of embankment (Figure 26-5) . (8) In a case that topography will tend to collect precipitation from mountain side through cutting, the railway operator must assure excellent water drainage from road floor (Figure 26-5). (9) For a topography being vulnerable to a disaster by precipitation, the railway operator must implement a special reinforcement for it.

Location where roadbed transverse water drainage method will be required.

(1) Location where mud pumping occurs.

(2) Passage route of ground water.

(3) Location with flooding.

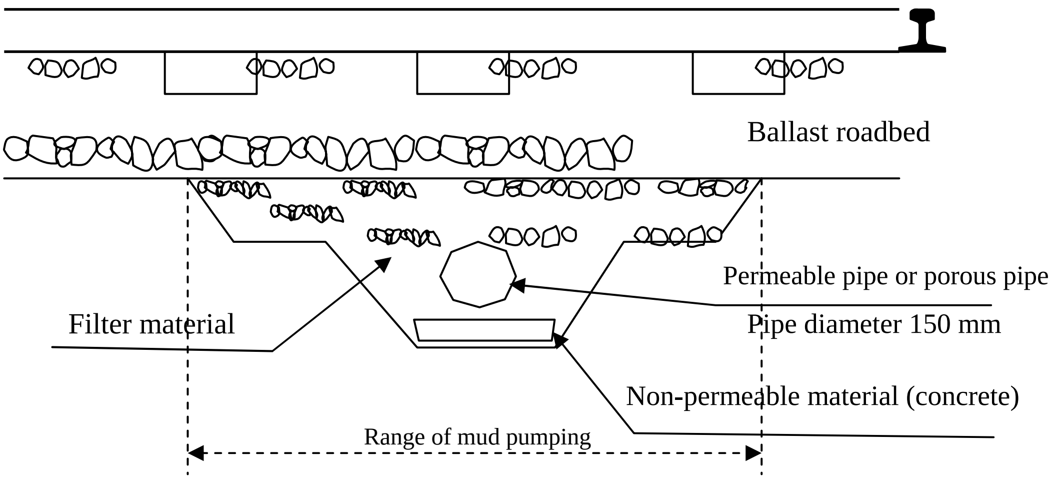


Figure 26-1　Roadbed transverse water drainage method

Location where roadbed replacement method will be required.

(1) Groundwater level is lower than the replaced layer.

(2) The thickness of replaced layer should be 30 cm as a standard.

(3) As the replacement material, sand, crashed stones (macadam) or crashed stones having adjusted grain size should be used.

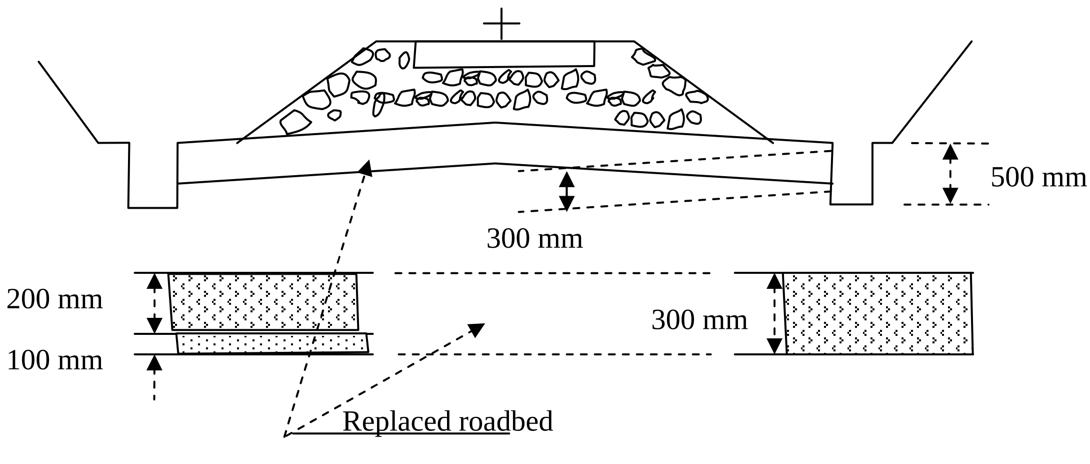


Figure 26-2 Roadbed replacement method

Case that sheet water shielding method will be required.

(1) Groundwater level is 50 cm or more below formation level.

(2) Roadbed replacement method can not be adopted.

(3) Protection layer, water shielding sheet and water drainage layer should be combined.

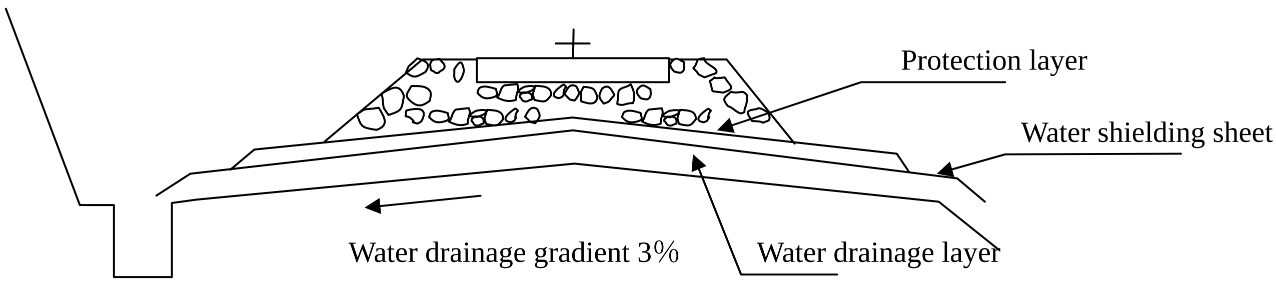


Figure 26-3 Roadbed structure (sheet water shielding method)

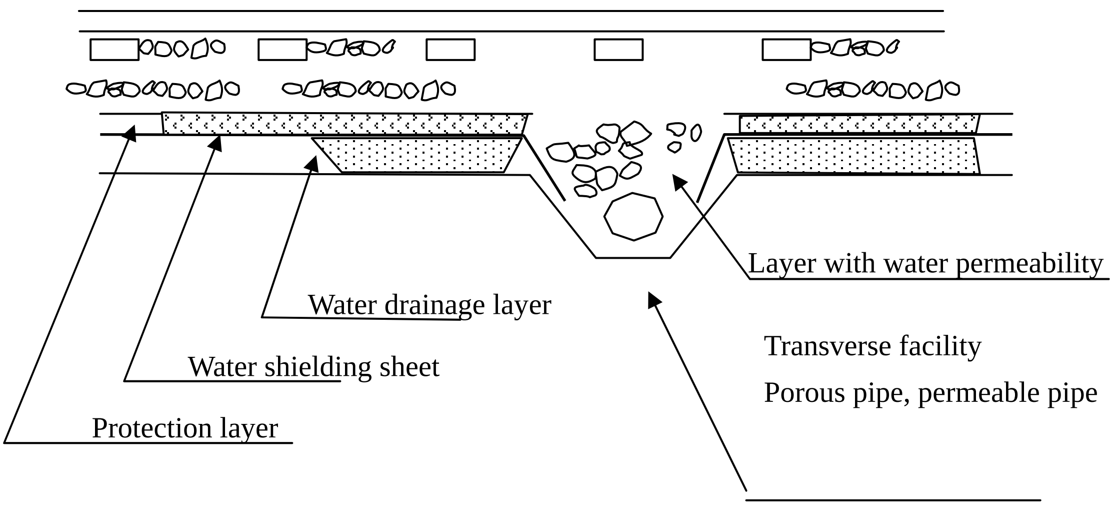


Figure 26-4 Treatment of a location with transverse facility

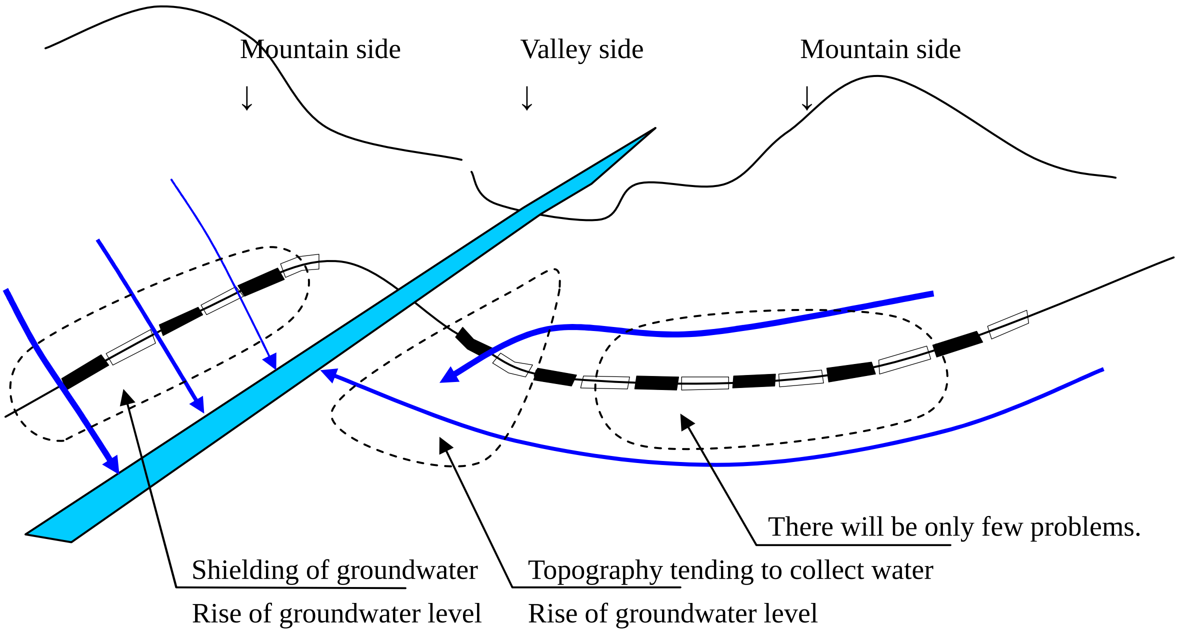


Figure 26-5 Relation between the rainwater direction and railway embankment

Article 29: Facilities for reducing significant noise and vibration

1. The railway operator must take the measures against noise and vibration along high-speed railway, as follows.

1.1 Depending on the siting conditions (present or absent of facilities such as schools, hospitals, and density of residences) of wayside schools, hospitals and residences, etc. (“etc.” include child day-care centers), at the locations requiring any care for environmental preservation, the railway operator must install the facilities including soundproof walls as the alleviation measures against noise from ground facilities to reduce significant noise caused by train operation.

1.2. Depending on the siting conditions of wayside schools, hospitals and residences, etc., at the locations requiring any care for environmental preservation, the railway operator must install the facilities including vibration-reducing track as the alleviation measures against vibration from ground facilities to reduce significant vibration caused by train operation.

2. The railway operator must take the measures against noise and vibration for ordinary railway, as follows.

When implementing new construction or major improvement, depending on the siting conditions of wayside schools, hospitals and residences, etc., at the locations requiring any care for environmental preservation, the railway operator must install the facilities to alleviate significant noise and vibration caused by train operation.

3. Noise should comply with the following target values.

3.1. Noise level target values along high-speed railway

Area I: 70 db (decibel） or lower;

Area II: 75 db (decibel） or lower.

Where, peak value of noise caused by successive 20 passing trains should be used.

The measurement location should be at 25 m away from track center and at 1.2 m above ground.

The assessment should be carried out by the power average of peak values included in upper half group of 20 measurements by a sound meter.

3.2. Vibration level target values along high-speed railway

Area requiring measures: 70 db (decibel) or lower;

Area where calm environment should be maintained such as school and hospital area: practicable measures.

3. The target value of noise level of a wayside of railways is as follows.

(1) The target value of noise level of a new line is as an equivalent sound level (LAeq),

(a) It is 60dB (A property) about daytime (from 7:00 to 22:00).

(b) It is 55dB (A property) about night (from 22:00 to next morning 7:00).

(c) If it is in the area which should protect housing environments, such as an exclusive residential district, take effort strive for much more reduction.

(2) The target value of noise level of a large scale improvement line should improve the situation of noise level from before.

(3) A measuring method and a valuation method

The single-train noise exposure level (LAE) of a passage train is measured, and an equivalent sound level (LAeq) is computed.

$$L_{Aeq}=10\log_{10}\left[\left(\sum_{I=1}^{n} 10^{L_{AE\,i}/10}\right)/T\right]$$

T: Time made into the subject of LAeq (second)

7:00 to 22: 00 T= 54,000

22: 00 to 7:00 on the next day is T= 32,400

The measuring object considers it as the passing all trains, and when the trains number to measure is reduced, it is taken as a weighted average.

The measurement position of the horizontal distance from a center of track makes 12.5m and 1.2m height above ground.

4. The target value of vibration level of a high speed railway wayside is as followings.

(1) A target value of vibration level may be 70dB or less.

(2) Perform a preventive measure for vibration and a cure for a house affected (preventive measure against hindrance) about the residential section where the compensated vibration level of a vibration along a railway exceeds 70dB (decibel).

(3) In addition to the above, may perform any required cure for the location where calm environment required as for a school and a hospital, and others.

5. Examples of the measures to alleviate noise and vibration are as follows.

Examples of the measures to alleviate noise	
Measures on track facilities	Prolongation of rail length with welding Rail head grinding.
Measures against noise sources of ground facilities	Soundproof wall. Sound absorption panel.

Examples of the measures to alleviate vibration	
Measures on track facilities	Prolongation of rail length with welding. Ballast mat, vibration reducing sleepers. Elastic fastening system, elastic sleeper track.
Measures on ground facilities	Suppressing the vibration transmission through ground. Suppressing the ground vibration caused by structures.

Article 31: Protection of the area under of bridge

The railway operator must take the appropriate protection measures to prevent hazard of falling objects from railway-bridge on the road and to prevent hazard that automobile or ship may collide with railway structure. Examples of such the protection methods are as follows.

1. Protection against falling objects
   To prevent any falling of track parts from an open-floor bridge, the bottom of such the bridge should be covered with steel plate or wood plate, etc. The width to be covered should be 1.75 m or more from track center.

2. Protection of bridge girder against automobiles
   If not assuring the under girder space of 4.75 m (not including a margin) specified in Cabinet Order for Road Structures, the railway operator shall display a danger indication or install a protection measure for bridge girder.
   In a case of steel bridge and at the location where an object such as any load on automobile may collide with it, the railway operator shall install a protection measure before steel girder.
   In a case that an installation of a protection measure is difficult due to the reason of topography, the railway operator may indicate that there may be a hazard at the location.
   For concrete bridge, the railway operator may display a danger indication.

3. Protection of pier
   At the location where automobile or ship may collide with a pier, the railway operator shall install a protection measure to reduce any impact to the pier.

4. Methods of protection

It may be unnecessary to assume high speed collision of an automobile or that of a ship at its maximum speed. Rather, the railway operator should display a danger indication, reduce impact, or prevent any damage of bridge girder or pier.

To reduce impact and to prevent damage, rubber shock absorbers, steel frame or crash barrier can be used.

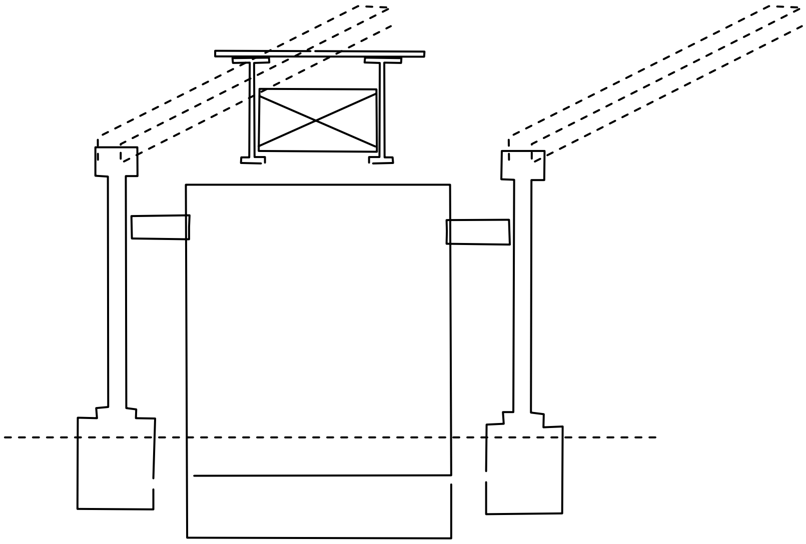


Figure 31-1 Example 1 of the protection work for bridge girder

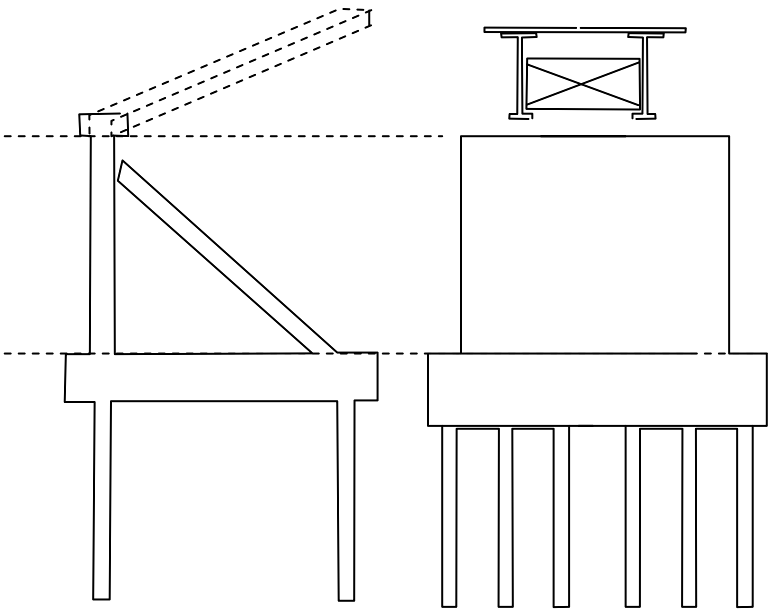


Figure 31-2 Example 2 of the protection work for bridge girder

Photograph 31.1 Example of protection work for bridge girder

Photograph 31.2 Example of protection work for pier

Article 32: Prevention of rolling stock overrun, etc

1. At the location where railway vehicle other than electric car without rails may overrun or train may overrun and cause hazard, the railway operator must install the following facilities.

1.1. At the location where main lines or important side lines intersect at level crossing or branch and may endanger each other, the railway operator must install safety siding (Figure 32-1). However, in a case that a device allowing train to stop automatically by an interlocking action with a main signal at the start end of the section has been installed, the requirement may not apply.

1.2. At the location such as track end, the railway operator must install the measure including car stop device, as follows.

1.2.1. At the end of a safety siding or a line, which may cause significant damage, the railway operator must install a car stop device such as a gravel pile or other facility with equal or more buffer capacity depending on assumed car speed and weight (Figure 32-2).

1.2.2. At the end of track other than one specified in above 1.2.1, the railway operator must install a car stop device to accept a car body or coupler depending on the conditions of the section (Figures 32-3, 32-4 and 32-5).

1.2.3. At the location of side lines and where two lines connect or cross each other and where drawbridge is installed, the railway operator must install derailer or scotch block (Figure 32-6).

1.3. In a section with continuous downward slope, to deal with poor braking action of train or vehicles, the railway operator must consider the following safety measures and take appropriate actions.

(1) Establishing limit speed by taking braking distance of train on downward slope into account.

(2) Equipping an emergency braking device on vehicle.

(3) Constructing an evacuation side line.

2. Construction of safety siding

A safety siding is a side line, which is constructed to prevent an accident such as collision when train and vehicle may overrun. Such the safety siding should be constructed at the location shown in Figure 32.1 as a standard manner.

The turnout of a safety siding should be run-over turnout, in principle.

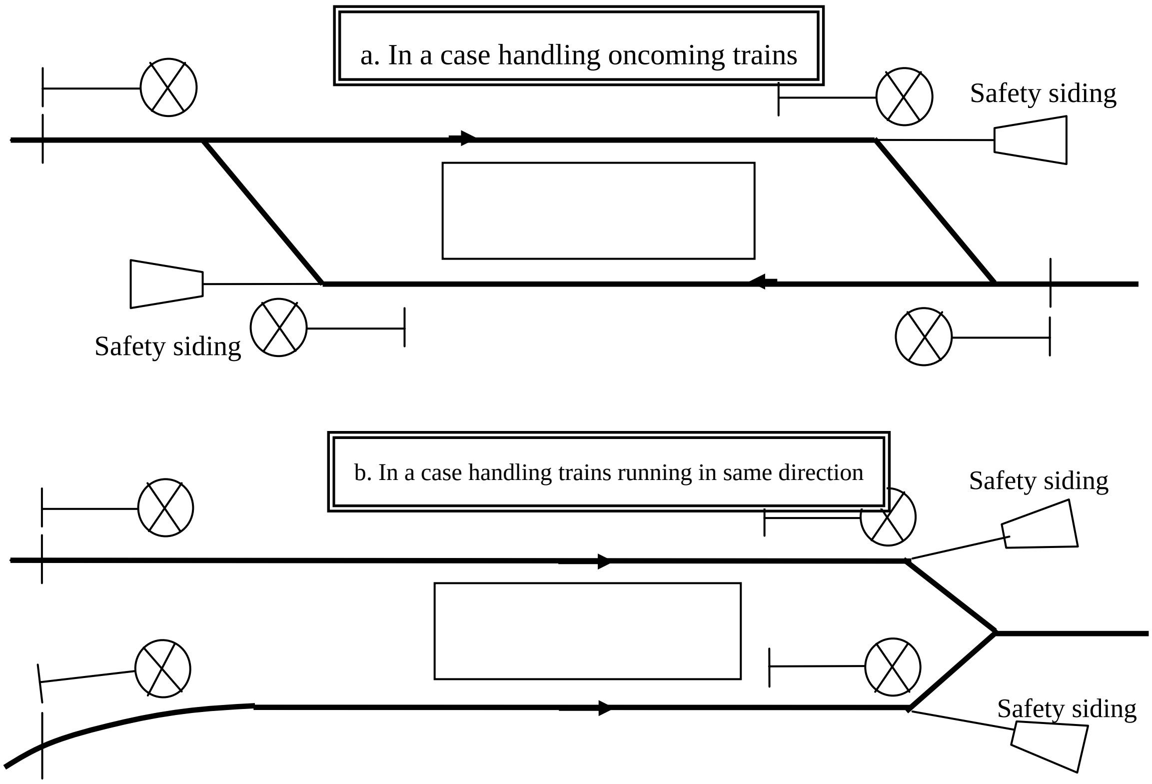


Figure 32.1a　Construction example of safety siding

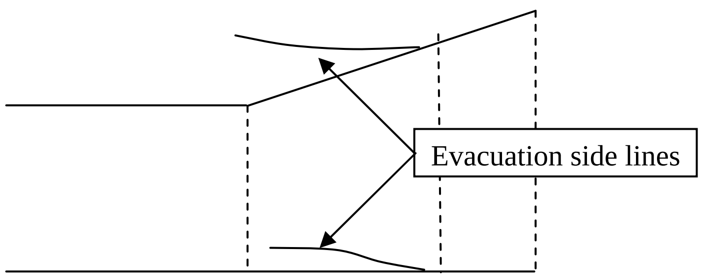


Figure 32-1b　Construction example of evacuation side line

3. Car stop device

3.1. Type and outline of car stop device

The end of track shall be equipped with a car stop device to prevent hazard due to any overrun of vehicle or train. For the purpose, the railway operator must select each appropriate type of car stop device based on the factors including importance of the line section, speed of incoming vehicle and the conditions of the line section such as whether protection systems are present or not. In the following subsections, the examples of the usage standards, shapes and dimensions, etc. of car stop device in the train operators.

3.1.1. Gravel pile (car stop device with buffering function) (Figure 32.2)

(1) An example of 1st class car stop device to be installed at the end of safety siding

In Figure 30.4, the dimensions, T, W and gravel pile thickness are determined appropriately based on the conditions.

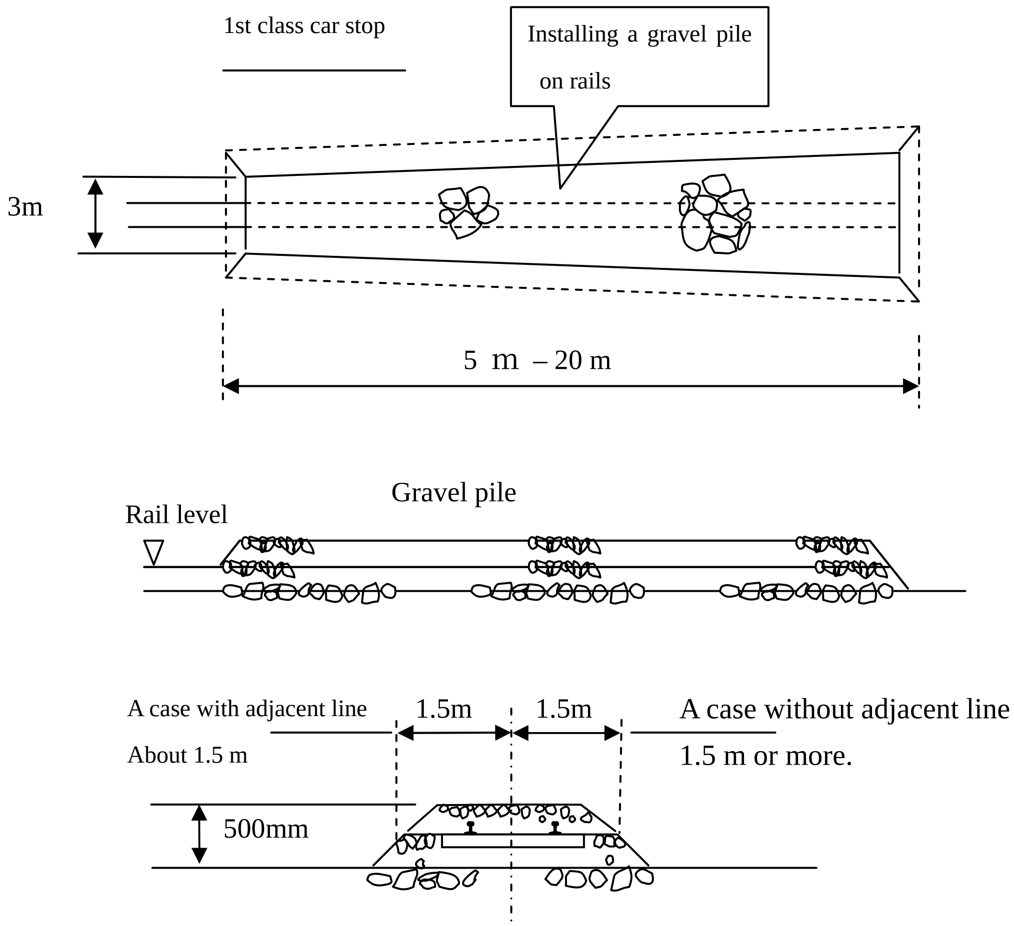


Figure 32.2 Example of 1st class car stop device

(2) Function of gravel pile

The braking force on vehicle is determined by the factors including the drag force by gravel of a car stop and the frictional force between track and wheels, etc. after derailment, or collision force among vehicles. This relation is indicated by Formula (32.1).

$$F \times S = 0.5 \times W / g \times V^2 \quad \text{(32.1)}$$

Where,

F: Braking force (KN)

S: Collision distance (distance from car stop to stopping point) (m)

W: Vehicle weight (KN)

g: Gravitational acceleration (m/sec^2)

V: Velocity (m/sec)

The left hand side and the right hand side of above formula represent braking energy and kinetic energy just before collision, respectively.

According to previous research activity, the braking force of this car stop device should be 320 KN or lower.

3.1.2 An example of 2nd class car stop device （Figure 32.3a） is installed at the following locations.

(1) The end of a main line becoming a dead end.

(2) The end of an important side line.

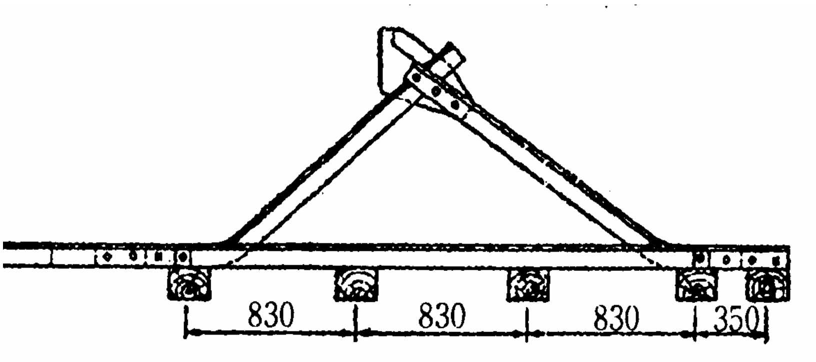


Figure 32.3-a Example of car stop device (using rails)

3.1.3. An example of 3rd class car stop device (Figures 32.3-b and 32.3-c)

In general, this type of the device is installed at the following locations.

(1) The end of car depot line or similar line (car stop device (steel work))

(2) The end of side line other than abovementioned one (car stop device (processed rails))

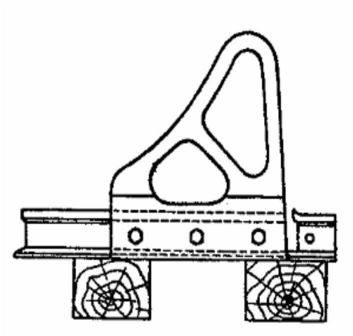


Figure 32.3-b Car stop device (steel work)

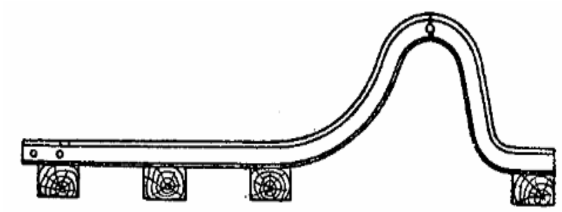


Figure 32.3-c Car stop device (processed rails)

3.1.4 Buffer stop

The device shall be installed at the location where a train or vehicle may cause significant damage if it stops at incorrect position in a case that the structure such as building, high embankment or cutting has been constructed.

While reference structure of such the device is embankment, concrete block and similar structure, normally it is made of concrete and so designed that its height is about 2 m and length is about 1.5 – 2 m. By taking the strength of vehicle into consideration, it is supposed that the device can withstand about 1000 KN or more. If the force increases further, its design allows the car stop to turn over.

Table 32.1 Measurement and test results

Measurement No.	1	2
Type of bumper device	Concrete	
Freight car weight W (tf)	23.35	
Velocity V (k/h)	3.9	26.1
Collision acceleration on car (g)	2.1	10 (or more)
Displacement after collision	11	Out of measurement

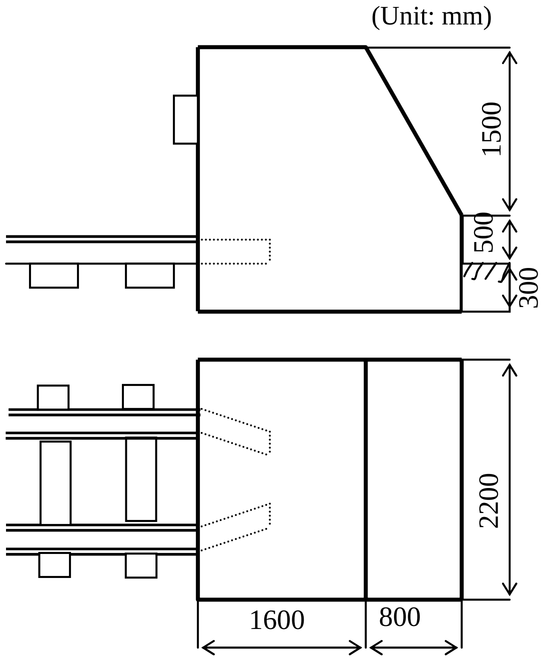
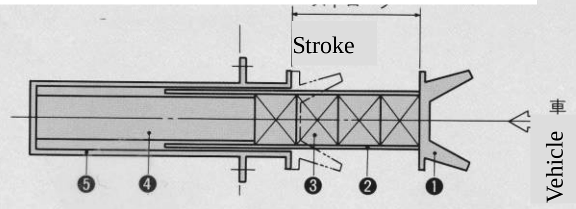


Figure 32.4 Dimensions of bumper device

3.1.5. Other car stop device

In a specific premise, a car stop device of mechanical type using hydraulic dumper, etc., may be used to assure effective length or to pay attention to safety of passengers and public. The device should be installed at the location where a function to minimize any damage of facilities is required in a case that an accident such as overrun of a train may cause significant damage to passengers, public and various station facilities, as well as major failure to existing structures at the end of main line becoming a dead end.

Structure of hydraulic dumper type car stop device



Symbol	Name
1)	Coupler receiver
2)	Movable case
3)	Buffering material
4)	Rod
5)	Fixing case

Figure 32.5　Car stop device of hydraulic dumper type

4. Installation of derailer or scotch block (Figure 32.6)

Derailer or scotch block are installed at the following locations. Scotch block should be installed at a position of 2 m inward from vehicle contact limit of a side line.

(1) Location where it is a side line and the installation of a safety siding will be difficult from the reason such as topography.

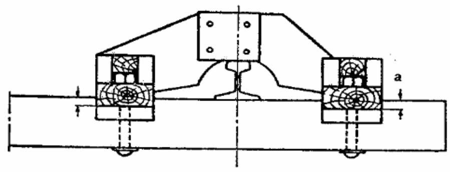
(2) Location where rolling of vehicle, etc. in parking may cause hazard.

(3) Location where vehicle may overrun toward a traverser table (Photograph 32.1) or a turntable.

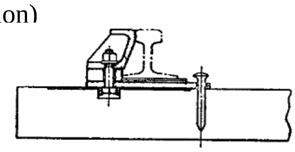
(4) Location where a drawbridge is installed.

Photograph 32.1 Example of traverser table (in a factory)

Wooden scotch block (cross section)



Steel scotch block (cross section)



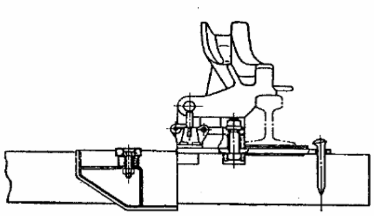


Figure 32.6 Examples of scotch block device

Article 33: Prevention of entry into roadway

1. In a case of ordinary railway, facilities and residences have been constructed in the adjacent locations of railway. Thus, at the place where peoples may enter, the railway operator must prevent such the entrance by the means such as fence and indicate that unauthorized entrance will be hazardous.
2. In a case of high speed railway, the railway operator must install the facilities such as fence to prevent inadvertent entrance at the place where peoples or large animals may enter.

   At the location of abutment or tunnel entrance, etc. and where large animals can enter, the railway operator must prevent their entrance by the means such as fence.

For a maintenance stairway, maintenance slope and entrance facility in a viaduct section, the railway operator must install the facilities such as fence to prevent unauthorized entrance.

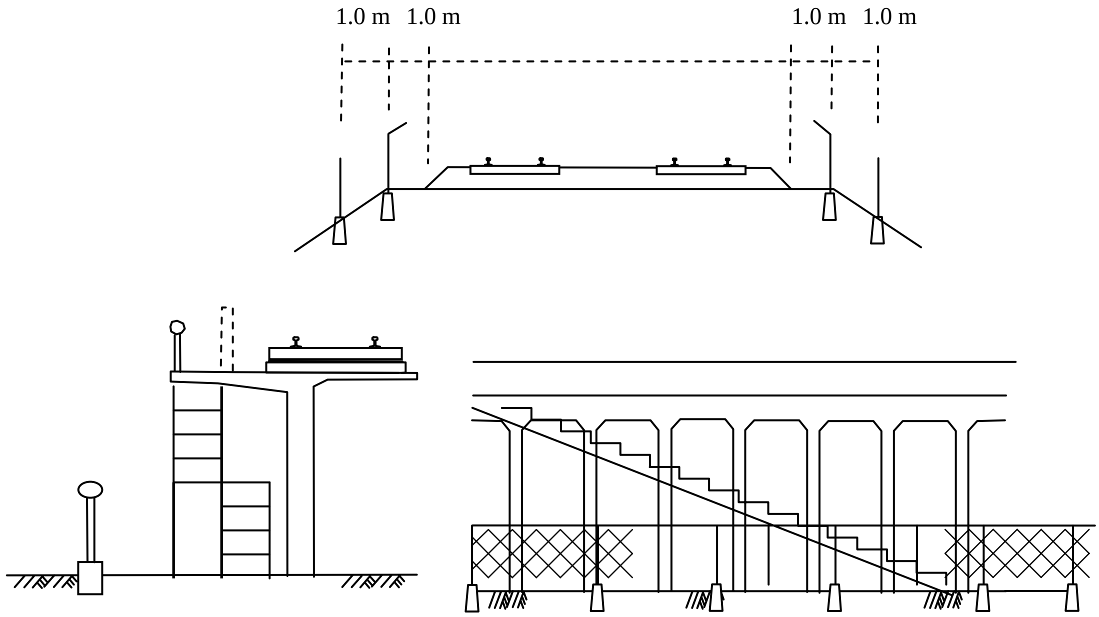


Figure 33-1　Example of fence to prevent unauthorized entrance

Article 34:　Evacuation equipment, etc.

Track shall allow passengers requiring evacuation to walk. However, in a case of suspended railway, straddled type monorail and levitated transportation system and that an evacuation facility such as descending device for vehicle, etc. or an evacuee guide route, etc. are installed, the requirement may not apply.

Article 35: Track sign posts

1. For a main line, the railway operator must install the following markers and indicators required to maintain track or to assure the safe operation of trains.
   (1) Clearance post
   (2) Kilometer post
   (3) Curve post
   (4) Gradient post

Standard types of track marker and indicator are as follows.

Kind of track sign posts	Installation location
Clearance post	Location where a line branches.
Kilometer post	Kilometer post of 1 km, 500 m and 100 m. Location, at which distance is calibrated.
Curve post	BTC, ETC, BCC, ECC
Curve transition post	In a linear line without transition curve, location, at which cant of circular curve is gradually diminished on a straight line (locations of BTC, ETC in a case that transition curve is provided）.
Gradient post	Location, at which gradient changes.

Examples of marker and indicator are as follows.

Purpose of installing marker and indicator	Installation location
Control classification	Distance post from station, station boundary marker and control boundary marker
Train operation	Braking sign, deceleration sign, guide sign, lightning warning sign and whistle board
Wayside facility	Bridge name, tunnel name, level crossing name and distance post of facility
Warning sign	During construction, rock fall and other warning sign
Safety facility	Evacuation guide sign and notice of no trespassing

Chapter 5 The intersection with a different railway and with roads

Article 42: The intersection with a different railways and with roads

1. As defined in Article 23, Clause 1 of Railway Law.
2. As defined in Article 23, Clause 2 of Railway Law.
3. When building new railways, the investors in the construction of railways works shall have to build the intersections in accordance with the clause 1 and 2 of this article; when building new land roads, the investors in the construction of land roads shall have to build the intersections in accordance with the clause 2 of this article.
4. Other cases which do not subject to the regulations in Clause 2 of this Article and when do not have sufficient conditions for grade crossings, Ministry of Transport, people committees of all levels, investors or individuals, organizations wanting to cross the railways must obey the following regulations:
   (1) At places where the construction of level crossings is allowed, regulations of Minister of Transport shall be obeyed.

(2) At places where the construction of level crossings is not allowed, collection roads shall be constructed outside the railway traffic safety corridors in order to lead to the nearest crossings or different level intersections

Article 43: Level crossing

Level crossing of ordinary railway (except for high speed railway) shall comply with the following standards.

(1) Surface of level crossing shall be paved.
Paved finish means the condition paved with the material such as concrete blocks, asphalt, wood or rubber.

(2) Crossing angle between railway and road shall be 45 degrees or more.

(3) The railway operator must post a warning sign.

(4) The railway operator must construct the crossing safety facilities.
Crossing safety facilities mean automatic barrier machine, road warning device and accident alarm device, etc.

(5) For a level crossing where train passes at extremely high speed (over 130 km/h and lower than or equal to 160 km/h) , the railway operator must install an automatic barrier machine (the requirement is applied only for a level crossing letting automobiles through). The railway operator shall not allow large-size cars to pass a level crossing letting automobiles through. However, for a level crossing reluctantly letting large-size cars through, the railway operator must take the measures to prevent any trouble when large-size cars pass it by installing two steps barrier machine, large automatic barrier machine and overhang warning device, or by enhancing visibility on the level crossing.

(6) For a track on a level crossing, the railway operator must install crossing guard.
Crossing guard means guardrails and L shape guardrails.

2 Structures and Station facilities

Table of Contents

Reference

Chapter 1 General Rules

Article 6 Prevention of harm

In the case implementing the railway work including soil excavation such as slope cutting, cutting, excavation, embanking and pilling, the Construction entrepreneur must assure that any trouble such as slope collapse, caving-in or mud sliding does not endanger the safety of persons and other facilities during the work and throughout the period of time, during which the facility is present.

Article 7 Prevention of heavy noise

The railway operator must take the noise alleviation measures under Article 29 depending on the sitting condition including schools, hospitals and housings along a railway line.

Article 8 Measures to be taken in order to facilitate the smooth movement of passengers

The railway operator must assure smooth movement by providing following facilities in one or more routes between public passages connecting to a station and train doors to enhance the convenience and safety of the persons of advanced age and physically handicapped persons during movement.

Facilities for smooth movement:

1) Slopes with inclination of 1/12 or smaller, elevators and escalators;

2) Installation of guiding blocks for the persons with visual handicap;

3) Installation of rest room for the physically handicapped persons when installing rest room; and

4) Installation of the device for providing audiovisual information.

Chapter 3　Track

Article 22　Construction gauge related

The railway operator must specify the construction gauge and must not install any buildings and other structures within the construction gauge. Standard diagrams of the construction gauge in a straight line are shown in Figure 1-1~4A and Figure 1-1~4B for ordinary railway (except for high speed railway) and high speed railway, respectively. In addition, for special railway the railway operator must specify necessary geometry and dimensions clearly based on the kind.

(1) Extension width of construction gauge from rolling stock gauge

1) The construction gauge in a straight line of ordinary railway shall comply with the values in below table.

Location of construction gauge	Construction gauge (mm)
Main line	The construction gauge ・Must be larger than or equal to the width determined by adding 800 mm to the maximum width of rolling stock gauge. ・Must be larger than or equal to the width determined by adding 400 mm to the maximum width of rolling stock gauge in the section, in which only the cars of structure not allowing passengers to let out their body from window run.
Side track	The construction gauge ・Must be larger than or equal to the width determined by adding 400 mm to the maximum width of rolling stock gauge.
Location higher than or at side of a platform	The value which added 50mm to rolling stock gauge

2) The construction gauge in a straight line of high speed railway shall comply with the values in below table.

Location of construction gauge	Distance between construction gauge and rolling stock gauge (mm)
Main line	The construction gauge ・Must be larger than or equal to the width determined by adding 800 mm to the maximum width of rolling stock gauge. ・Must be larger than or equal to the width determined by adding 500 mm to the maximum width of rolling stock gauge in the section with unavoidable restriction by terrain.
Side Track	The construction gauge ・Must be larger than or equal to the width determined by adding 500 mm to the maximum width of rolling stock gauge.

(2) The items, which are required for train operation and the maintenance of facilities and can not impose hazard on train operation safety (contact lines, of contact wire and guardrails etc.), may be installed within the fundamental range of construction gauge. In the case, the operator must describe the items clearly in the construction gauge.

(3) The construction gauge in the railway curve (including the construction gauge for a platform along a curve) must be enlarged by adding the values calculated from below formulas to each side of the construction gauge in a straight line based on a carbody displacement at curve. In addition, the correction shall be determined by Formula 3) as inclined one based on the cant. However, for the construction gauge in the curve other than platform, since a carbody displacement due to curve radius will be sufficiently smaller than the distance between construction gauge and rolling stock gauge in a high speed railway of radius greater than 2,500 m, the enlargement based on the carbody displacement at curve may be omitted.

1) Carbody displacement toward curve interior W_1

$$W_1 = R - \sqrt{\{(R-d)^2 - (L1/2)^2\}}$$

$$d = R - \sqrt{\{R^2 - (L0/2)^2\}}$$

2) Carbody displacement toward curve exterior W_2

$$W_2 = \sqrt{\{(R+B/2-W1)^2+(L2/2)^2\}} - R - B/2$$

Where, L0, L1, L2, B, R, W1 and W2 are defined as follows.

L0: Wheel base

L1: Distance between bogie axlesL2: Overall length of car body

B: Overall width of car body

R: Radius

W_1: Carbody displacement toward curve interior

W_2: Carbody displacement toward curve exterior

However, in the case of a national railroad, you shall use the following simple type。

Gauge 1000mm

The thing which substituted distance (L1) 14m between bogie axles for $W1 = L1^2/8R$(An approximation type) and added quantity of widening of road by the slant with cant to

W_1=24,500/R+4h (mm)

The thing which substituted overall length of car body (L2) 20m, distance (L1) 14m between bogie axles for $W2 = L2^2/8R - L1^2/8R$(An approximation type)

W_2=25,500/R (mm)

Gauge 1435mm（It usually restricts to ordinary railway ）

The thing which substituted distance (L1) 18m between bogie axles for $W_1 = L1^2/8R$(An approximation type) and added quantity of widening of road by the slant with cant to

W_1=40,500/R+H.h/1500 (mm)

The thing which substituted overall length of car body (L2) 26m, distance (L1) 18m between bogie axles for $W_2 = L2^2/8R - L1^2/8R$(An approximation type)

W_2=44,000/R (mm)

3) Inclination due to cant A

$A = CH/G$

C: Cant

H: Height of even angle section in a construction gauge or height of considered location

G: Value used for a reference to determine a cant at gauge or rail center interval

(4) The construction gauge in an interval from the end of a circular curve (in a case that both the transition curves are connected directly, the point connecting both the transition curves, the same shall apply hereinafter) to the point corresponding to maximum train length operated in the line outside the end of transition curve (if a transition curve is absent, the end of the circular curve) must be determined by calculating the value to be added at the end of the circular curve under above (3), then by decreasing the calculated value gradually in the interval, and finally by adding the reduced value to each side of the construction gauge in straight section (see Figure 22-3).

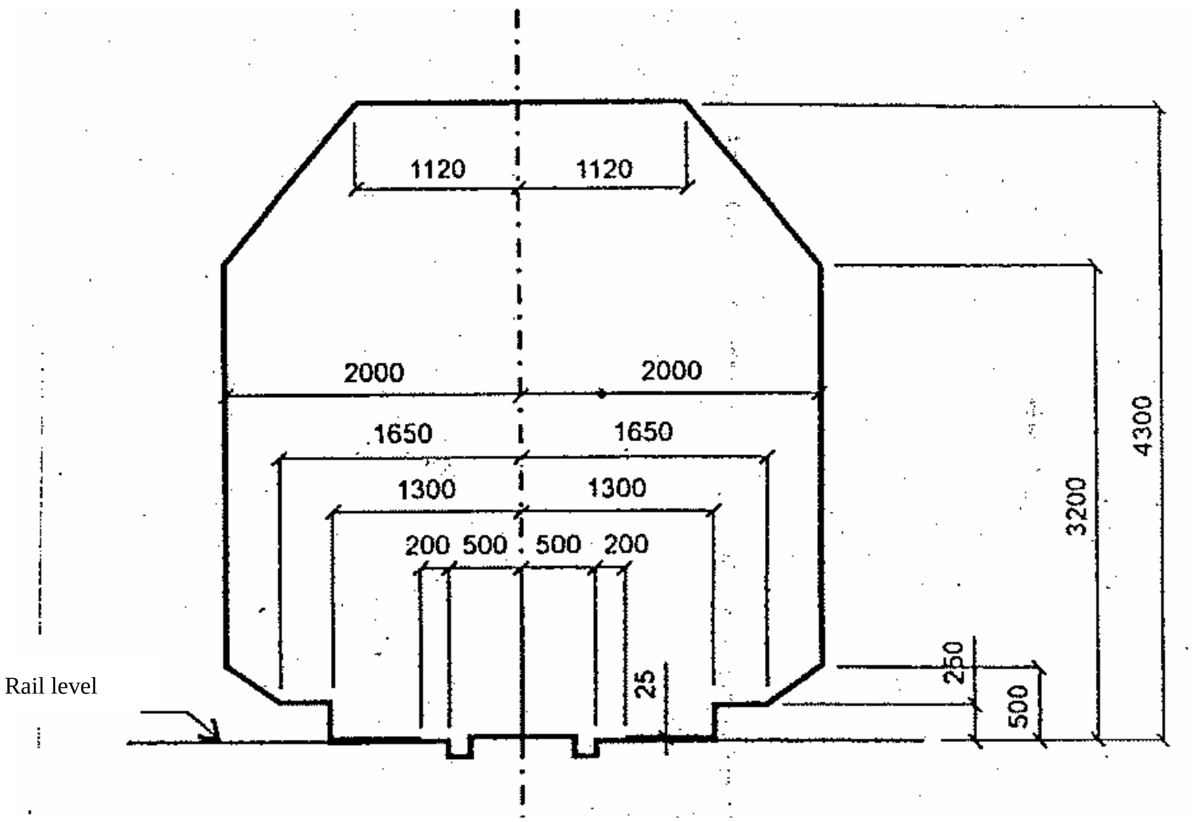
Attachment 1

The construction gauge figure of a national railroad (it restricts to ordinary railways of non-electrification) is carried out as follows.

(1) The construction gauge figure of 1000mm gauge

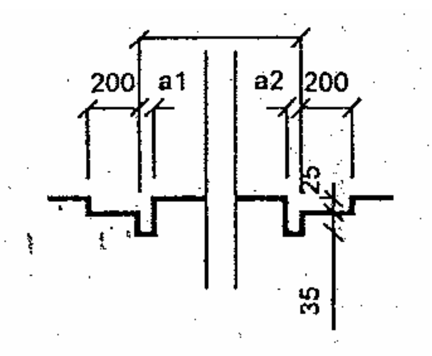
Figure 1-1A Construction gauge in the straight section of eathwork interval or in the main line of a station

(1000mm Gauge)



Rail clearance

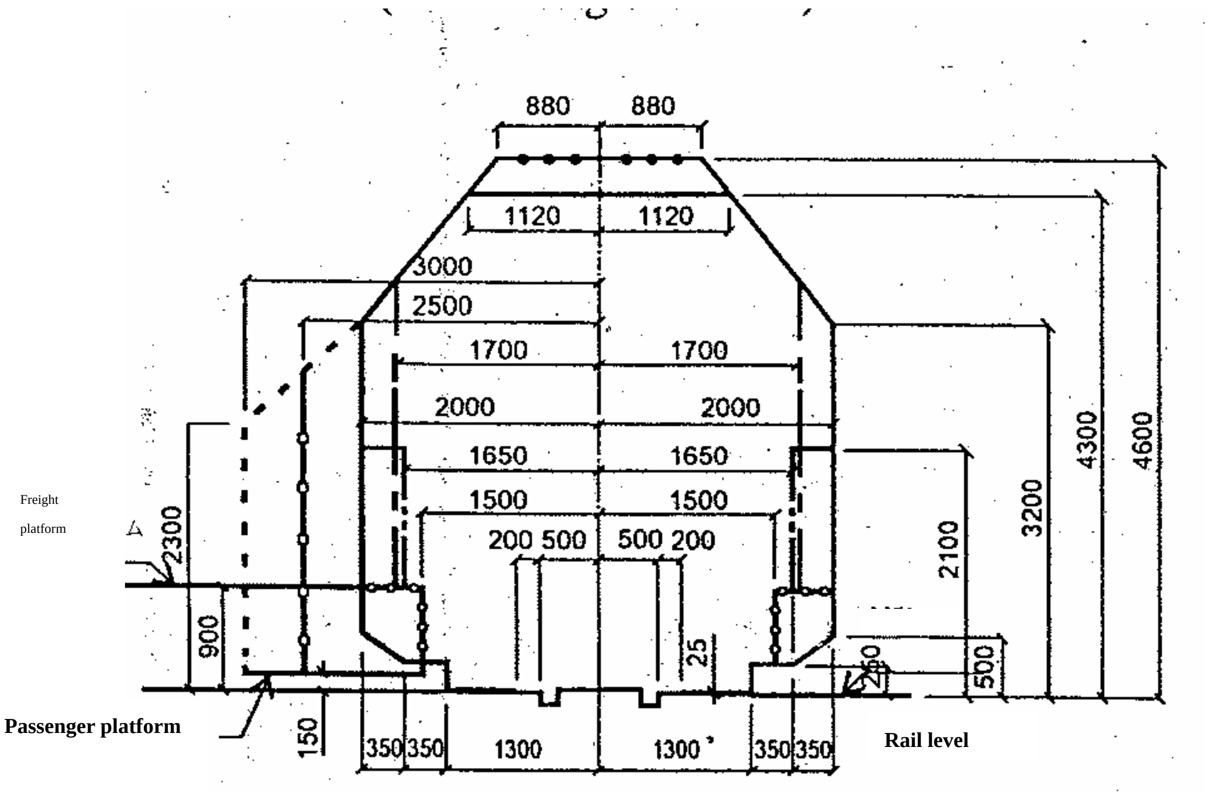
Inner distance of a rail pair



a1.a2 Distance between stock rail and anti-deraling rail

Figure 1-2A Construction gauge in the straight section of a station

(1000mm Gauge)

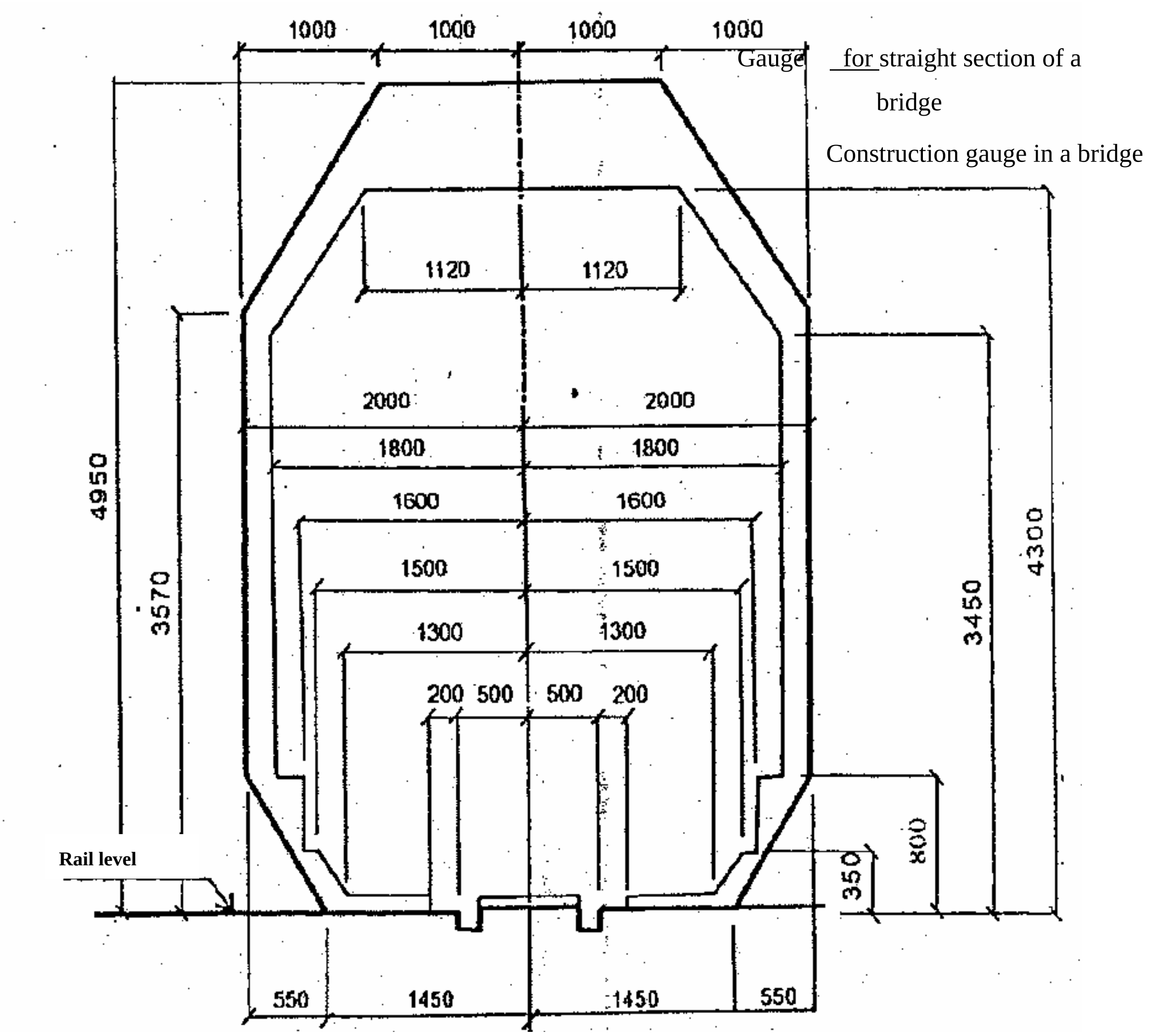


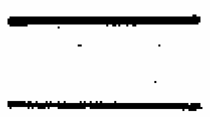
Explanation of Figure 1 -2A

- General construction gauge in a station
- Clearance for rain gable of a station and overbridge
- Clearance between train depot and signaling poles
- Clearance for station signs and signals
- Freight platform
- Poles in a platform (except for tablet exchange poles)
- Construction gauge in a platform

Figure 1-3A Construction gauge in the straight section of a bridge

(1000mm Gauge)



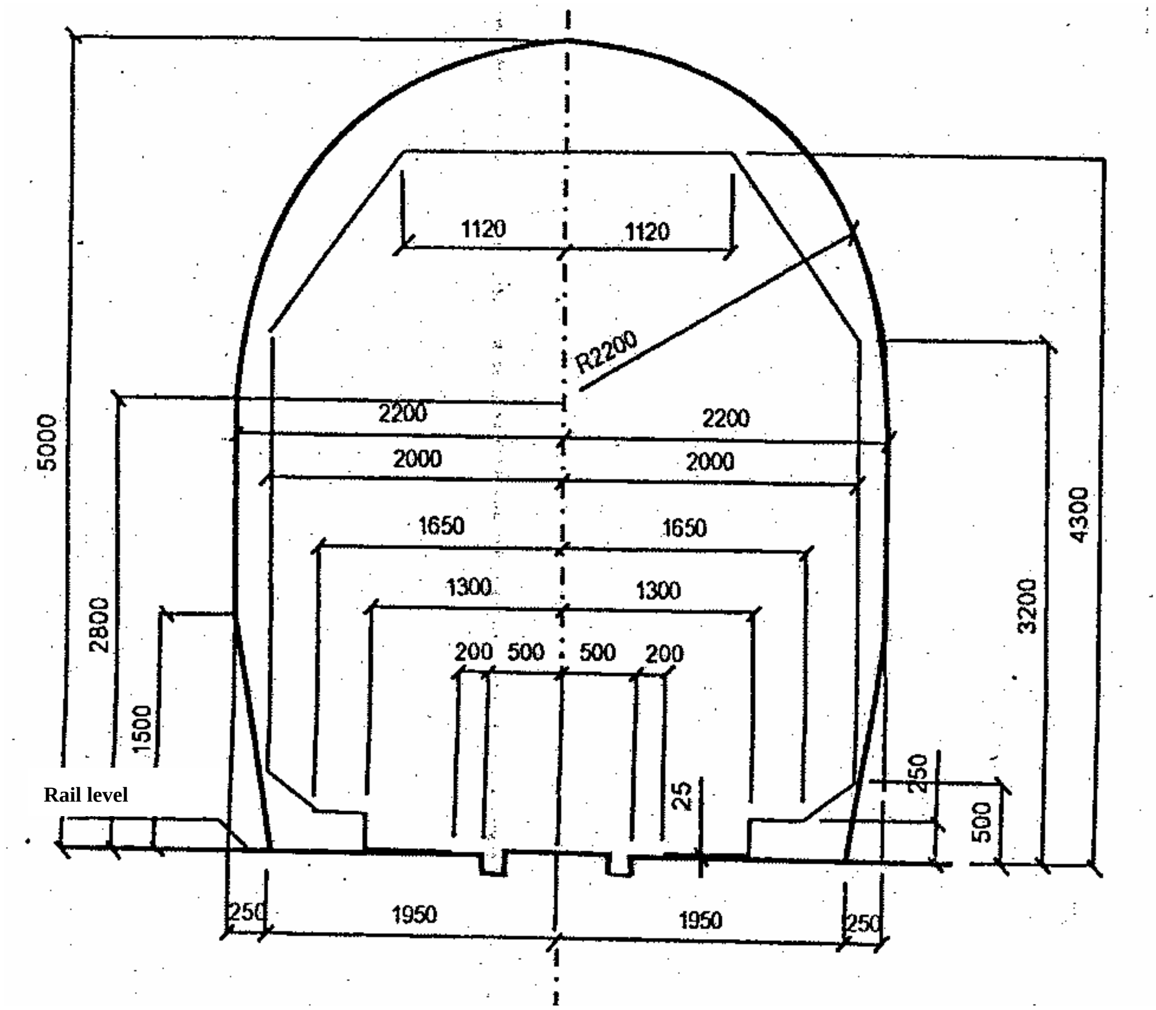


Gauge for straight section of a bridge

Construction gauge in a bridge

Figure１-4A　Construction gauge in the straight section of a tunnel

（1000mm Gauge）



Gauge for straight section of a tunnel

Construction gauge in a tunnel

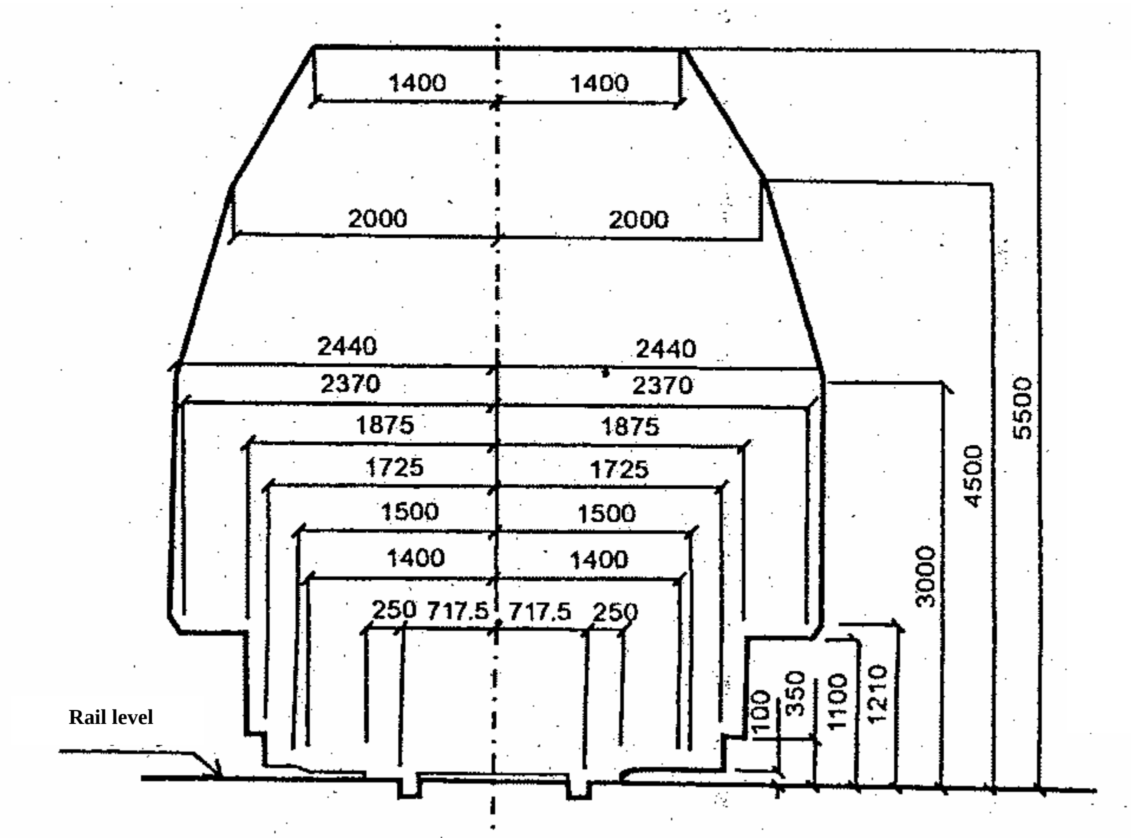
Explanation of Figure 1A to Figure 4A

The construction gauge in a curve shall be enlarged by following formulas based on the construction gauge in a straight section.

1. For enlargement toward curve interior：W_1=24,500/R+4h(mm)
2. For enlargement toward curve exterior：W_2=25,500/R(mm)

h：Cant of curve exterior （mm） and R: Radius of curve （m）

Figure 1-1B Construction gauge in the straigh section of a interval or the main line of a station（1435 mm Gauge）



Rail clealance

Inner distance of a rail pair

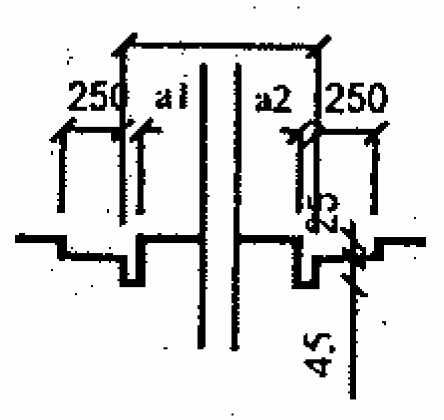
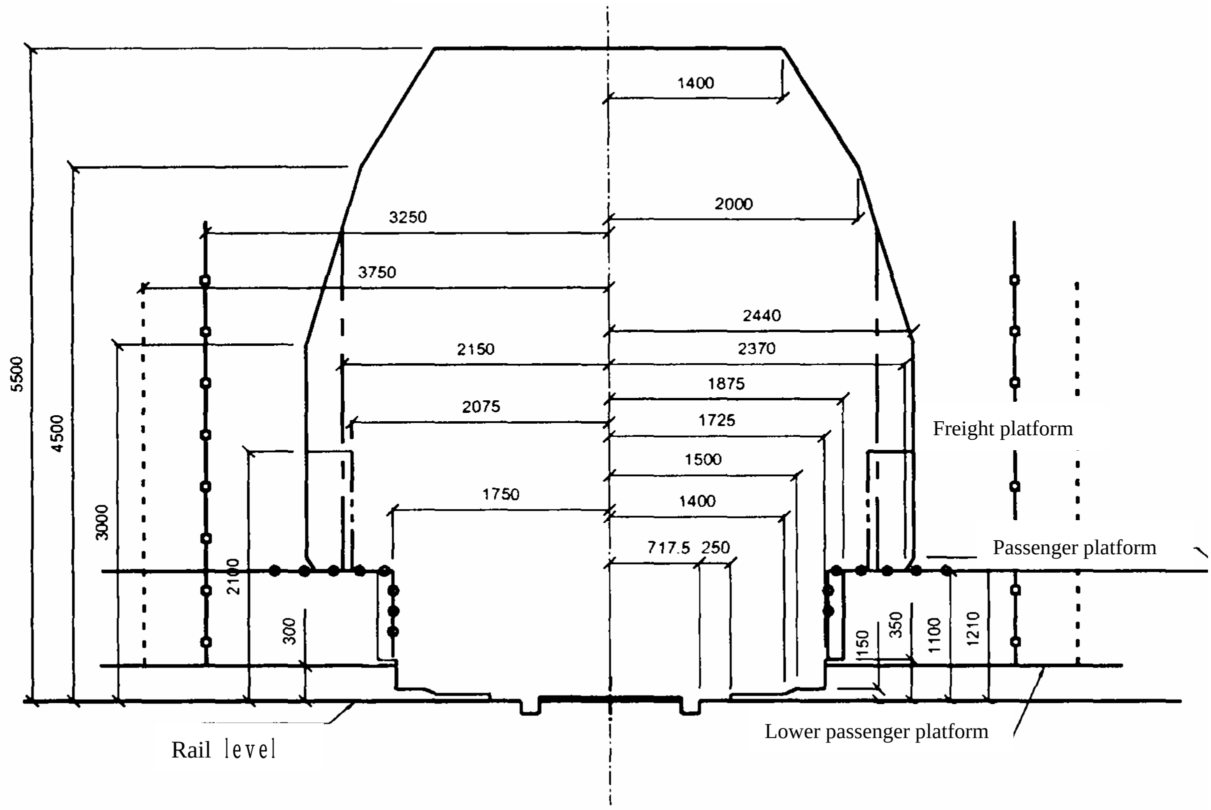


Figure 1-2B Construction gauge in the straight section of a station (1435mm Gauge)

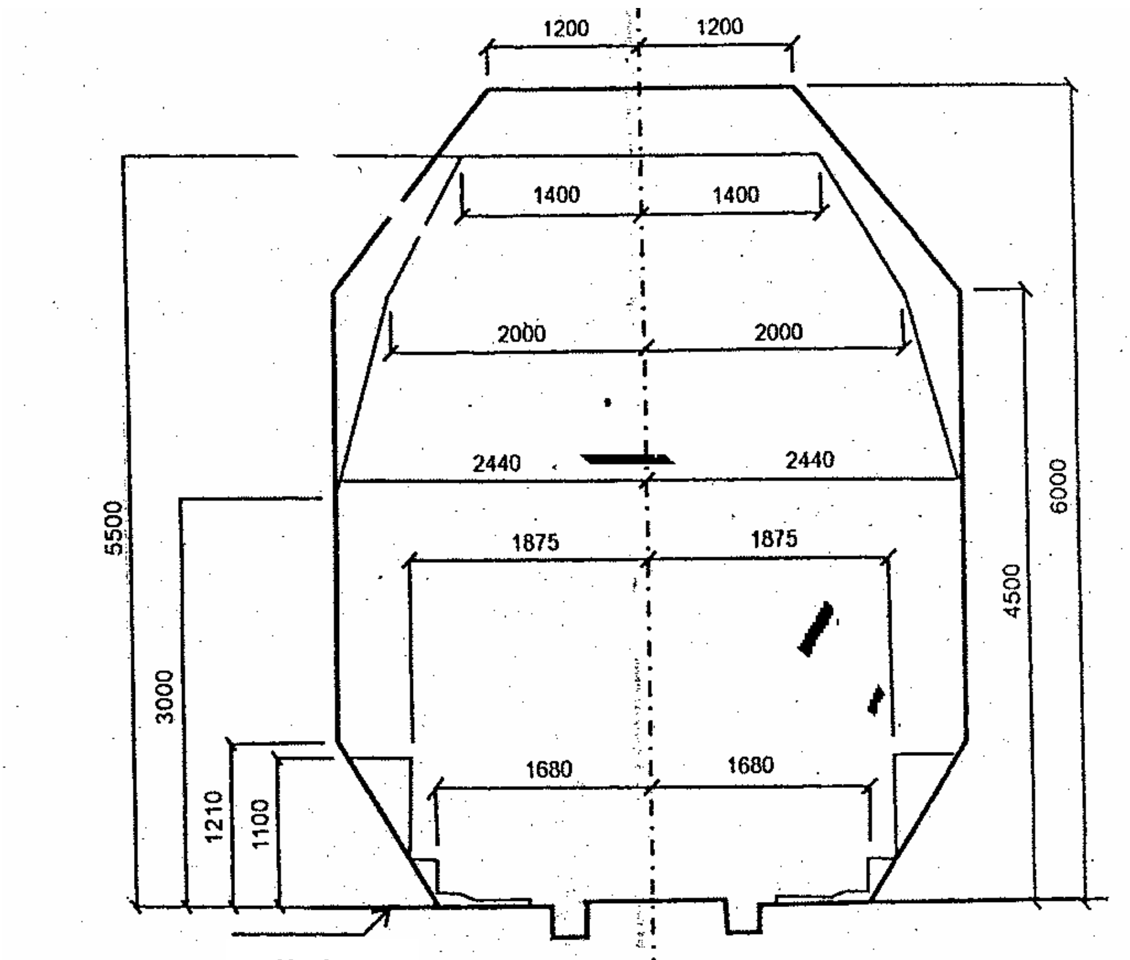


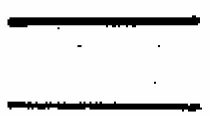
Explanation of Figure -2B

- General construction gauge in a station
- Clearance for rain gable of a station and overbridge
- Clearance between train depot and signaling poles
- Clearance for station signs and signals
- Freight platform
- Poles in a platform (except for tablet exchange poles)
- Construction gauge in a platform

Figure 1-3B Construction gauge in the straight section of a bridge

(1435mm Gauge)

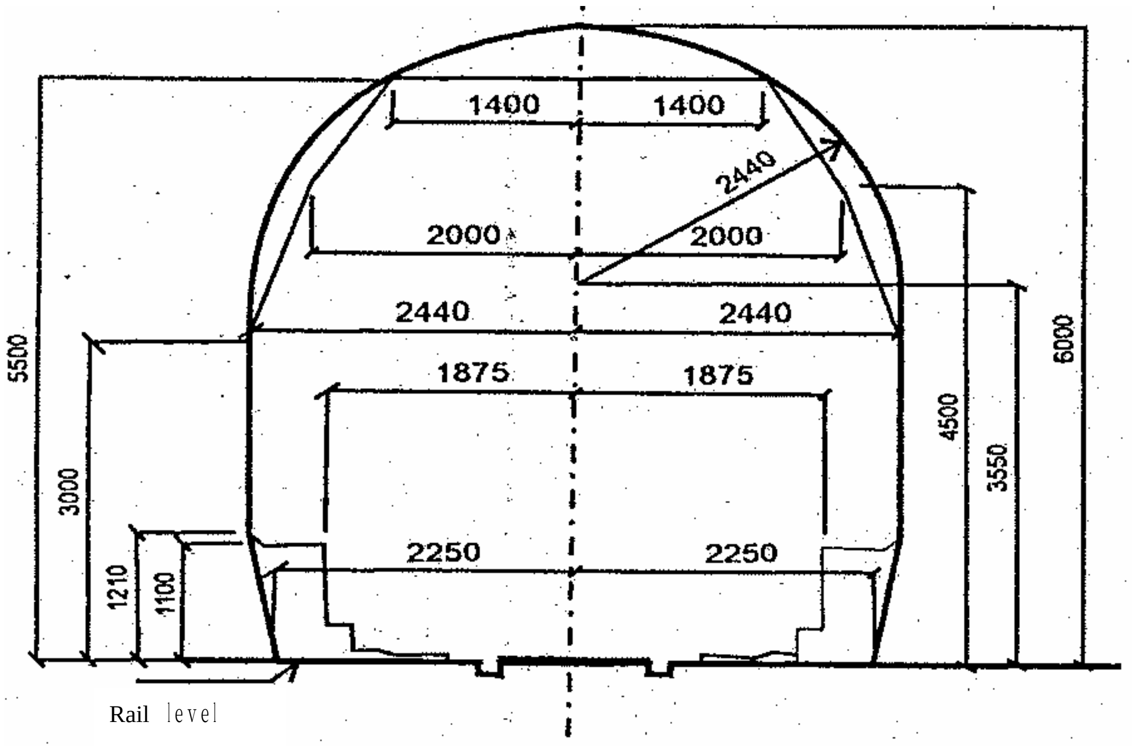




Gauge for straight section of a bridge

Construction gauge in a bridge

Figure １-4B Construction gauge in the straight section of a tunnel
(1435mm Gauge)



Gauge for straight section of a tunnel

Construction gauge in a tunnel

Explanation for Figure - 1B to Figure - 4B

The construction gauge in a curve shall be enlarged by following formulas based on the construction gauge in a straight section.

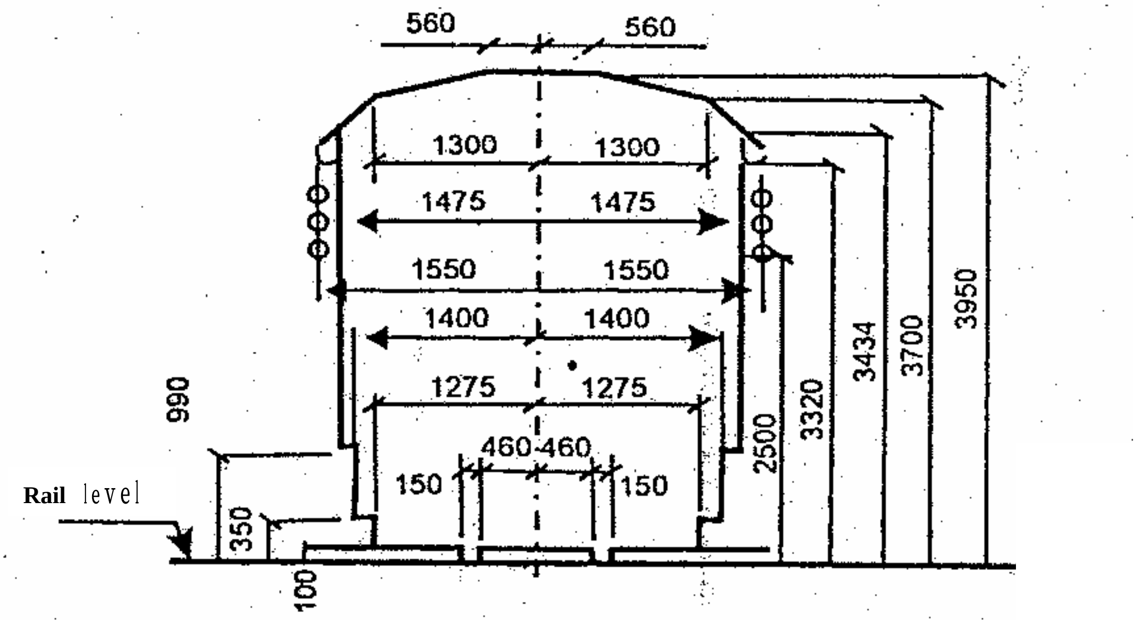
1. For enlargement toward curve interior: W_1=40,500/R+H*h/1,500mm
2. For enlargement toward curve exterior: W_2=44,000/R

H: Height from calculation point to rail surface
h: Cant of curve exterior (mm)
R: Radius of curve (mm)

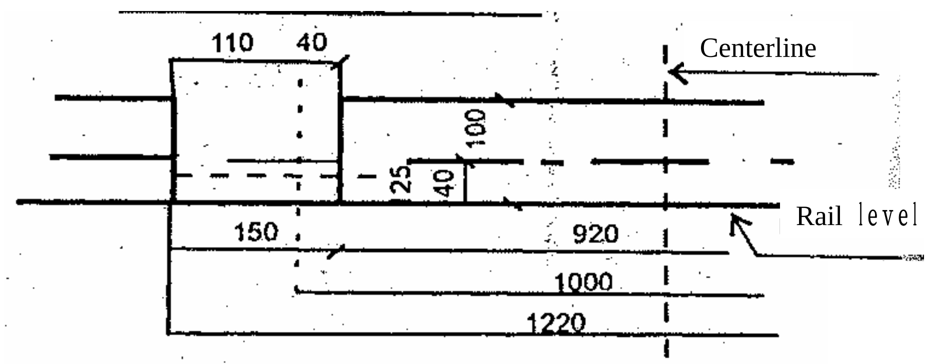
Attachment 2

Figure 1-1 Rolling stock gauge

(1000mm Gauge)



Rail clearance



Rolling stock gauge

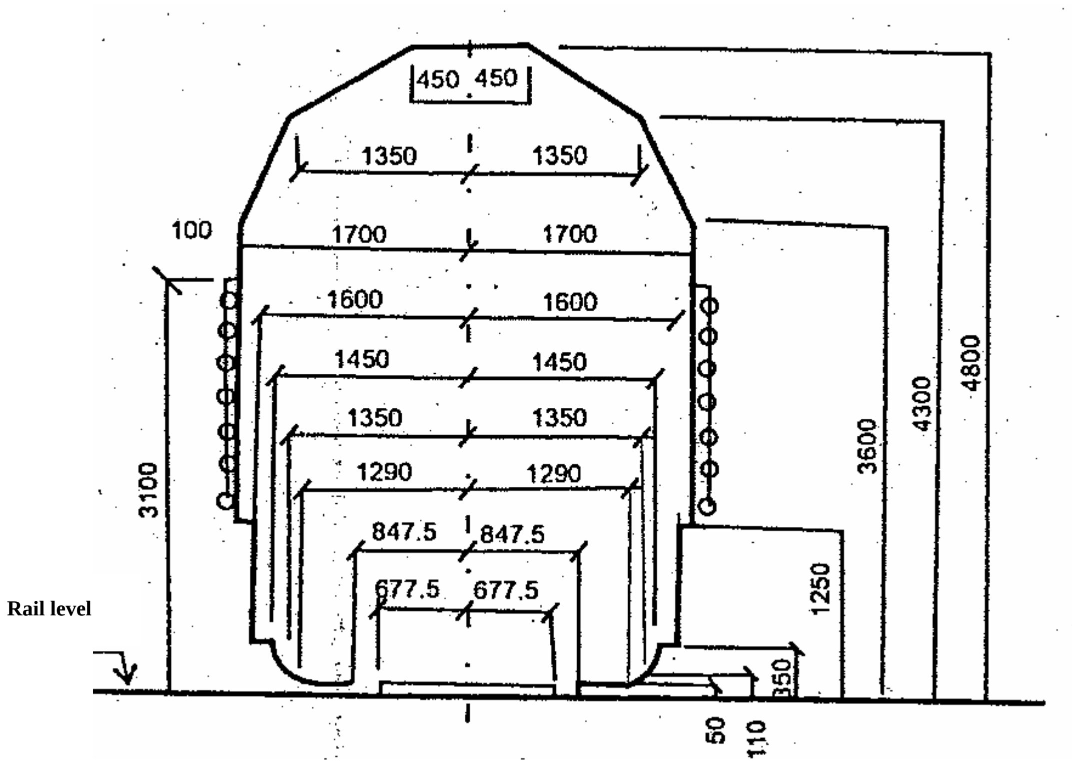
Clearance for signaling device on a train

Clearance for spring part

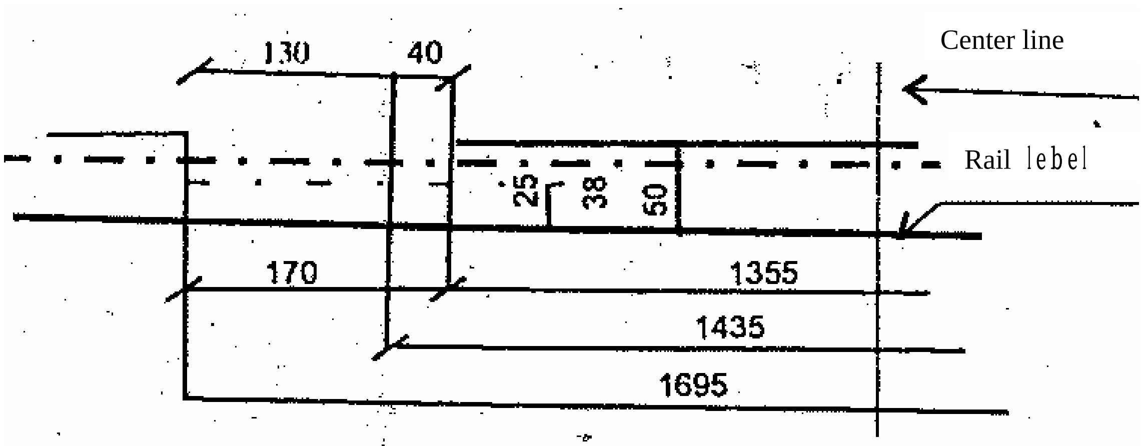
Clearance for brake shoe and sanding device

Figure 1-2 Rolling stock gauge

(1435 mm Gauge)



Rail clearance



Rolling stock gauge

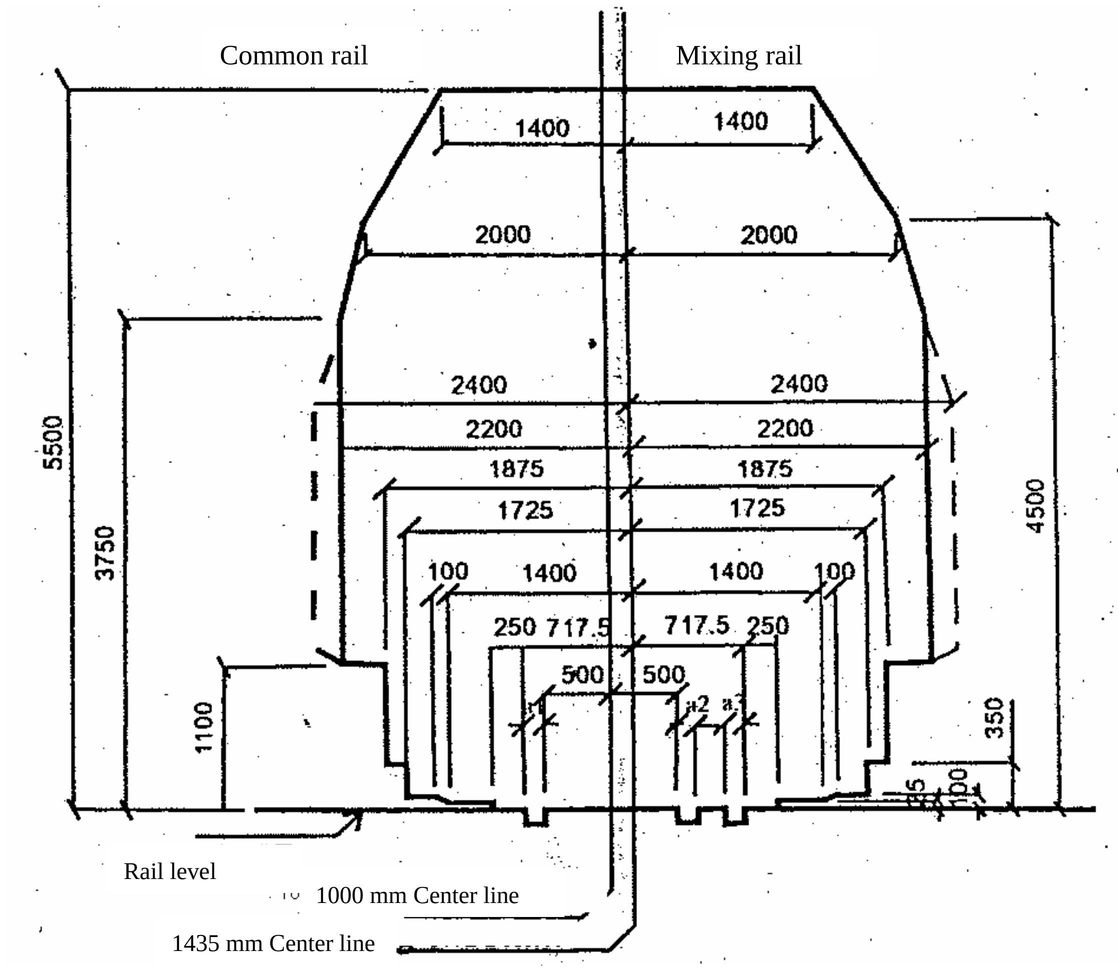
Clearance for signaling device on a train

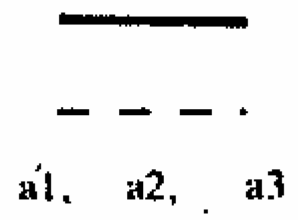
Clearance for spring part

Clearance for brake shoe and sanding device

Attachment 3

Figure 1-DL1 Temporary construction gauge for unmodified item near the connecting line of 1000 mm gauge and 1435 mm gauge





Construction gauge envelop for connecting railway

Construction gauge for 1435 mm gauge

Distance between stock rail and guardrail

Note: The rolling stock, which runs on the line of 1000 mm gauge, has the distance of 1100 mm from rail surface to the bottom of bogie frame, has the width of 3000 mm, and is separately authorized for the purpose such as carrying freight, may exceed the rolling stock gauge.

Figure 1-DL2 Temporary construction gauge for unmodified item near the connecting line of 1000 mm gauge and 1435 mm gauge

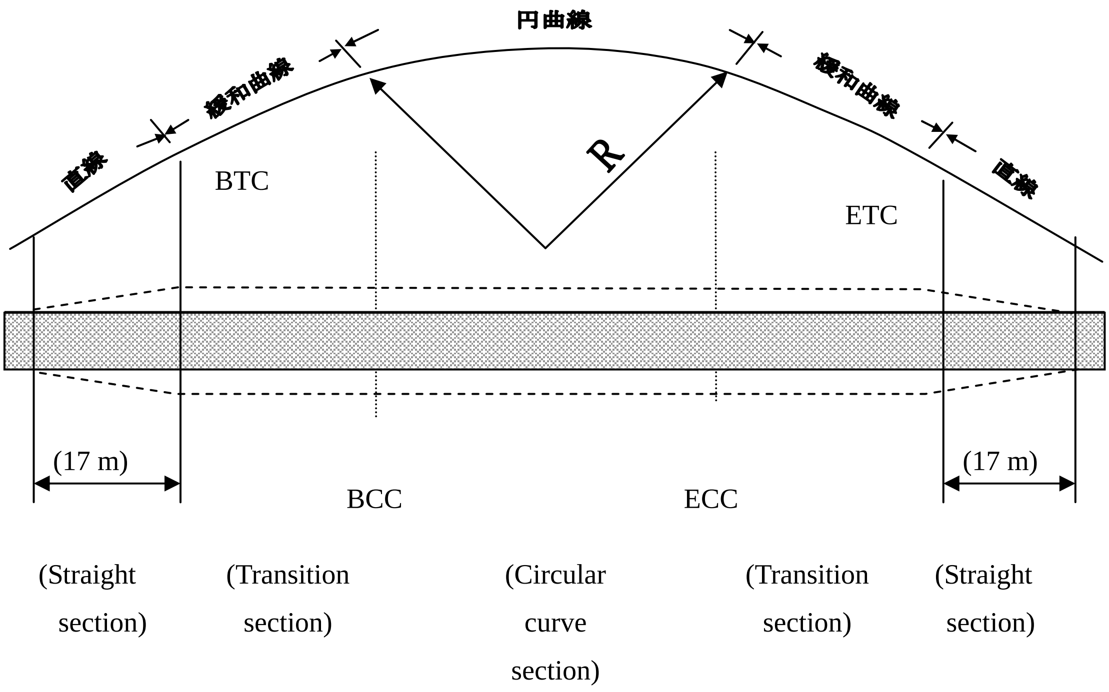


Figure 3 Enlargement of construction gauge in curve section

Section 4 Width of formation level, Minimum distance between track centers

Article 23　Width of formation level

The formation width must be able to maintain the function of track under the considerations of the factors including gauge, track structure, railway utilities and maintenance work, and must comply with the following standards.

1.1 The formation width of ordinary railway (except for high speed railway) must be the values specified in below table or larger.

track class ranking	Design speed	Width of formation level(m)		
		City railway G1435mm	National railway G1000mm	National railway G1435mm
First class line	121km/h~150km/h			4.0m
	101km/h~120km/h	3.1m (3.0m)	2.9m (2.6m)	
Second class line	71km/h~120km/h			3.5m
	61km/h~100km/h	3.1m (2.8m)	2.7m (2.5m)	
Third class line	70km/h			3．1m
	60km/h	2.8m (2.5)m	2．5m	

Note ：The values of lower line show ones in unavoidable case

1) The one side width of formation level (the length from track center line to outer edge) in embankment section and cutting section must allow the load accommodated by track depending on the track structure to be transmitted on roadbed smoothly and must be able to maintain the function of the track. In addition, for the side where personnel carries out work or seeks refuge, the track clearance envelope in the section must be enlarged by 0.6 m or more to assure the safety of personnel and maintenance equipment.

2) The one side width of formation level under (1) must be enlarged by appropriate margin in curve section. The standard enlargement must be calculated from following formula.

$$y = \alpha \cdot C$$

Where, y, α and C indicate following values.

y： Increment to be enlarged (mm)

α： Coefficient calculated at standard cross section of each gauge and a standard value.

(In a case of 1,000 mm gauge, 3.51)

(In a case of 1,435 mm gauge, 3.06)

C： Real cant (mm)

3) The one side width of formation level in the section of other structure such as viaduct must be 2.75 m or larger. However, in a case that any trouble may not occur under the considerations of the factors including track structure and refuge, the value may be reduced.

4) For the bridge without ballast floor and tunnel, etc. where the one side width of formation level may be difficult to be assured for refuge of personnel, the railway operator must install shelters by taking the train speed, etc. into account. In such the case, the shelters must be provided at interval of 50 m.

1.2 The one side width of formation level in high speed railway must be as follows.

1) The one side width of formation level in embankment section and cutting section must be established as 3.8 m for a standard and its lower limit must be 3 m or larger.

2) The one side width of formation level under 1) must be enlarged by appropriate margin in curve section. The formula to calculate the enlargement is similar to that of (1)-2). However, the standard value of α must be as follows.

α: 2.94

3) The one side width of formation level in the section of other structure such as viaduct must be 3 m or larger. However, in a case that any trouble may not occur under the considerations of the factors including refuge, the value may be reduced.

4) The one side width of formation level must be enlarged to 3.5 m or larger for the side where personnel seeks refuge by taking the factors such as wind pressure due to the running of trains into account. However, in a case that the speed is faster than 250 km/h, the railway operator must take required measures to assure the safety of personnel, etc. seeking refuge.

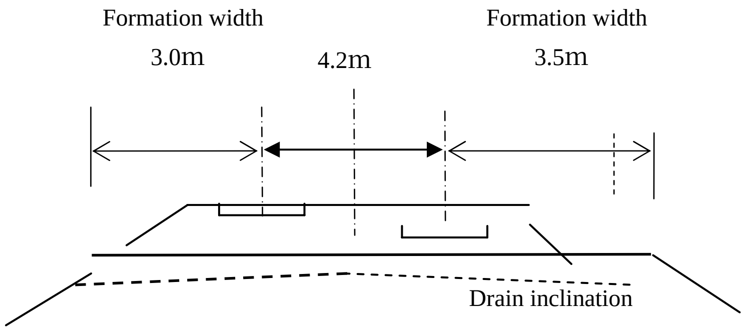


Figure 23.1 Formation width

(high speed railway)

1.3 The standards for formation width in cutting and embankment section must be as follows.

(a) In a case of 1000 mm gauge: Figures 23.2 and 23.4.

(b) In a case of 1435 mm gauge: Figures 23.3, 23.4 and 23.5.

(c) Table 21.1 shows the examples of fundamental cross section of track in earthwork section under the considerations of straight line, curve and embankment height.

1.4 The reference examples of the formation width in viaduct section and tunnel section are shown as follows.

Figures 23.6, 23.7, 23.8 and 23.9.

Figure 23.2

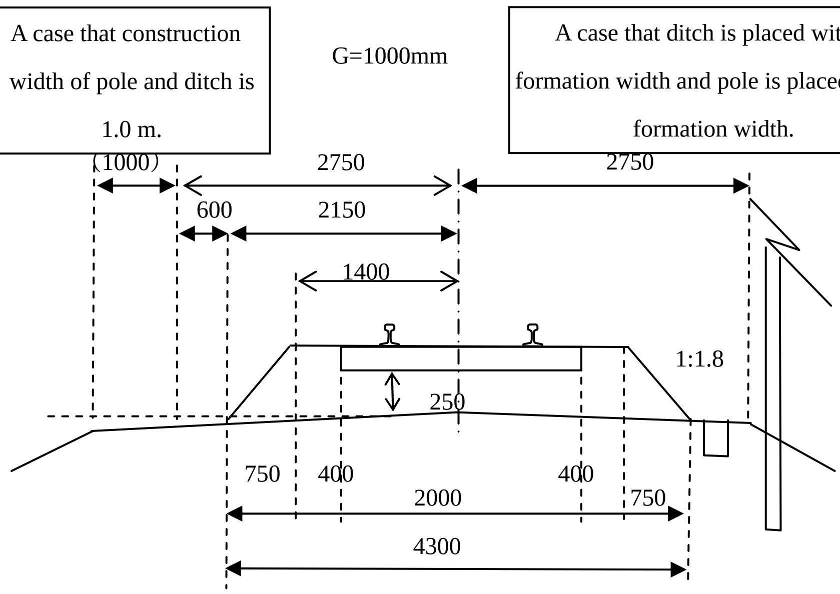


Figure 23.3

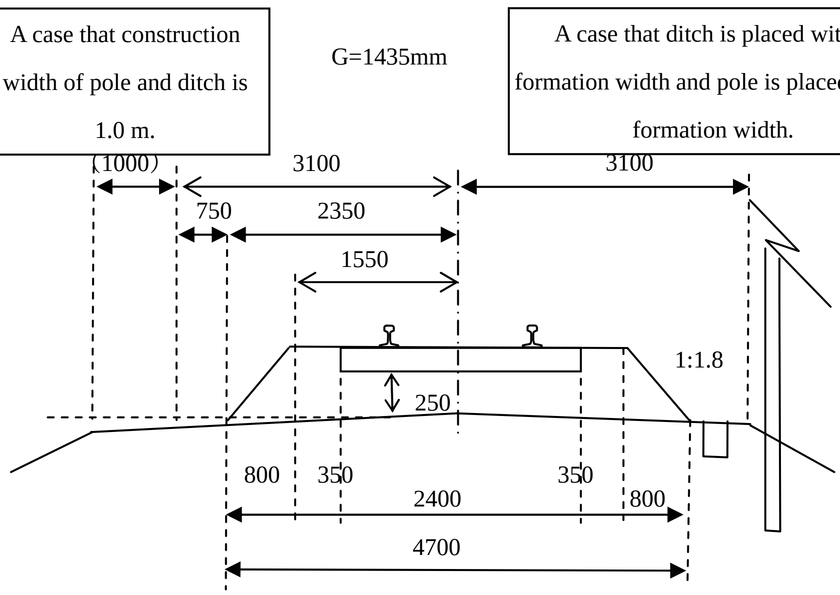
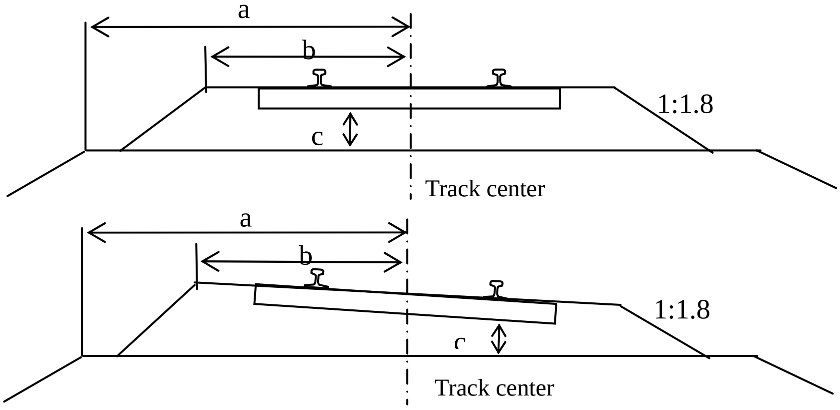


Table 23.1 Example of fundamental cross section of track in ballast section (single track)



(Unit: mm)

Gauge	Track category	Width from track center to formation shoulder (a)			Width from track center to bed shoulder (b)	Bed thickness (c)	Formation width in curve (Outside of curve)
		Height of embankment					
		Lower than 5 m	5 m or higher to lower than 10 m	10 m or higher			
1m435	Class 1 line	3,100	3,400	3,700	1,550	250	(a)＋300
	Class 2 line	3,100	3,400	3,700	1,550	200	
	Class 3 line	2,800	3,100	3,400	1,450	150	
1m000	Class 1 line	2,900	3,200	3,500	1,350	250	(a)＋200
	Class 2 line	2,900	3,200	3,500	1,350	200	
	Class 3 line	2,600	2,900	3,200	1,300	150	

Note 1. The case of curve refers to one that the radius is less than 3000 m.

2. The value of (c) is applied for soil roadbed section (except for concrete structure section).
3. The cross inclination on roadbed shall be 3% in principle and (a) must be enlarged, as necessary.
4. The value of (a) must be enlarged depending on the height of embankment (5 m, 10 m).

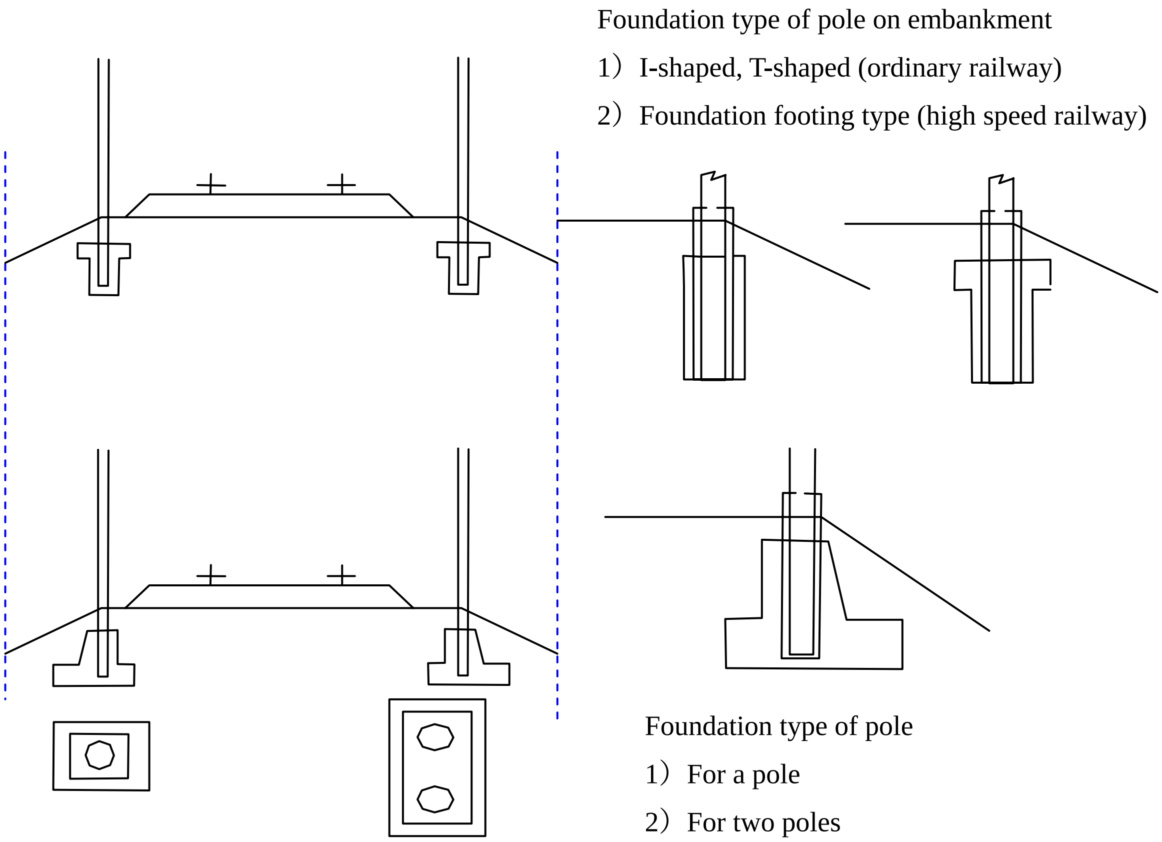
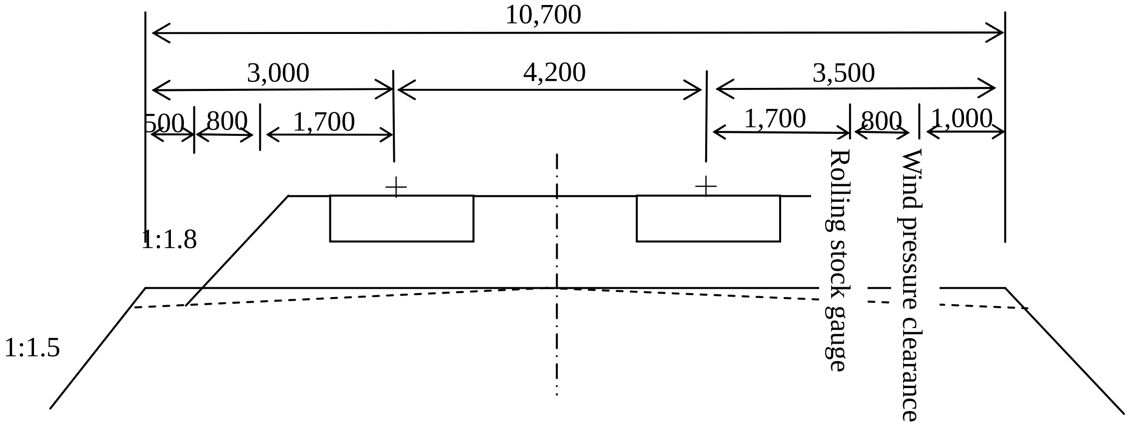
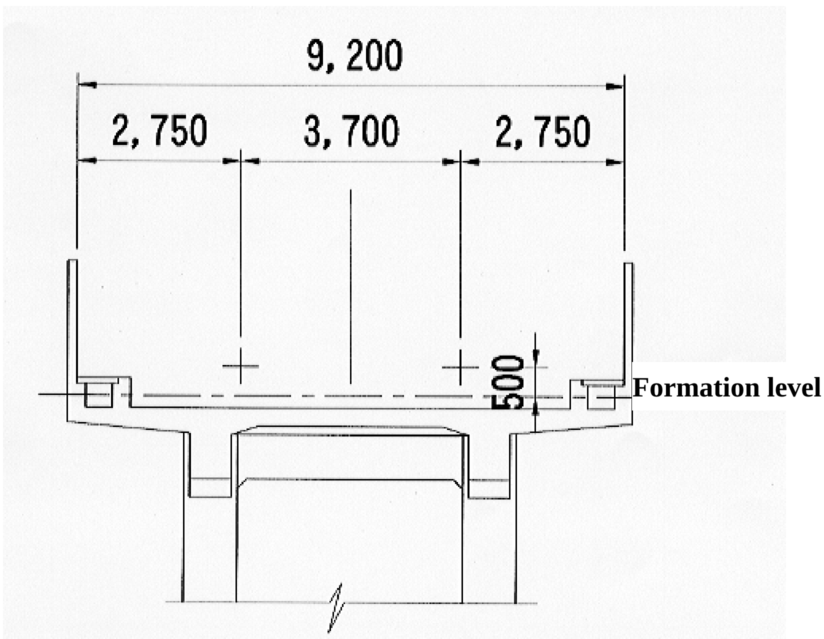


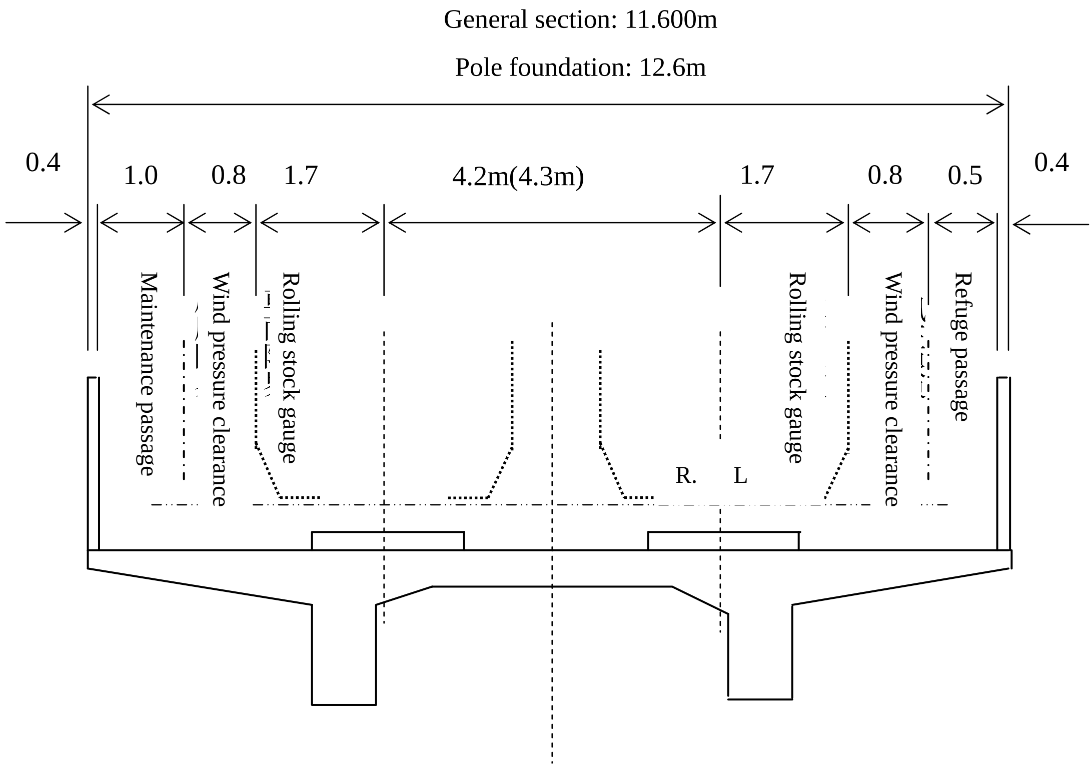
Figure 23-4　Construction examples of pole on embankment



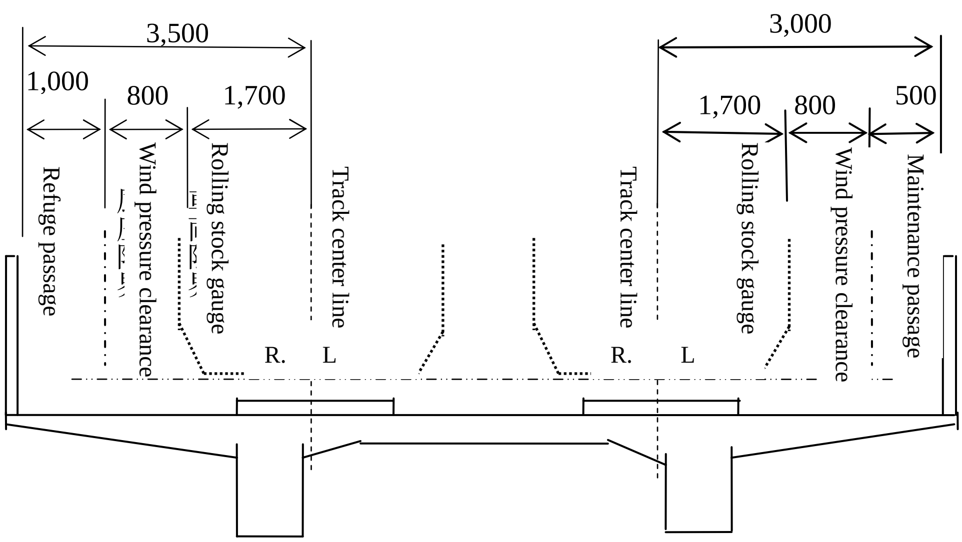
(1) Figure 23.5　Formation width of Shinkansen (earthwork section)



(2) Figure 23.6　Example of formation width in viaduct (gauge: 1,435 mm)



(3) Figure 23.7　Track cross section width of viaduct of Shinkansen



(4) Figure 23.8　Example of formation width (viaduct section) of Shinkansen

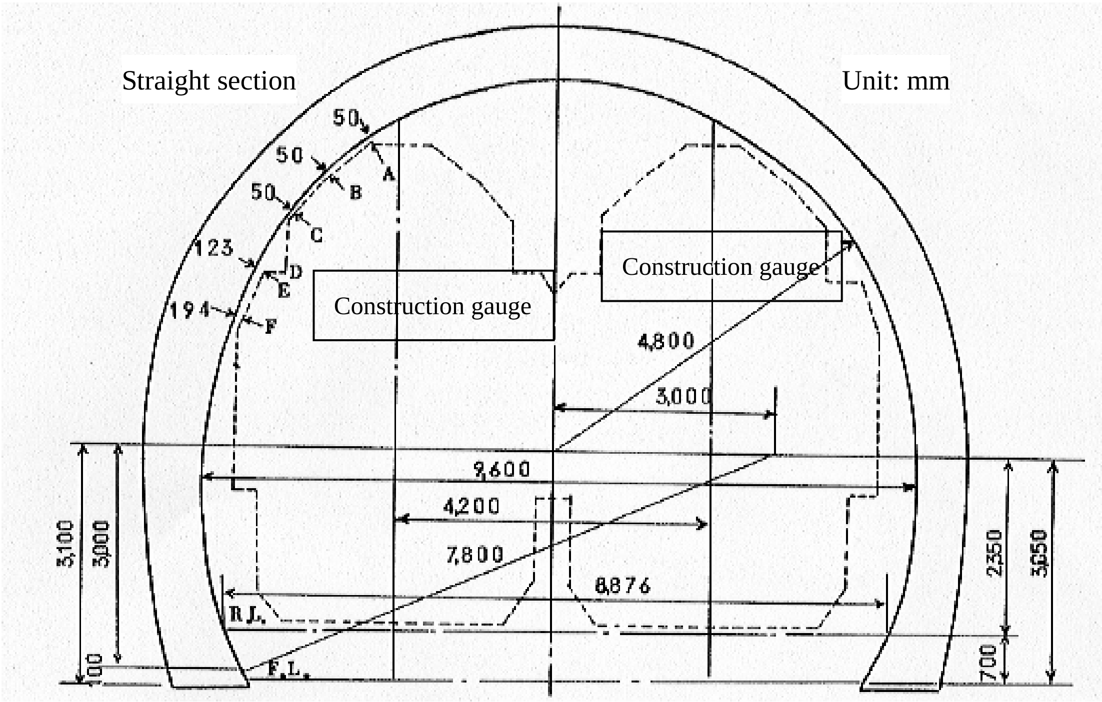


Figure 23.9 Example of formation width (tunnel section) of Shinkansen

Section 5 Railway structure

Article 27　Structures

The earthworks, bridges, tunnels and other structures must meet their purpose, must be economical, and must allow trains to run in safe manner. Therefore, in their design the railway operator must consider their safety, durability against environment and weather conditions, earthquake-resistance, their beauties and maintenance, etc. The structures must be designed based on respective current standards. For the structures, for which current standards can not be applied, or for new technologies, it may be accepted that the railway operator can adopt the design methodologies considered to be as most appropriate under thorough considerations. Generally applied design standards for structures are shown in Table 27.1.

Table 27.1　List of design standards

Structure and item to be considered	Kind of standard design
Track, etc.	Design standards for earthworks. Design standards for foundation structures and retaining structures. Design standards for earthworks for low maintenance tracks.
Bridge, etc.	Design standards for concrete structures. Design standards for steel and synthesized structures. Design standards for steel and concrete composite structures.
Tunnel, etc.	Design standards for mountain tunneling method. Design standards for shield tunnels. Design standards for open cut tunnels.
Common	Design standards for earthquake-resistant structures. Design standards for displacement limitation.

Article 28　Buildings

Architectures refer to the fixed structures on the site including ones having roofs and pillars and walls, their accompanying gates or fences, overbridges, upper buildings of platform, or the offices, stores, theaters, warehouses and other similar facilities installed in underground or in elevated structures, and includes any architectural equipment.

In designing the architectures relating to the operation and security in a track premises, the railway operator must apply the construction design standards for public facilities, structures and housings and the related legislation. In addition, the railway operator must assure appropriate space for track clearance envelope to secure train operation and to prevent any trouble in passenger flow.

Section 6 Safety Facilities

Article 30　facilities for the prevention of a disaster

The railway structures are subjected to natural effects due to precipitation, water rise in river, wind and earthquake, and it may be difficult to entirely prevent potential changes or disasters caused by such the effects. Therefore, the railway operator must appropriately place the instruments including rain gauges, water level gauges, anemometers and seismometers and must establish the handling of alert condition against disasters due to precipitation, water rise in river, wind and earthquake, etc. based on their information.

Example of alert standards for disaster of railway, etc. (in a case of precipitation)

The disaster due to precipitation occurs frequently as an earth and sand disaster of earthwork including embankment and cutting or a mudslide of natural slope. Such the disaster may occur due to precipitation or precipitation intensity. Thus, the railway operator must observe the precipitation to grasp any sign of disaster and to assure the safe operation of trains and must implement the actions including the declaration of alert and the limitation of operation when observed precipitation exceeds prescribed standard value, as follows.

Category	Alert	Limitation of speed	Suspension of operation
	While there is almost no possibility of disaster, a part of its sign may be observed.	In some cases, minor disaster may occur.	Disaster may occur.
Contents of operational limitation		When criteria are reached, the railway operator must limit the speed of trains.	The railway operator must suspend the operation of trains.
Contents of patrol	The railway operator must carry out patrol for prescribed locations by waking, etc. at the interval of 3 – 4 hours.	Besides left requirement, the railway operator must carry out the patrol of whole line by train at the interval of 2 hours.	The railway operator must endeavor to carry out patrol for whole line by walking, etc.
Cancellation standards	When it has been confirmed that rain tends to terminate and hourly precipitation becomes less than declaration criteria. Or, when significant time has been elapsed after precipitation ceased.	When it has been confirmed that there are no troubles at prescribed locations, precipitation becomes less than declaration criteria, and the passage of train has revealed that there are no troubles in whole line.	When precipitation ceases or precipitation becomes less than declaration criteria, and the check by walking, etc has revealed that there are no troubles in whole line.

Chapter 4 Stations

Article 36 Station layout

A station being an infrastructure to transport passengers and freight may be deemed as a railway node consisting of general station, signal station and yard. Thus, a station can realize its function by installing the facilities commensurate with transportation volume and maximum train length. Therefore, the track layout of a station shall be compatible with the operational plan of trains, design speed, the safety assurance of works in a station and maximum train length.

Furthermore, there may be a case that the provision of transportation service along with social development, the convenience of transfer, shortening transit route, inter through operation between lines and any connection with planned future line should be considered.

2. The track layout must be appropriately planned by referring to below list of items to be considered.

(1) List of items to be considered:

Category of station: passenger station, freight station or hybrid station;

Category of station in terms of transportation: terminal, intermediate station, junction station;

Station main building of passenger station: ground station, over-track station, elevated station, underground station;

Line capacity: maximum number of trains operable per day in a line;

Category of line: main track, passing track, service track;

Measure to enlarge line capacity: sheltering track (crossing facility, passing facility), turning back facility, signal facility, operational handling of arrival and departure, shortening stoppage time, modifying operational schedule of trains, and adding arrival / departure tracks and storage tracks;

Passing speed of trains in station premises: passing speed at turnout;

Category of intermediate station: station, at which all trains stop, station, at which some trains pass through;

Category of platform: opposite platform and island platform;

Inclination of track in a station: level;

Linearity of a station: linear;

Location of a station: distance between stations, location of the station, connection with other transportation infrastructures, passenger connecting facilities, road traffic, buildings along the line;

Functions of freight station: loading and unloading track, arrival and departure track (arrival track and departure track), lead track, coupling and decoupling track, sorting track, shunting track, storage track; and

Function of depot line: storage track, inspection track, repair track, washing track.

(2) List of items to be checked:

Line class, construction gauge, platform clearance, track center interval, formation level, inclination, longitudinal curve, planer curve, transition curve, design maximum speed, number of turnout, effective length of track, safety margin for overrunning, buffer stop and safety track.

3. Vehicle maintenance and repair shops are classified as follows.
・Electric car base, diesel railcar base, passenger car base, locomotive base, freight car base and general railcar base.
Normal track facilities of vehicle maintenance and repair shop include:
・entering and exiting track, arrival and departure track, storage track, shunting track, washing track, inspection track, and repair track.
Vehicle maintenance and repair shop has following facilities, as necessary.
・lead track, trial operation track, wheel turning track and depot track (warehouse track).

4. Change of track layout
The track layout of new station relating to commercial line(s) and any modification to the track layout of existing station must be considered by taking the process for changing the track layout into account. The process in change of the track layout shall appropriately combine the insertion / removal of turnouts and the track change by track skeleton movement.

Article 37 Station facilities

１. Appropriate facilities required for the handling of passengers or freight are as follows and shall include equipment commensurate with the volume of entrainment and detrainment or handled quantity of freight, etc.

(1) The facilities of station required for the handling of passengers include platform, flow installation (passages, concourses, stairways, overbridges, elevators and escalators, etc.), facility for passenger service (ticketing), queue facility (ticket counter and waiting room), service facilities (facilities for station work), rest rooms and illumination facility, etc.

(2) The facilities of station required for the handling of freight include the loading and unloading facilities of freight (platform and loading and unloading facility of container arrival and departure track), freight passage, freight sorting storage facilities, related buildings (station main building, storage and personnel office) and customs related facilities, etc.

2. Equipment to provide passengers with helpful information means the equipment for appropriately guiding passengers to the station facilities such as ticket gate, concourses, platforms and rest rooms. Such the equipment includes guidance signs, location signs, guide signs and control sign, etc.

Article 38　Platforms

Platform shall not endanger the safety of the usage of passengers and must comply with the following standards.

(1) The effective length of railway platform must cover the maximum length from the forefront passenger car to the last passenger car on the train that may stop at the platform, and must not cause any trouble when safe and smooth getting on and off of passengers. However, in a case unavoidable from any reason such as train operation and that the volume of entrainment and detrainment will be not large on the platform, if the railway operator implements no handling of doors and take the measure such as public announcement to prevent any hazard that passengers will fall, the railway operator may shorten the effective length of a platform than the train length stopping at it.

(2) The width of a platform must be as follows.

1) The width of platform in normal railway (except for high speed railway) and special railway must be 3 m or more at the center and 2 m or more at the end for the platform using its both sides, and 2 m or more at the center and 1.5 m or more at the end for the platform using its one side.

2) The width of platform in high speed railway must be 9 m or more for the platform using its both sides and 5 m or more for the platform using its one side. However, the width at the end of a platform along curve may be 5 m or more for the platform using its both sides and 4 m or more for the platform using its one side.

(3) The distance from platform edge to poles and the wall of overbridge entrance, etc. on a platform in normal railway (except high speed railway) and special railway must be as follows.

1) The distance from platform edge to poles on a platform must be 1.0 m or more.

2) The distance from platform edge to overbridge entrance, underground passage entrance and waiting room, etc. on a platform must be 1.5 m or more.

3) The requirements of above 1) and 2) may not apply to the platform where facilities such as platform doors to sufficiently protect passengers against trains (hereinafter referred to as “platform doors, etc.”) are installed.

4) For a platform where platform doors, etc. are installed, the distance from platform edge to overbridge entrance, underground passage entrance and waiting room, etc. on a platform must be 1.2 m or more (at the location where there may be no disturbance to getting on and off of passengers, 0.9 m or more).

(4) The distance from platform edge to poles and the wall of overbridge entrance, etc. on a platform in high speed railway must be as follows.

1) The distance from platform edge to poles on a platform must be 2 m or more.

2) The distance from platform edge to overbridge entrance, underground passage entrance and waiting room, etc. on a platform must be 2.5 m or more (on a platform where some trains pass through and do not stop, 3 m or more).

3) The requirements of above   and   may not apply to the platform where platform doors, etc. are installed.

4) For the platform where platform doors, etc. are installed, the requirement of above (3) 4) must apply.

(5) To assure the safety of passengers on a platform, the railway operator must take the following measures based on train speed, the number of trains operated and operation scheme, etc.

1) As essential requirements from the viewpoint of safety to assure the passenger movement, the railway operator takes the following standard measures.

(a) The floor of a platform and passenger doors of train should be as flat as possible.

(b) The gap between platform edge and the edge of floor or entrance / exit step of passenger car should be as narrow as possible within the range not endangering the train operation. However, in a case that such the gap is unwillingly large from structural reason; the railway operator must provide any equipment to call passenger's attention to it.

(c) At the end other than track side of a platform, the railway operator must install fence to prevent any fall of passengers. However, in a case that a stairway is installed at such the end and thereby passengers may not fall, the requirement may not apply.

(d) The railway operator must so finish the platform floor surface to allow passengers to walk without slipping hazard.

(e) The railway operator must provide the facility to warn passengers on a platform against approaching train by the means such as characters and the facility to warn similarly by voice. However, in an unavoidable case from technical reason such as the case that electrical equipment is unavailable; the railway operator must arrange appropriate personnel.

2) The railway operator must so finish the hem stones on platform edge to prevent slippage by the method such as attaching non-slip member.

3) In a case of a platform in ordinary railway that a train may pass it at speed over 130 km/h, the railway operator must take one of the following measures based on the speed of passing train and train shape, etc.

(a) Installation of movable platform fence, etc.

(b) A measure not allowing passengers to enter the platform when train passes it.

(c) Assurance of passenger's safety by the measure such as warning from platform personnel.

4) In straddled type railway or suspended railway, the railway operator must take the following measures for a platform in a section where train speed is high and the volume of train operation is large, to secure passenger's safety. However, the requirement may not apply to the case that platform doors, etc. are installed.

(a) Installation of emergency train stop buttons to stop train at emergency situation and falling detection mats.

(b) Provision of sheltering space under a platform along its whole length to allow fallen passenger to seek refuge. However, in an unavoidable case due to structure, the railway operator may install steps to allow passenger to return on a platform

5) For a railway platform where personnel operating power car does not get on, the railway operator must install platform doors or movable platform fences.

(6) In clause (1), "a case unavoidable from any reason such as train operation" and "the measure to prevent any hazard that passengers will fall" in "the case that the railway operator may shorten the effective length of a platform than the train length stopping at it" are specified as follows.

	A case unavoidable from any reason such as train operation
A case that the resolution may be difficult due to a reason such as terrain problem (e.g., presence of crossing or river at platform end) and even if after consultation, and the reinforcement of transportation capacity may be regarded as urgent, when extending a platform due to reason such as the reinforcement of transportation capacity.	1) Implements no handling of doors, and 2) Carries out public announcement.
A case that the railway operator stops extra train, etc. operated to meet temporary demand.	1) Implements no handling of doors or equivalent measures or carries out the guidance when getting off, and 2) Carries out public announcement.

(7) In clause (3) 3), "facilities such as platform doors to sufficiently protect passengers against trains (hereinafter referred to as "platform doors, etc.")" shall include movable platform fence and not include fixed fence.

(8) The requirement of clause (3) 4) applies to a location where fixed fence is installed in a platform provided with fixed fence.

(9) In the clause (5) 3), "movable platform fence, etc." shall not include fixed fence.

Article 39　Passenger ways

To assure the smooth flow of passengers and to prevent the fall of passengers from passenger stairway, the width of passenger passage and passenger stairway must comply with the following standards.

(1) The width of passenger passage and passenger stairway must be 1.5 m or more.

(2) For passenger stairway, the railway operator must provide landing at every height of about 3 m.

(3) For passenger stairway, the railway operator must install handrail.

2. In principle, the passenger passages among platforms shall not cross with track in a level. However, they may cross with infrequently used track in a level. In a case of level crossing, the railway operator must take the safety measures including the installation of train approach warning bell for passengers.

3. The railway operator must take the measures to be taken for promoting easily accessible public transportation specified in Article 8.

Article 40　Facilities of underground station, etc.

For underground railway, fresh air shall be introduced into it to prevent any temperature rise due to exhausted heat from train operation, heat from illumination and electrical equipment, etc., and to suppress the concentration increase of carbon dioxide, etc. due to passengers getting on and off. Therefore, the railway operator must adopt appropriate ventilation scheme or ventilation facilities by considering the cross section and length of tunnel, groundwater and geology in the vicinity of tunnel, the type, construction, operation frequency and air-conditioning of passing trains, the illumination facilities, station facilities and the volume of entrainment and detrainment, etc. Furthermore, these ventilation facilities must function also as the smoke exhaustion facilities when fire. The standard ventilation type shall be the longitudinal flow type for single track cross section and the intermediate ventilation type for double track cross section.

2. Fire prevention and fighting measures for underground station, etc. must comply with the following standards.

1) Application range

These standards shall apply to underground stations and tunnels connected to underground stations. “Underground station” means the station with underground platform (except for the station placed in mountainous district).

2) Incombustibility of structures, etc.

(1) The railway operator must endeavor to realize incombustibility of the structures in accordance with the following standards.

1) Structural materials and interior decorations (including foundation) must be incombustible materials. However, the interior decorations of floor and wall (limited to the finished portion lower than or equal to 1.2 m from floor level) in the staying room of traffic control station, electric power control station, signal control station and disaster management room, etc. (hereinafter referred to as “staying room”) should be as incombustible as possible.

2) For furniture such as desks and lockers, the railway operator should not use combustible ones.

3) Substation, power distribution station and machinery room must be separated from other part by fire resistant floor, wall or fire door. In a case that cable, etc. penetrates the compartment, the railway operator must fill any gap of the penetration with incombustible material.

The fire door shall be equipped with automatic closing device such as door closer.

(2) Station store (limited to simple type) shall be constructed by incombustible structural materials, interior decoration and bookshelf, etc.

(3) Since underground railway may form a closed space, to prevent potential explosion the railway operator must not install any gas facility.

3) Preparation of disaster management room

(1) For a station the railway operator must prepare the disaster management room where personnel is stationed for the duties including information collection, communication and command transmission, public announcement for passengers, and monitoring / control of fire shutters, etc. In this case, the railway operator should so locate the disaster management room that it is attached to station office.

(2) In the disaster management room the railway operator must install illumination facility, which can be automatically turned on or maintained by emergency power supply when normal power is lost.

(3) Emergency power supply shall be storage battery facility or a private electric generator. The same shall apply to following emergency power supply.

4) Preparation of alarm facilities, notice facilities and evacuee guidance facilities, etc.

(1) Alarm facilities

1) The railway operator must install automatic fire alarm in a station and provide their receiver in the disaster management room.

2) The sensors of automatic fire alarm facility must be placed in staying rooms, station stores, substations, power distribution stations and machinery rooms, etc., and automatic fire alarm facility must be provided with emergency power supply.

(2) Notice facilities

1) The railway operator must install the following notice facilities in a station.

(a) Communication facilities allowing the communication among the disaster management room, fire station, police, operation control station, power control station, every locations in a station (staying rooms, both ends of platform and principal locations in the area controlled by the station) and related adjacent buildings, etc.

(b) Broadcasting facility controlled by the disaster management room (the broadcasting from the disaster management room must be able to cover platforms, concourses and passages, etc. controlled by the station).

(c) Wireless communication auxiliary facilities

2) The railway operator must install the communication facilities between stations to allow the communication from trains and tunnels to an operation control station. In this case, the communication facilities allowing the communication from tunnel to an operation control station must be located at interval of 250 m or shorter in a tunnel.

3) The communication facilities and the broadcasting facilities must be provided with emergency power supply.

(3) Evacuee guidance facilities

1) The railway operator must install the following facilities in a station.

(a) Different two or more evacuation routes from platform to ground

Different evacuation route means that all the points along an evacuation route do not overlap that of other evacuation route at all.

In this case, evacuation passages (stairways are limited to ones of the structure not spiral staircase) must allow passengers to evacuate to ground in safe manner and their length to ground must be as short as possible. In addition, they must allow passengers to reach ground only by upward movement from platform in principle. However, the requirement may not apply to a case that passengers evacuate down from platform to adjacent structure or a case that passengers go down from a platform to another platform in an opposite platform type and any obstacle against smoke flow is placed between tracks. In a platform, the distance from the end of platform to entrance / exit of nearest evacuation passage must be as short as possible.

(b) Illumination facility, which can be automatically and instantaneously turned on or maintained by emergency power supply and assure the illumination higher than or equal to one lux at principal area of floor when normal power is lost.

(c) Evacuation exit guide lights and passage guide lights

The railway operator must install the evacuation exit guide lights at evacuation exits and the passage guide lights indicating evacuation direction along passage.

However, in a case that the distance from the end of platform to entrance / exit of nearest evacuation passage is long, the railway operator must install the passage guide lights on floor or lower section of wall, etc.

2) Between stations, the railway operator must install the following facilities.

(a) Illumination facility, which can be rapidly turned on or maintained by emergency power supply and assure the illumination higher than or equal to one lux at principal area of road surface during evacuation when normal power is lost.

(b) Signs indicating the distance and direction to a station or tunnel entrance. The signs shall be provided at the locations near the illumination equipment by emergency power supply.

The signs must be located at the height lower than or equal to 1.5 m from the road surface used as a passage during evacuation and at interval of 100 m or shorter in sufficiently understandable manner.

(4) Smoke exhaustion facilities

1) The railway operator must install smoke exhaustion facilities to assure safe evacuation of passengers in a station and between stations, as necessary.

(a) Required smoke exhaustion rate, etc. must be calculated according to Attachment 1.

(b) It is acceptable to use the smoke exhaustion facilities as mechanical ventilation facilities.

(c) In a case that smoke exhaustion effect from a tunnel can be sufficiently expected also by natural ventilation ports due to longitudinal linearity of tunnel, smoke exhaustion machineries may not be installed.

(d) Smoke exhaustion facilities requiring electric power must be provided with emergency power supply.

2) The railway operator must install a measure such as hung down wall, etc. to prevent smoke flow between platform and track, and at locations of stairway and escalator, etc. in a station, as necessary.

In this case, a measure to prevent smoke flow means a hung down wall projecting downward from ceiling and an object having its equivalent or more effect to prevent smoke flow (including a measure, which goes down by an interlocking with sensors and also can go down by remote operation from the disaster management room), which is made of or covered by incombustible material.

(5) Fire door, etc.

1) The railway operator must install a fire door, etc. (a hinged door or a fire door with sliding door or a fire shutter (limited to one moving up and down), the same shall apply to following fire door, etc.) at a underground location where a station communicates with a station of other line (except for a station using same platform) and underground street, etc.

2) The railway operator must install a fire door, etc. at evacuation stairway, etc of a platform and at locations required for the safe evacuation of passengers.

In this case, fire shutter shall go down to the height of 2 m from floor by an interlocking with sensors and also can go down by remote operation from the disaster management room. The fire shutter must be two steps down structure. Namely, the shutter must be designed to close by the operation of personnel where it is installed. Falling and close of fire shutters shall be confirmed from the disaster management room.

(6) Others

1) The railway operator must provide a station with self contained breathing apparatuses. In this case, installed number of such the self contained breathing apparatuses must be larger than or equal to the number of the personnel engaged in the duties such as rescuing passengers, distinguishing fire and guiding fire fighting personnel.

2) The railway operator must install dedicated ventilation facility for a substation. However, in a case that dedicated ventilation facility may be difficult to be installed for existing substation, the railway operator must install fire damper at its ventilation port.

3) The railway operator must not install station shop at the location disturbing the evacuation of passengers and between the end of platform and the entrance / exit to nearest evacuation passage.

4) The railway operator must take the measure to set fire and smoke compartment for convenience type station stores.

5) The railway operator must provide emergency electrical outlet facility in each story of fourth or lower basement levels where the total floor area of the fourth or lower basement levels is 1,000 m^2 or larger in a station.

6) The emergency electrical outlet facilities must be provided with emergency power supply.

7) In a station, the distance from each part of staying room to evacuation entrance shall be shorter than or equal to 100 m.

8) The section used as a passage during evacuation between stations must have a structure not disturbing evacuation.

5) Fire extinguishing facilities

(1) The railway operator must provide a station with the following equipment and facilities.

1) Fire extinguishers

The railway operator must place fire extinguishers at the location deemed as necessary for fire fighting activity in a station.

2) In-door fire hydrant facility

The railway operator must install in-door fire hydrant facility at the locations deemed as necessary for fire fighting activity in a station and provide them with emergency power supply.

3) Connected water spray system or sprinkler system with water supply port

The railway operator must install connected water spray system or sprinkler system with water supply port for staying room (except for the room related to operational security), etc.

The railway operator must install sprinkler system with water supply port for convenience type station stores.

4) Connected water supply line

The railway operator must install connected water supply line in a station and the discharge port shall be provided at the locations deemed as necessary for fire fighting activity in platform, concourse and passage. However, in a case that in-door fire hydrant facility with water supply port is installed and deemed as effective for fire fighting activity, the requirement may not apply.

(2) The railway operator must install connected water supply line between stations when the distance to the discharge port of connected water supply line installed in a platform of adjacent station is longer than 500 m.

The interval among discharge ports of connected water supply line must be the distance deemed as necessary for fire fighting activity.

6) Maintenance of fire fighting facilities

The railway operator must maintain fire fighting facilities by checking their function at once or more a year in principle.

7) The railway operator must install indication facilities to provide passengers with following information in a station.

(1) A principle that train shall run and shelter to next station when fire occurs in the train running in a tunnel.

(2) Passengers can evacuate from the front and rear of a train.

(3) Information required for the safe evacuation of passengers in emergency situation, for example, evacuation route diagram, etc.

8) The railway operator must provide a station with the instruction manuals, etc. specifying the following items relating to the actions by personnel against fire event, education and training, and cooperation with fire fighting organization. Such the manuals, etc. shall be established after thorough consultation with fire fighting organization.

(1) The rule for the actions by personnel when fire event.

(2) The method, etc. of education and training (which mainly refers to the training on initial fire fighting and guidance for evacuees) for personnel.

(3) The rule for provision of helpful information for fire fighting activity to fire fighting organization.

Attachment 1

Required smoke exhaustion rate, etc. for smoke exhaustion facilities of underground station shall be calculated by the procedures such as following collation method.

Ⅰ Smoke exhaustion measures at platform story and concourse story

1 Postulated fire and the collation method of evacuation safety

Postulated fire in rolling stock and station shall be classified into normal fire and large fire source fire (Attachment Table 29.1).

The collation method of evacuation safety should be applied according to the following assumptions depending on the characteristics such as fire property and smoke flowing nature in the basic principle that passengers can evacuate to a shelter (finally to ground).

Attachment Table 40.1 Postulated fire

Fire	Kind	Fire source
Normal fire	Rolling stock	Outbreak of fire from rolling stock underfloor equipment
	Shop	Arson by lighter, etc.
Large fire source fire	Rolling stock	Arson with gasoline
	Shop	Arson with gasoline

(1) In a case of normal fire, the collation should be carried out by smoke concentration (light attenuation coefficient) Cs in platform story, or smoke diffusion volume V of a concourse.

(2) In a case of large fire source fire, the collation should be carried out by the elapsing time until that smoke descends to a height endangering evacuation.

The acceptable values in each collation are as follows.

1) In a case of normal fire at platform story, smoke concentration Cs shall be: $Cs \leq 0.1(1/m)$.

2) In a case of normal fire at concourse story, the volume shall be greater than or equal to the smoke diffusion volume calculated from evacuation time.

3) In a case of large fire source fire, the height from floor used for evacuation to bottom of smoke layer shall be greater than or equal to 2.0 m.

2 Calculation of evacuation time

Queue time to calculate evacuation time shall be determined by below formula.

$$T = Q / (N \times B)$$

T: Queue time (sec)

Q: Number of evacuees (persons)

N: Discharge coefficient of crowd (persons/m/sec)

B: Parameter such as width of stairway (m)

Waking speed and discharge coefficient used for calculating the necessary walking time t and the queue time T in an evacuation route shall be as follows.

Walking speed: Horizontal section 1.0 (m/sec) Stairway section 0.5 (m/sec)

Discharge coefficient: Horizontal section 1.5 (persons/m/sec)

Stairway section 1.3 (persons/m/sec)

3 Calculation method of the number of evacuees

The number of evacuees in the collation of evacuation safety is shown for each postulated fire in bellow table. In a case that fire is postulated in concourse, if no shop is installed in the concourse of a station, number of evacuees may be assumed as zero.

(1) Station in top three metropolitan districts

1) Island platform station

Postulated fire		Assumption number of passengers／passenger capacity (%)			Assumption number of passengers／passenger capacity (%)	
		Passenger car	Passengers waiting on a platform		Without first train	With first train
			Without first train	With first train		
Vehicle	Normal	200	—	—	200	200
	Large source	200	75(150)	125(200)	275(350)	325(400)
Platform shop	Normal	200	75(150)	125(200)	275(350)	325(400)
	Large source	200	75(150)	125(200)	275(350)	325(400)
Concourse	Normal	—	75(150)	125(200)	75(150)	125(200)
	Large source	—	75(150)	125(200)	75(150)	125(200)

2) Opposite platforms and single platform station

Postulated fire		Assumption number of passengers／passenger capacity (%)			Assumption number of passengers／passenger capacity (%)	
		Passenger car	Passengers waiting on a platform		Without first train	With first train
			Without first train	With first train		
Vehicle	Normal	200	—	—	200	200
	Large source	200	50(100)	100(200)	250(300)	300(350)
Platform shop	Normal	200	50(100)	100(200)	250(300)	300(350)
	Large source	200	50(100)	100(200)	250(300)	300(350)
Concourse	Normal	—	50(100)	100(200)	50(100)	100(150)
	Large source	—	50(100)	100(200)	50(100)	100(150)

(2) Station in the area other than top three metropolitan districts

1) Island platform station

Postulated fire		Assumption number of passengers／passenger capacity (%)			Assumption number of passengers／passenger capacity (%)	
		Passenger car	Passengers waiting on a platform		Without first train	With first train
			Without first train	With first train		
Vehicle	Normal	150	—	—	150	150
	Large source	150	60(115)	95(150)	210(265)	245(300)
Platform shop	Normal	150	60(115)	95(150)	210(265)	245(300)
	Large source	150	60(115)	95(150)	210(265)	245(300)
Concourse	Normal	—	60(115)	95(150)	60(115)	95(150)
	Large source	—	60(115)	95(150)	60(115)	95(150)

2) Opposite platforms and single platform station

Postulated fire		Assumption number of passengers／passenger capacity (%)			Assumption number of passengers／passenger capacity (%)	
		Passenger car	Passengers waiting on a platform		Without first train	With first train
			Without first train	With first train		
Vehicle	Normal	150	—	—	150	150
	Large source	150	40(75)	75(115)	190(225)	225(265)
Platform shop	Normal	150	40(75)	75(115)	190(225)	225(265)
	Large source	150	40(75)	75(115)	190(225)	225(265)
Concourse	Normal	—	40(75)	75(115)	40(75)	75(115)
	Large source	—	40(75)	75(115)	40(75)	75(115)

Note: 1. The numbers in （ ） of each table indicate the set value in terminal station.

2. Terminal station refers to a station that the volumes of entrainment and detrainment in daily average are larger than or equal to 100,000.

3. Top three metropolitan districts mean:

Existing city areas specified by Article 2, Metropolitan Development Law (Law No. 83, 1956) (Special wards, Musashino Shi and Mitaka Shi of Tokyo metropolitan area; Yokohama Shi and Kawasaki Shi of Kanagawa Prefecture; and Kawaguchi Shi of Saitama Prefecture),

Existing city areas specified by Article 2, Kinki Bloc Development Law (Law No. 129, 1963) (Kyoto Shi, Kyoto Fu; Osaka Shi, Moriguchi Shi, Fuse Shi, Higashi-Osaka Shi and Sakai Shi of Osaka Fu; and Kobe Shi, Amagasaki Shi, Nishinomiya Shi and Ashiya Shi of Hyogo Prefecture), and

Of the city areas specified by Article 2, Chubu Bloc Development Law (Law No. 102, 1966), Area (Nagoya Shi of Aichi Prefecture) specified in Attachment Table, “Law Enforcement Ordinance on Special Measures of National Finance for Development of Peripheral Development Areas of Metropolitan District, Kinki Bloc and Chubu Bloc”.

4. Collation method for normal fire

4.1 Collation of smoke concentration in platform story

Smoke concentration Cs at evacuation completion time t shall be calculated by calculating fire point block volume at platform story and then using below formulas depending on postulated fire and evacuation completion time (result is rounded off to the second decimal place). Then, it shall be confirmed that Cs is less than or equal to the acceptable concentration 0.1 (1/m).

(1) Vehicle fire

1) In a case that evacuation completion time is shorter than or equal to 7 minutes:

$Cs=21 \cdot (1-e^{-Ve \cdot t/V})/Ve$

2) In a case that evacuation completion time is longer than 7 minutes:

$Cs=(66 \cdot V \cdot e^{-Ve \cdot (t-7)/V}-21 \cdot Ve \cdot e^{-Ve \cdot t/V}+66 \cdot Ve \cdot t-441 \cdot Ve-66V)/Ve^2$

(2) Shop fire

1) In a case that evacuation completion time is shorter than or equal to 10 minutes:

$Cs=2.1 \cdot (Ve \cdot t-V+V \cdot e^{-Ve \cdot t/V})/Ve^2$

2) In a case that evacuation completion time is longer than 10 minutes to 11 minutes inclusive:

$Cs=\{(24 \cdot V-21 \cdot Ve) \cdot e^{-Ve \cdot (t-10)/V}+24 \cdot Ve \cdot t-198 \cdot Ve-26.1 \cdot V+2.1 \cdot V \cdot e^{-10 \cdot Ve/V}\}/Ve^2$

3) In a case that evacuation completion time is longer than 11 minutes:

$Cs=\{(1.8 \cdot V-45 \cdot Ve) \cdot e^{-Ve \cdot (t-11)/V}+1.8 \cdot Ve \cdot t+91.2 \cdot Ve-27.9 \cdot V+2.1 \cdot V \cdot e^{-10 \cdot Ve/V}+(24 \cdot V-21 \cdot Ve) \cdot e^{-Ve/V}\}/Ve^2$

Where, Cs: Smoke concentration (1/m)

V: Fire point block volume (m^3)

t: Evacuation completion time (min)

Ve: Ventilation rate of smoke exhaustion facility per fire point block volume (m^3/min)

If no shop is installed on a platform story, set t＝0 (Cs＝0).

(3) Fire point block volume

Fire point block volume means a space where smoke concentration is estimated as maximum, in the space where smoke diffuses in a platform when train fire occurs.

Fire point block should be determined as follows.

a.. The cross section perpendicular to track should be determined as shown in Attachment Figure 29.1 and for the station structure other than that of the figure, the assumption similar to that of the figure should be adopted.

b. The cross sectional area is determined by subtracting the cross sectional area of vehicle from the cross sectional area where smoke diffuses and is illustrated by the shaded portion in the figure.

c. The length along track should be 20m.

d. The volume of fire point block should be calculated by below formula.

$V=(Ao-Av)\times 20$

$Ao=(Va-Vm)/L$

Where, V: Volume of fire point block (m^3)

Ao: Cross sectional area perpendicular to track (m^2)

Av: Cross sectional area of vehicle (including underfloor portion) (m^2)

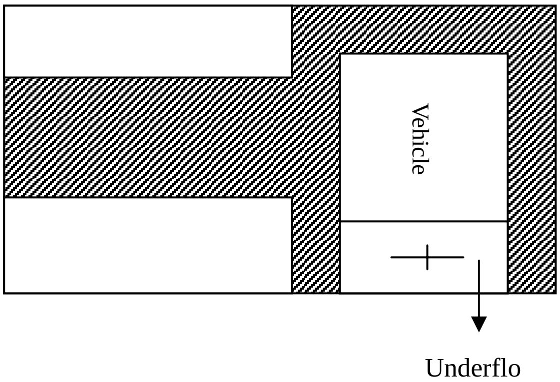
Va: Total volume of platform effective portion with set fire point cross section of a platform (m^3)

Vm: Volume of non diffusing portions such as pillars and stairways in Va (m^3)

L: Effective length of a platform (m)

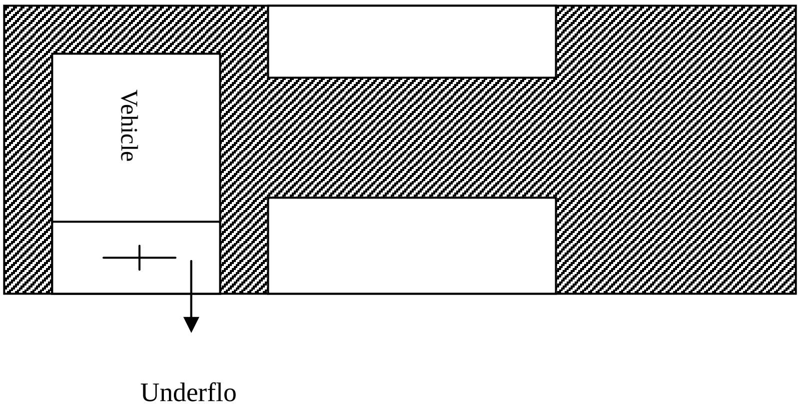
Attachment Figure 29．1 Range of cross section perpendicular to track to set fire point block

(A) Single track platform



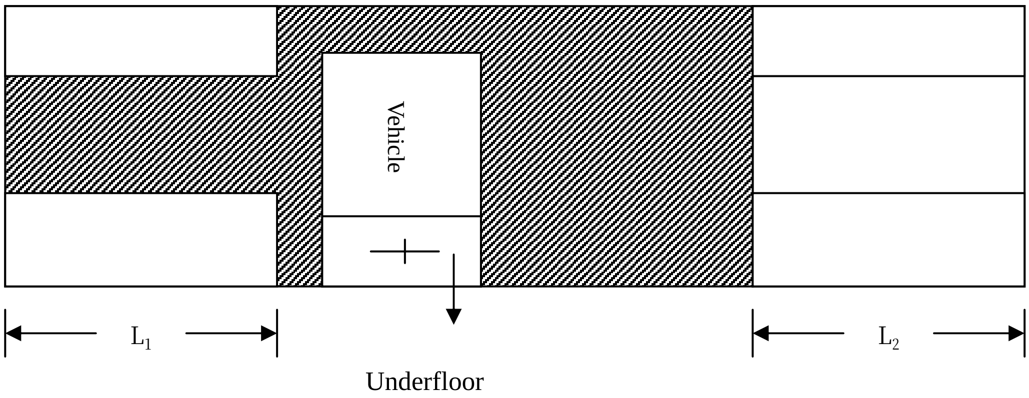
（Assumption） Smoke diffuses in whole cross section.

(B) Two tracks island platform



（Assumption） Smoke diffuses to adjacent platform and opposite track through ascending current due to heat.

(C) Two tracks opposite platforms



(Assumption) Smoke does not diffuse to the platform in opposite side of burning vehicle since its ceiling is lower than track. Thus, smoke diffuses only to adjacent platform and track. Therefore, the cross section should be determined as smaller cross section of the cross section set by a burning train, which enters (example: in this figure, when the platform width is $L_1 \leqq L_2$, shaded portion is deemed as a set range).

Note: It may be assumed that smoke diffuses in shaded portion.

(4) Minimum smoke exhaustion rate

The railway operator must install the smoke exhaustion facility having a capacity higher than or equal to 5,000m^3/h for fire point block volume.

4.2 Collation of required smoke diffusion volume in concourse (except for a case that concourse story is single and divided into two or more portions)

Required smoke diffusion volume Vo in concourse at evacuation completion time t shall be calculated by using below formulas depending on evacuation completion time (result is rounded off to the first decimal place). Then, it shall be confirmed that calculated smoke diffusion volume V of concourse is greater than or equal to Vo.

1) In a case that evacuation completion time is shorter than or equal to 10 minutes:

$$Vo = 10.5t^2$$

2) In a case that evacuation completion time is longer than 10 minutes to 11 minutes inclusive:

$$Vo = 120t^2 - 2{,}190t + 10{,}950$$

3) In a case that evacuation completion time is longer than 11 minutes:

$$Vo = 9t^2 + 252t - 2{,}481$$

Where,

Vo: Required smoke diffusion volume (m^3)

t : Evacuation completion time (min)

Smoke diffusion volume of a concourse should be calculated by below formulas.

$V = V' + t \times Ve'$

$V' = (Af - At) \times (H - 2)$

$Ve' = Ve \times (H - 2)/H$

Where,

V': Smoke diffusion volume without considering the ventilation rate of smoke exhaustion facility (m^3)

Ve': Effective smoke exhaustion volume (m^3/min)

Af : Floor area of concourse story (m^2)

At: Area of non diffusing portions such as pillars in concourse story (m^2)

H: Ceiling height of concourse story (m)

Ve: Ventilation rate of smoke exhaustion facility in concourse story (m^3/min)

5. Collation method for large fire source fire

Elapsing time t_o until that smoke, etc. from large fire source descends to a height of 2 m from the floor used for evacuation shall be calculated by below method. Then, it shall be confirmed that the t_o is longer than or equal to evacuation completion time t_o calculated elsewhere.

(1) In a case of vehicle fire and shop fire at platform story

$t_o = V_E / (Vs - Ve')$

$V_E = (A_E - Av') \times L$

$Ve' = Ve \times (A_E - Av') / (Ao - Av)$

However, when $V_E - Ve' \leqq 0$, set $t_o = \infty$.

V_E: Effective volume of a space higher than or equal to 2.0 m from platform floor in whole platform story (m^3)

Vs: Discharged smoke flow rate and smoke, etc. production rate. Each of them is set as 300 (m^3/min).

Ve': Effective smoke exhaustion rate for the effective volume V_E of whole platform (m^3/min)

A_E: Cross sectional area perpendicular to track and higher than or equal to 2.0 m from platform floor, excluding non diffusing portion such as stairways and pillars (m^2)

Av': Vehicle cross sectional area higher than or equal to 2.0 m from platform floor (m^2)

Ve: Ventilation rate of smoke exhaustion facility in whole platform story (m^3/min)

Ao: Cross sectional area perpendicular to track in the calculation of fire point block volume (m^2)

Av: Cross sectional area of vehicle (including underfloor portion) (m^2)

(2) In a case of fire in concourse story (except for a case that concourse story is single and divided into two or more portions)

$t_o = V'/(V - Ve')$

$V' = (Af - At) \times (H - 2)$

$Ve' = Ve \times (H - 2)/H$

However, when $Vs - Ve' \leqq 0$, set $t_o = \infty$.

When no shop is installed in concourse story, if $t_o \geqq 3$, set $t_o = \infty$.

Where,

V': Smoke diffusion volume without considering the ventilation rate of smoke exhaustion facility (m^3)

Vs: Smoke, etc. production rate and set as 300.0 (m^3/min).

Ve': Effective smoke exhaustion rate (m^3/min)

Af: Floor area of concourse story (m^2)

At: Area of non diffusing portions such as pillars in concourse story (m^2)

H: Ceiling height of concourse story (m)

Ve: Ventilation rate of smoke exhaustion facility in concourse story (m^3/min)

In a case of underground station where complicated smoke flow may be expected, for example, that the ceiling of platform story is vaulted and has the same height as that of concourse story, t_o may be calculated by other method such as "two layer zones smoke flow prediction calculation", etc. 6 Actions

As the result of collation for large fire source fie, if the situation can not be treated by smoke exhaustion facilities, the railway operator must take actions as follows.

(1) Newly installing the evacuation route(s) or enlarging the evacuation route width to shorten evacuation time.

(2) Enlarging the smoke diffusion volume.

(3) Setting the fire and smoke compartments for shops as fire source and installing the sprinkler system for them.

(4) Not installing shops, which may become fire source.

(5) Other devices to assure the safety of passengers during their evacuation.

For the cases of (1), (2) and (5), the railway operator must collate them again after taking the actions and for the cases of (3) and (4), the railway operator must collate them again by assuming no shops.

II. Smoke exhaustion measures for staying room

The railway operator must install smoke exhaustion device for staying room. The smoke exhaustion device shall be automatically started by the open of smoke discharge port and have the exhaust capacity greater than or equal to 120 m^3 per minute, and shall discharge the air volume of $1m^3$ or more per floor area of $1m^2$ in smoke compartment (for the smoke exhaustion device related to two or more smoke compartments, $2m^3$ or more per floor area of $1m^2$ in the floor with largest floor area of the smoke compartments). Other structures, etc. shall comply with the requirements under Article 126-3, Ordinance for the Enforcement of the Construction Standard Law.

Article 41 Sheds, depots and workshops, etc

Depot, vehicle maintenance and repair shop, and rolling stock workshop, etc. in a national railway may be characterized as follows.

Depot

1. Depot shall have sufficient track layout and facilities allowing the technical starting inspection such as brake check, storage battery inspection, water supply, fuel supply, disinfection, car cleaning prior to the

start of train.

2. Depot shall have sufficient storage capacity for trains after their operations.
3. Depot must be placed in a location near yard and station to carry out technical handling.

Vehicle maintenance and repair shop

Vehicle maintenance and repair shop shall be placed in a location near yard and the large scale technical handling station.

Vehicle maintenance and repair shop shall have sufficient track layout, buildings and facilities allowing repair in periodic repair class.

Vehicle maintenance and repair shop shall have sufficient track layout for daily repair or storage, accommodation.

Such the shop is classified as follows.

Electric car base

Diesel car base

Base for passenger car

Base for freight car

Passenger car operation base

Freight car operation base

Repair base for passenger car

Repair base for freight car

Freight car operation and repair base

Passenger car operation and repair base

Rolling stock workshop

Rolling stock workshop for locomotives, vehicles and trains is a plant consisting of premises, buildings, facilities and track facilities to carry out large scale repair and new fabrication.

Rolling stock workshops are appropriately distributed in domestic railway lines and shall have track layout connected to adjacent stations.

Chapter 9 Device and Rolling Stock Maintenance

Section 1 structure, track

Article 92 Preservation of facilities

The railway operator must attach greater importance to the maintenance of facilities throughout their usage life by implementing the inspection for transfer after completing their construction work. Article 31 of the government ordinance 204/2004VD-CP on the quality control of construction work and Clause I, Article 5 of the government ordinance 08/2006IT-BXD on the order for construction work and maintenance activities categorize the maintenance activities into four classes: service level, small-scale repair, medium-scale repair and large-scale repair. When any trouble categorized into specific class is found in a facility or track during the inspection patrol of a main line, the railway operator must carry out its maintenance work in accordance with its class.

Article 93 Inspection and trial operation of facilities

1. For the tunnel with concrete lining, the railway operator must implement its initial comprehensive inspection when the tunnel is completed or re-constructed, in accordance with the following method. Thereafter, the railway operator must implement the normal comprehensive inspection and the special comprehensive inspection at the interval specified in Article 90. The railway operator must record the results of the initial comprehensive inspection on an alteration expansion plan of the lining work as basic information for subsequent inspection. The railway operator must modify the alteration expansion plan based on the results of the normal comprehensive inspection and the special comprehensive inspection to update the alteration situation.

(1) The initial comprehensive inspection must be implemented as follows.

1) Visual inspection

Visual inspection must be carried out for all the items in close range under sufficient illumination for their cracking, flaking, deterioration or water leakage. Their conditions must be recorded by photograph, as necessary.

2) Hammering test

For the locations requiring special care or for the items determined by visual inspection, hammering test shall be carried out.

(2) The results of hammering test must be judged in accordance with Table 1. The results of visual inspection and hammering test must be judged in accordance with Table 2 by establishing the acceptance criteria for cracking, bulging out, deterioration and water leakage due to flaking or external force.

Table 1 Guidelines for judging the hammering test results

Hammering test results	Knocking off		Judgment for flaking
	Required or not	Remarks	
Clear sound	Not required.		When the item was judged as intactness β based on Table 2, the result should be recorded.
Dull sound	Required (but, in the feasible range)	・ In principle, knocking-off should be carried out up to the depth that intact concrete will expose, and up to 1/4 of design lining thickness or 15 cm at maximum. ・ If there are further locations with dull sound, the judgment for flaking should be carried out.	・ When the item was judged as intactness α based on Table 2, any remedial work against flaking should be required. ・ When the item was judged as intactness β based on Table 2, the result should be recorded.

Note 1: In principle, the deteriorated location shall be knocked off when hammering test.

Table 2 Criteria for flaking

Judgment class	Action	Condition
α	Action is necessary.	1) Cracks steep to lining surface due to (compression or shearing) + dull sound *1 2) (Closing or crossing or parallelism) with inclusion of (compressive or shearing) cracks, etc. + dull sound *1 3) Radial cracks + dull sound *1 4) Closing of crack, etc. + dull sound 5) (Parallelism or crossing) of cracks, etc + discrepancy (step) of about 3 mm or more + dull sound 6) (Parallelism or crossing or discrepancy (step) of about 3 mm or more) of cracks, etc. + water leakage + dull sound 7) When even knocking-off does not allow judgment or when any unstable condition is left after knocking-off, it may be junk or material deterioration.
β	Special attention is needed.	1) Cracks steep to lining surface due to (compression or shearing) *1 2) (Closing or crossing or parallelism) of cracks, etc. including (compressive or shearing) cracks *1 3) Radial cracks *1 4) Closing of cracks, etc. 5) (Parallelism or crossing or discrepancy (step) of about 3 mm) of cracks, etc. + dull sound
γ	(No problem)	Other than the case of α or β

For *1, the judgment should be required for work against earth pressure applied to a tunnel at the same time.

(3) Normal comprehensive inspection

1) Visual inspection

Visual inspection must be carried out for all the items under sufficient illumination for their cracking, flaking, deterioration or water leakage by walking, etc. Their conditions must be recorded by photograph, as necessary.

2) Hammering test

For the items determined by visual inspection (including the items determined in previous inspection), hammering test shall be carried out.

(4) Special comprehensive inspection

1) Visual inspection

Visual inspection must be carried out for all the items in close range under sufficient illumination for their cracking, flaking, deterioration or water leakage. Their conditions must be recorded by photograph, as necessary.

2) Hammering test

For the items determined by visual inspection (including the items determined in previous inspection), hammering test shall be carried out.

(5) The normal comprehensive inspection and the special comprehensive inspection must be judged in accordance with (2).

2. The railway operator must confirm that the track installations allow trains to be operated at design speed (or operation speed in the section) by their inspection.

Article 94　Inspection patrol and monitoring of facilities

1. To maintain the main line in the condition allowing trains to be operated at specified speed in safe manner, the railway operator must implement the patrol for it based on the condition of each section and the operational conditions of trains. The railway operator must specify the frequency, timing and methods of patrol based on the situation.

When finding the failure of facility or a part of facility during patrol, the railway operator must so repair the failure depending on its maintenance class to rapidly reestablish the condition assuring the safe operation of trains in the section.

2. When there may be a possibility of a disaster endangering train operation in a main line, the railway operator must monitor the track, limit the operational speed or suspend the operation in the track or section, as necessary. In addition, the railway operator must establish the monitoring system for the track depending on assumed disasters and specify the limiting speed of trains, etc. in advance.

When finding the factors such as cracking, subsidence or failure leading to accident, the railway operator must resolve the trouble depending on its maintenance class to reestablish the condition assuring the safe train operation in the section.

Article 95　Periodical inspection of facilities

1. For roadways, periodic inspections must be carried out for each of the railway types listed in the upper column of the table below, according to each of the facility types listed in the middle column of the table and at an interval not exceeding each of the periods listed in the last column of the table.

Railway type	Facility type	Period
Railways other than high-speed railway	Track （periodic inspection）	A year
	Bridge, tunnel and other structures	Two years
High-speed railway	Track (only gauge, cross level, irregularity, alignment and twist in the main track)	Two months
	Track （periodic inspection）	A year
	Bridge, tunnel and other structures	Two years

2. The railway operator must implement the periodic inspection of track for its displacement (gauge, cross level, longitudinal level, alignment and twist) and the conditions of track materials and rail joints, etc.
3. For a tunnel with concrete lining, the railway operator must implement the inspection by the following methods.
(1) Normal comprehensive inspection is the inspection carried out at interval not exceeding two years, in which the visual inspection under sufficient illumination by walking, etc. and the hammering test for the locations determined as necessary are carried out.
(2) Special comprehensive inspection is the inspection carried out at the interval not exceeding 10 years for high speed railway and at the interval not exceeding 20 years for the railway other than high speed railway, in which the visual inspection in close range and the hammering test for the locations determined as necessary are carried out. The special comprehensive inspection can replace the normal comprehensive inspection.
(3) The railway operator must specify the methods of visual inspection and hammering inspection in elsewhere.
(4) The railway operator must judge the inspection results by specifying the separate criteria for flaking, external force, deterioration and water leakage.
4. For bridges and other civil structures, the railway operator must implement the normal comprehensive inspection at the interval not exceeding two years and the special comprehensive inspection at the interval not exceeding 10 years. The special comprehensive inspection can replace the normal comprehensive inspection. The railway operator must specify the methods of them in elsewhere.

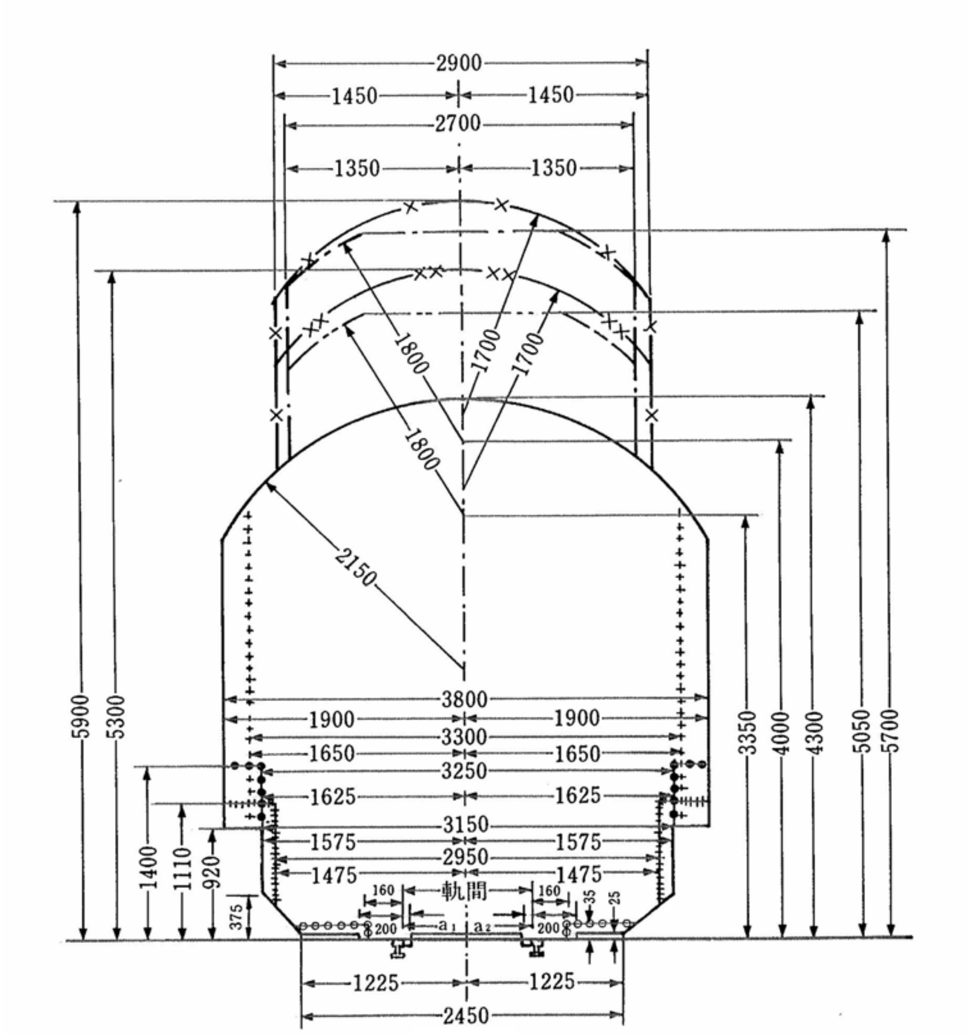
Article 96 Records

1. The railway operator must keep the records of periodic inspection, modification, reconstruction and repair of facilities by specifying their preservation period of time. In addition, the railway operator must so keep the alteration record of bridges, tunnels and other structures to allow their alteration history to be traced. The railway operator must record the results of the initial comprehensive inspection, normal comprehensive inspection and special comprehensive inspection, etc. for tunnels on their alteration expansion plans and must update the information at each inspection.

Reference 1 **Construction gauge**:

No. 1 – JP DWG

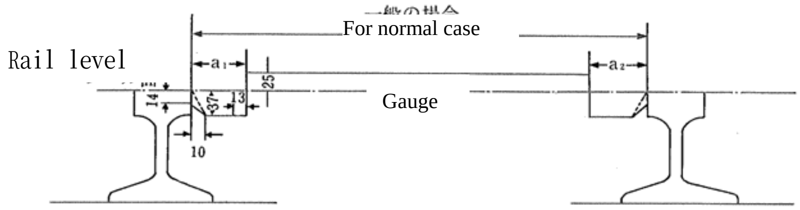
Construction gauge: G1067 mm (unit: mm)



Gauge

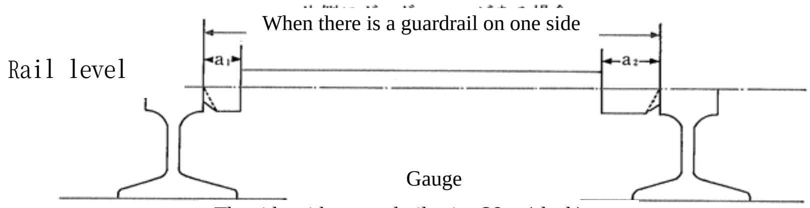
————	Basic gauge
-·-·-·-·	Gauge to overhead contact lines on the tracks operated through the supply of DC electricity from overhead contact lines, and their suspension device and those other than insulation reinforcement.
—··—··—	Gauge to overhead contact lines on the tracks operated through the supply of DC electricity from overhead contact lines, and their suspension device and those other than insulation reinforcement when it is necessary in tunnels, bridges, overbridges, snow sheds, platform sheds and sections around them.
——×——	Gauge to overhead contact lines on the tracks operated through the supply of AC electricity from overhead contact lines, and their suspension device and those other than insulation reinforcement.
	Gauge to overhead contact lines on the tracks operated through the supply of AC electricity from overhead contact lines, and their suspension device and those other than insulation reinforcement when it is necessary in tunnels, bridges, overbridges, snow sheds, platform sheds and sections around them.
—●—●—	Gauge to signaling devices, sign markers, sign devices, and special tunnels and bridges.
—○—○—	Gauge to run-over type turnouts
+++++	Gauge to supports of filling stations, water stations, and signal posts on main lines and side lines on which only freight trains are operated, and turntables, weighers, washing stations, rolling stock warehouse entrance and its internal devices, and freight unloading platform sheds built between tracks on side lines.

Detail drawing of lower part gauge of construction gauge (Unit: mm)



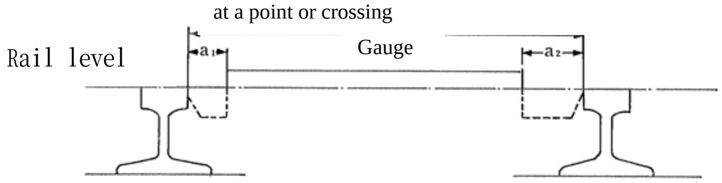
a1 = a2 = 76 + (slack)

For toe of tongue rail, a1 or a2 = 100.



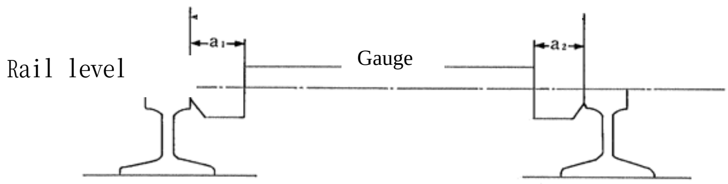
The side with a guardrail: a1 = 38 + (slack)
The side without a guardrail: a2 = 76 + (slack)

When there are guardrails on both sides
at a point or crossing



a1 and a2 $\geq$ 38 + (slack)
a1 + a2 = 84 + (slack)

For a crossing with a guardrail:



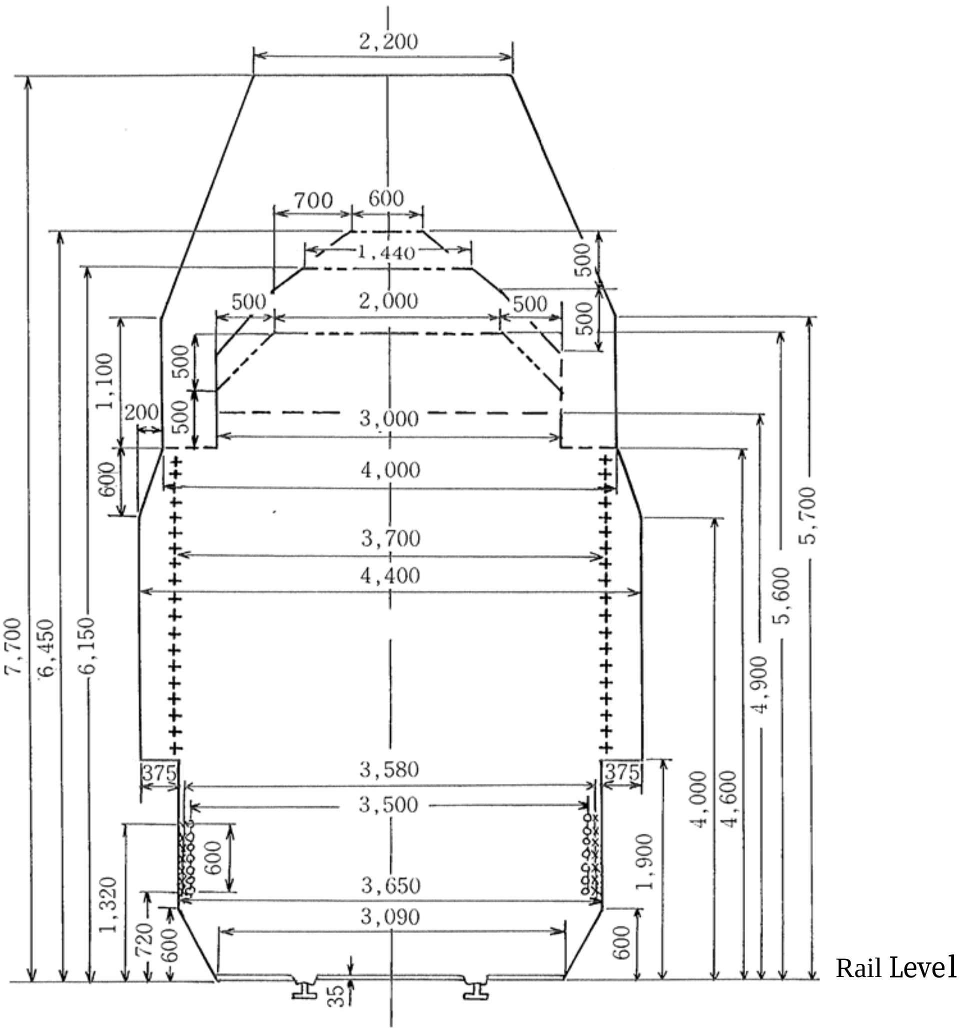
a1 = a2 = 44 + (slack)

Basic guage

Gauge at a point or crossing

No. 2 – JP DWG

Shinkansen Construction gauge: G1435 mm (Unit: mm)



Basic gauge

Gauge to tunnels, bridges, platform sheds, etc,

Gauge to over bridges, etc. in the case of using the central part for slack of overhead catenary

Gauge to tunnels, bridges, over bridges, platform sheds with a special structure for overhead contact lines in the section operating a train at speed of 120km/h or less

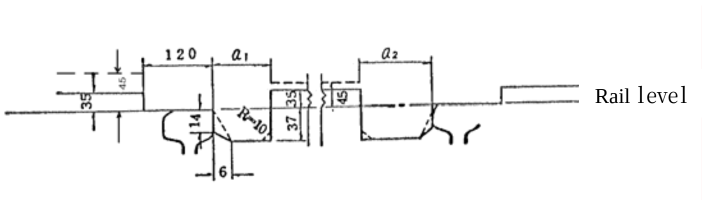
Gauge when there is no contact line

○ ○ ○ ○ Gauge to platforms (only when there is no passing train), platform for crews, rolling stock washing table, etc.

× × × × Gauge to platforms (only when there is a passing train)

＋ ＋ ＋ ＋ Gauge to sign markers inside maintenance and inspection/repair facilities and rolling stock base

Detail drawing of lower part gauge of construction gauge (Unit: mm)



Basic gauge

$a_1 = a_2 = 60$ + (slack)

Gauge to turnouts

1) For toe of tongue rail and other movable rails

a_1 or $a_2 = 75$ + (slack)

2) For guardrails and wing rails:

a_1 or $a_2 = 38$ + (slack)

$a_1 + a_2 = 83$ + (slack)

[Description]

1. Outline of construction gauge

For construction gauge, a minimum amount (dimension) of allowance is specified to the outer side of the rolling stock gauge to secure safe vehicle operation.
Allowances are specified taking into account that passengers and crews hang out of a window in normal railways and that crews stick their head out of a window to gaze at the vehicle side in high-speed railways, in addition to the vibration amount of rolling stocks (displacement of rolling stocks themselves, displacement caused by track irregularity).
In addition, rolling stock gauge, and insulation distance in electric railways, is specified as basic conditions. Concerning tracks, the operational safety is secured by always maintaining them based on the preset center of track and securing construction gauge paying attention to abnormalities in the structures and others.

2. Construction gauge of normal railways (excluding high-speed railways) and non-conventional railways

Construction gauge is specified taking rolling stock gauge and electrical isolation in electric railways into consideration, and of course, the dimension differs among railway operators. Therefore, it is described herein based on the construction gauge drawing (reference drawing of G1067 mm) shown in the “interpretation standards.”

2.1 Basic gauge of construction gauge (reference drawing of G1067 mm) on straight lines

(1) Lateral gauge of construction gauge
The lateral gauge of construction gauge is set at 3,800 mm adding 400 mm to each side of to the width of the rolling stock gauge of 3,000 mm taking account of carbody displacement at curve generated by track irregularity and train vibrations.

(2) Upper part gauge of construction gauge
The arcuate section of the construction gauge upper part was set at 4,300 mm above the rail surface and the radius of 2,150 mm after checking the cross section of the existing tunnels.

(3) Lower part gauge of construction gauge
The lower part gauge of construction gauge was specified to secure flangeway of rolling stocks.
(a) The depth of the flange contact point is specified at 37 mm because the maximum flange height from the wheel tread is 35 mm and an allowance of 2 mm is added (Fig. 20.1).
(b) The clearance between the rail surface and the construction gauge was specified at 25 mm taking

guardrails, turnouts, crossings, and others into consideration, but run-over type turnouts etc. were specified at 35 mm giving allowance.

(c) For a1 and a2 in normal cases, when the maximum value on the increasing side of the maintenance standard value of the gauge is set at 19 mm, it is obtained from

1,067 mm (gauge) + 19 mm －988 mm (back gauge)－22 mm (flange width) = 76 mm.

When there is a slack, it is added to both sides so that no problem will occur when the wheel leans to either side.

(d) For a1 and a2 for turnouts, it is based on

1,067 mm + 7 mm － 988 mm － 22 mm = 64 mm ≈ 65 mm.

The toe of tongs-rail is set at 65 mm + 20 mm (slack) + 15 mm (allowance) = 100 mm so that the wheel will not touch the toe of the open rail, and the toe of movable rail is set at 80 mm because in general it has no slack.

(5) For a1 and a2 on the side with a guardrail, the maximum flange thickness is set at 33 mm, and at 38 mm in total adding 5 mm of allowance (slack is added when there is a slack).

(6) For a1 and a2 on crossing with a guardrail installed, it is set at 44 mm adding an allowance of 1 mm to (1,067 mm + 7 mm － 988 mm)/2 = 43 mm (slack is added when there is a slack).

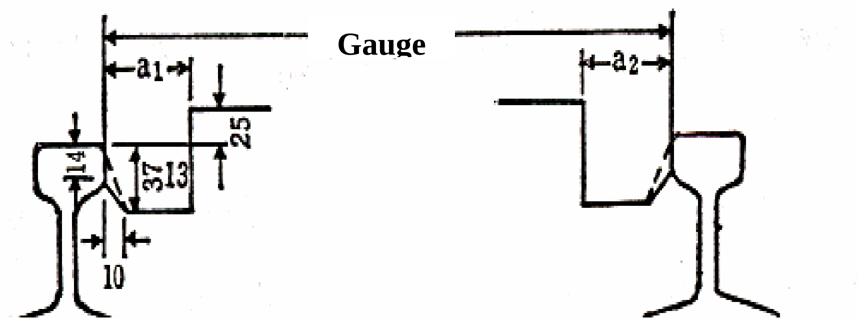


Fig. 20.1 Lower part gauge of construction gauge (for general cases)

2.2 Construction gauge corresponding to current collectors

For railways using electricity as an energy source, it is necessary to specify construction gauge taking insulation distance into consideration to rolling stock gauge to current collector in addition to general construction gauge so that rolling stock vibrations or electrical disturbances will not occur (hereinafter called “upper part gauge”). Since upper part gauge is a gauge corresponding to current collectors, contact lines used contacting with them, suspension devices used to install them, and others are excluded from the coverage of the upper part gauge ((1) to (6)).

Upper part gauge is set, for example, on the upper part of general construction gauge when it is operated by receiving electricity supply from DC overhead contact lines. The height above the rail surface is determined adding necessary height to install the suspension device to the contact line height, and the width is determined adding rolling stock vibrations and insulation distance to rolling stock gauge to current collectors. It is also necessary to take account of rolling stock vibrations and dynamic uplift of contact lines for the distance between the current collector end and the structures.

Upper part gauge height

(1) 5,900 mm

Applies to tracks operated by receiving AC (20 kV) electricity supply. This value indicates the height adding the height of the suspension device of 500 mm to the upper limit height of the contact line of 5,400 mm.

(2) 5,700 mm

Applies to tracks operated by receiving DC (1,500 V) electricity supply. This value indicates the height adding the height of the suspension device of 500 mm to the standard height of the contact line of 5,200 mm.

(3) 4300 mm

This value is a maximum value of general construction gauge in non-electrified sections, and at the same time, it is also a gauge to the roof devices when the pantograph is lowered within the rolling stock gauge.

Upper part gauge width

(4) 2900 mm

Applies to tracks operated by receiving AC (20 kV) electricity supply. This value includes electrical insulation space of 100 mm to each side of (5) DC gauge.

(5) 2,700 mm

Applies to tracks operated by receiving DC (1,500 V) electricity supply. This is a value adding an allowance of 400 mm (train vibrations, electrical insulation distance) to each side from the rolling stock gauge at the pantograph.

The erection systems of contact lines include single overhead system as well as third rail systems which collect current on the side of the rolling stock and double rigid conductor systems. It is also necessary to set the gauge to current collectors for all of these systems according to the shapes of current collectors and structures of contact lines, taking account of rolling stock vibrations and insulation distance just like the above upper part gauge by overhead contact lines.

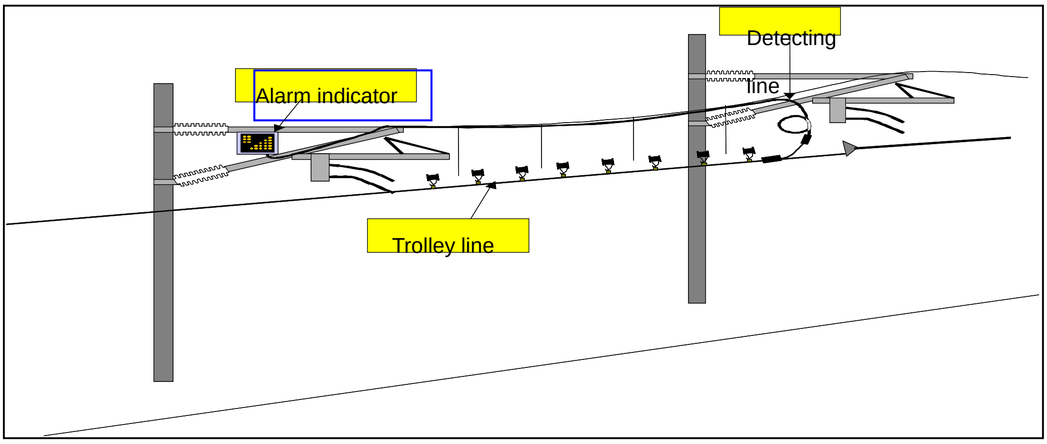


Fig. 20.2 Example of trolley lines

2.3. Expansion of construction gauge at curve

When a rolling stock is passing a curve, its both ends are displaced toward the outer side of the curve and its center is displaced to the inner side of the curve from the track. Therefore, it is necessary to expand the construction gauge to inner and outer sides of the curve. The general formula derived from Fig. 20.5 is shown in the description, but generally, an approximation is examined and used from general rolling stocks. The calculation method is described below.

The relationship between the carbody and the curve at a curve is expressed in Fig. 20.6.

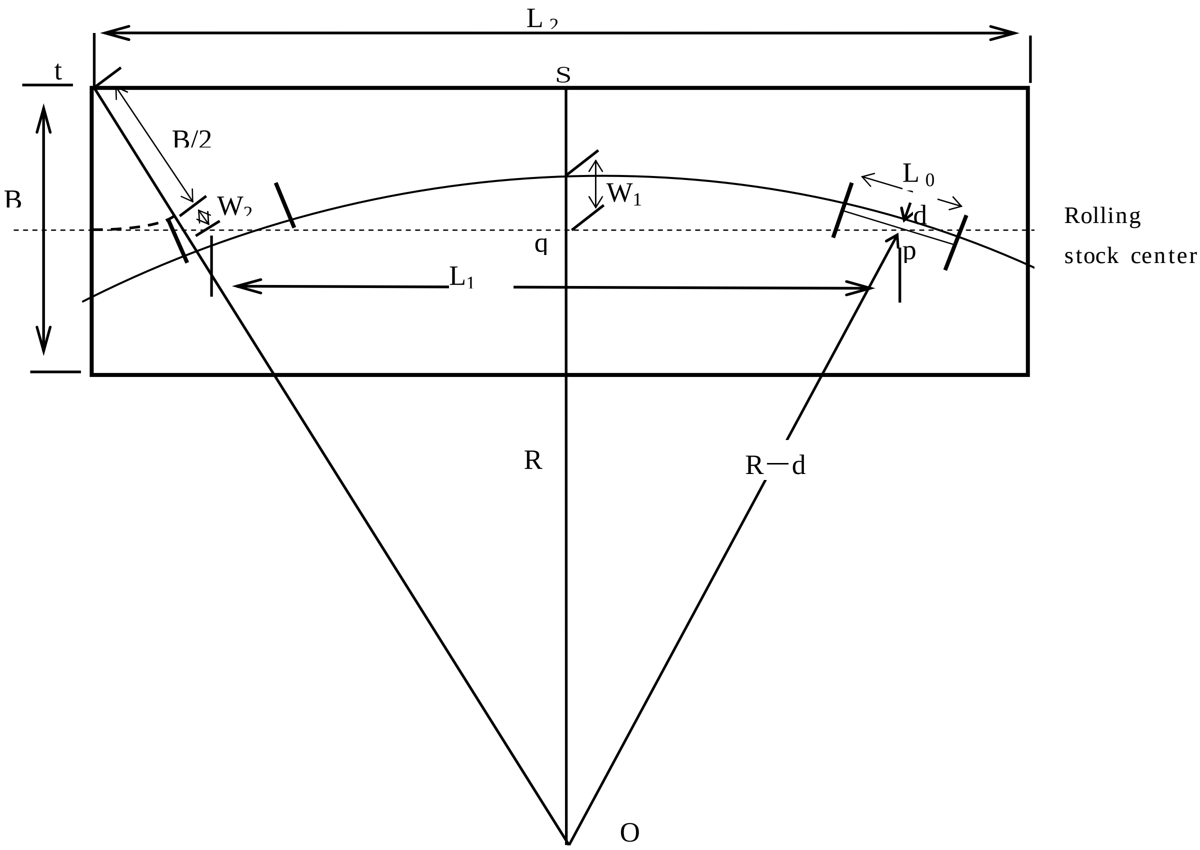


Fig 20.6
Carbody displacement
at curve

Displacement to the inner side of the curve: W_1 is

$(R - W_1)^2 = (R - d)^2 + (L_1/2)^2$ from △pqo having the origin at zero,

$$W_1 = R - \sqrt{\{(R-d)^2 - (L_1/2)^2\}} \quad \text{(20.1)}$$

Similarly, d is

$$d = R - \sqrt{\{R^2 - (L_0/2)^2\}}$$

On the other hand, displacement to the outer side of the curve: W_2 is expressed by Formula (20.2) taking △sto in the same manner.

$$W_2 = \sqrt{\{(R + B/2 - W_1)^2 + (L_2/2)^2\}} - R - B/2 \quad \text{(20.2)}$$

Where

L_0: Wheel base

L_1: Bogie wheel base

L_2: Overall length of car body

B: Overall width of car body

R: Radius of curve

W_1: Displacement to the inner side of the curve

W_2: Displacement to the outer side of the curve

d: Displacement taking bogie wheel base into consideration

[Example of calculation of approximation and simple formula]

General rolling stock dimension is assumed to have the overall length of car body L_2: 19 m and the overall width of car body B: 3 m.

When W_1 and W_2 are compared, W_1 is larger from Fig. 20.6, hence an approximation is derived from Formula (20.1).

When Formula (20.1) is transformed,

$$W = R - \sqrt{R^2 - (Lo^2 + L_1^2)^2/4} \quad \text{(20.3)}$$

When $(Lo^2 + L1^2)^2/4 = m^2$,

$$W = R - (R^2 - m^2)^{1/2} \quad \text{(20.4)}$$

When R is organized,

$$W = R\left[1 - \left\{1 - (m/R)^2\right\}^{1/2}\right] \quad \text{(20.5)}$$

When Maclaurin expansion is applied to $\left\{1 - (m/R)^2\right\}^{1/2}$ out of Formula (20.5) and minor terms after the cube are omitted,

$$W = R\left[1 - \left\{1 - 1/2(m/R)^2\right\}\right] \quad \text{(20.6)}$$

When m is returned from Formula (20.4),

$$W = \frac{Lo^2 + L1^2}{8R} \quad \text{(approximation)} \quad \text{(20.7)}$$

Calculate general rolling stocks using Formula (20.7).

When wheel base: Lo = 2,100 mm, and

Bogie wheel base: L1 = 13,400 mm,

W = 22,996.25/R ≈ 23,000/R (20.8)

When the calculation results of Formula (20.3) and Formula (20.8) are compared, those of Formula (20.8) become smaller by about 0.2 mm near R = 100 m. Therefore, the following formula is used for the amount of expansion of construction gauge in the curve section on the safe side.

W = 23,100/R (20.9)

(1) How to calculate streamline rolling stocks

For the calculation of streamline rolling stocks which have been introduced these days, it is necessary to examine overall length of car body: L_2 and overall width of car body: B in Fig 20.7 in addition to the above examination.

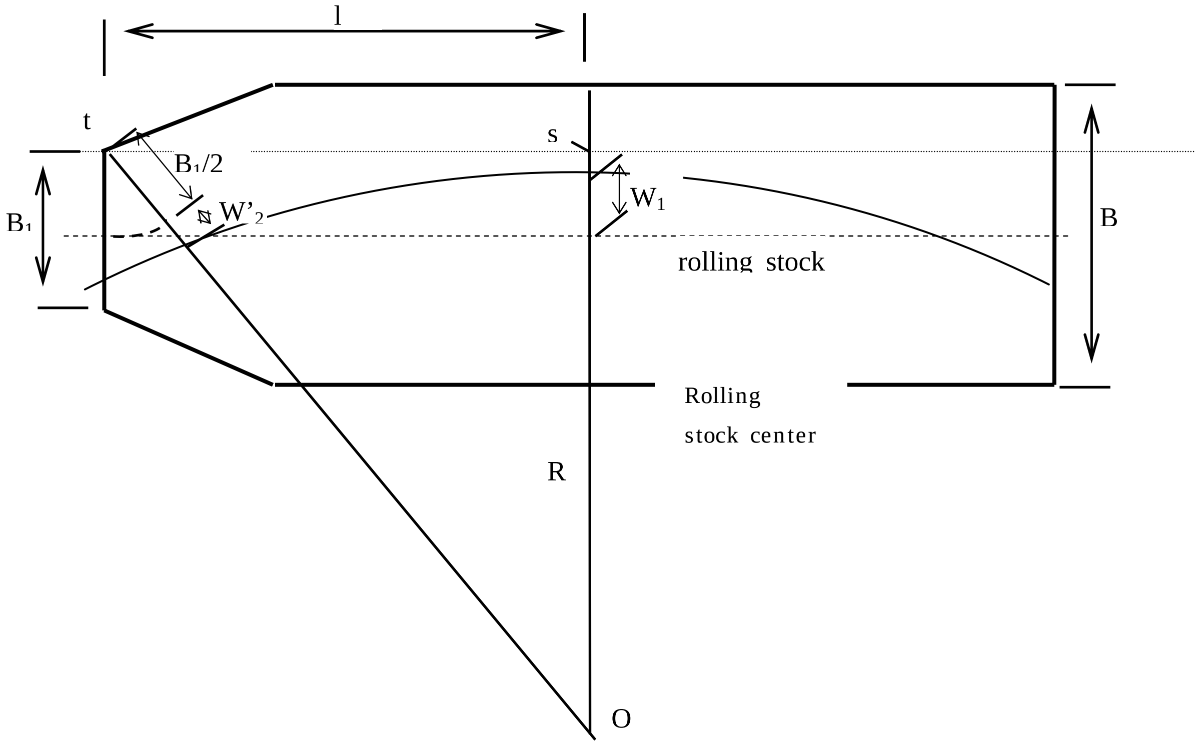


Fig. 20.7 Displacement of streamline rolling stock

Displacement to the inner side of the curve: W_1 is calculated from Formula (20.1) from Fig 20.7.

On the other hand, displacement to the outer side of the curve: W2 is from △sto in Fig 20.7

$$W'_2 = \sqrt{\{(R + B_1/2 - W_1) + l^2\}} - R - B_1/2 \quad (20.10)$$

Where

B_1: Overall width of car body when calculating the amount of displacement

l: Distance from the center of the bogy to B_1

Calculate W'_2 setting B_1 according to carbody shapes, and set the maximum value as W_2.

It is also necessary to specify the amount of expansion of construction gauge taking the amount of cant set in the curve section into consideration.

(2) Radius of curve that does not require the expansion of construction gauge (excluding a curve along platform)

Radius of curve that does not require the expansion of construction gauge (excluding a curve along platform) is calculated from a clearance between the construction gauge and the rolling stock gauge. In the standard drawing of conventional lines in the "standard notice for railway technical regulations," the point where the clearance between the construction gauge and the rolling stock gauge is the smallest is the section above the rail surface up to 920 mm and the length is 150 mm (Fig. 20.8). In addition, the amount of displacement when the radius is 1,000 m is 23 mm when calculated from Formula (20.9) and almost the same with the displacement of 20 mm when the radius is 2,500 m in high-speed railways. Therefore, the expansion of construction gauge can be omitted for a curve with a radius of 1,000 m or more (excluding a curve along a platform) as a value that can be included in the allowance range as in high-speed railways. As seen above, it is calculated from the clearance between the construction gauge and the rolling stock gauge, but for rolling stocks which have been introduced recently and have special front shapes, separate examination is necessary.

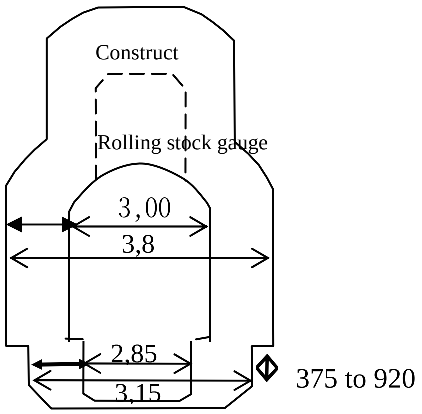


Fig. 20.8 Clearance between the construction gauge and the rolling stock gauge (General railway structural rule)

(3) Upper part gauge of electric traction sections by overhead contact lines

Concerning the upper part gauge of electric traction sections by overhead contact lines, the pantograph is generally located near the bogie center where the carbody displacement at curve is small, and the widening at curve is less necessary than the carbody portion, hence a half of the carbody displacement at curve is used as the expansion dimension.

However, when the pantograph is not located near the bogie center, it is necessary to calculate it separately taking rolling stock performances and others into consideration.

(4) Transition in the expansion of construction gauge at curve

Concerning transition in the expansion of construction gauge at curve, since the rolling stock is still displaced at the end edge of the transition curve, it is necessary to extend Lm from the end edge of the transition curve toward the straight line side in Fig. 20.9 considering the car end which is longer from the Bogie Center A of the bogie car.

When there is no transition curve, it is assumed that the expansion is transited at L (m) from the end of the circular curve (end of circular curve with a smaller radius for compound curves).

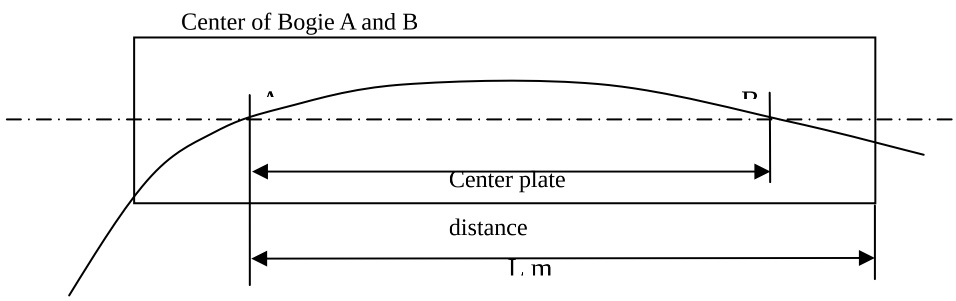


Fig. 20.9 Rolling stock and transition curve

[Carbody displacement at curve at the end edge of a transition curve**]**

Distance to the car end from the center of bogie whose center distance is 13.4 m when the transition curve is 17 m long.

The amount of displacement at the transition curve end when a 2.8-meter rolling stock is passing is 42 mm when the radius of curve is 200 m, and 28 mm when the radius of curve is 300 m.

(5) Impact of slack of construction gauge

In general, a slack expands the inner rail inward, hence the rolling stock generates some displacement toward the inner rail side from the track center line. The amount of displacement of the rolling stock at curve is described in"2.2 Expansion of construction gauge at curve," but it is a bogie car which generates such a displacement at the inner side of a curve. Therefore, when considering carbody displacement at curve generated by a slack for a bogie car, the leading wheel of the bogie car generally runs along the outer rail of the curve, hence the maximum displacement toward the inner side of the curve as the whole carbody is half of the amount of slack.

That means, even when the maximum slack is 25 mm, the maximum displacement is about 12.5 mm, hence it is judged that impacts by a slack of construction gauge need not to be considered in general.

2.4 Gauge to platforms

The distance between the construction gauge of platform and the basic gauge of rolling stock gauge is set at 50 mm or more, taking account of passenger boarding/alighting, freight handling, and others (the results of past rolling stock vibration test show that the maximum displacement in the horizontal direction of the floor surface was 47 mm excluding divergences).

The platform height is specified as follows taking the floor height of the running rolling stock into consideration.

(1) Passenger platforms

For platforms for trains, to promote smooth boarding/alighting of passengers, the height from the rail surface is set at 1,100 mm to make it almost the same height with the train floor surface (the length of a vertical line from the edge of the platform to a plane including the inner/outer rails when the platform goes along a curve), and at 920 mm where trains and other trains run, taking account of both trains without footsteps and normal passenger cars with footsteps (Fig. 20.10).

(2) Freight platforms

For platforms which handle only box wagons, it is set at 1,030 mm to make it almost the same height with the floor surface of box wagons taking account of loading and unloading of freight, and at 960 mm for general freight cars to make them almost horizontal when the side plate of an open wagon is opened and suspended over the platform.

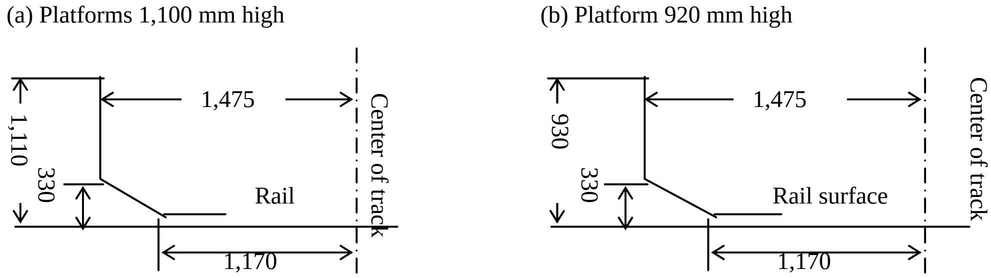


Fig. 20.10 Gauge to platforms (example of JR)

(2) Expansion of construction gauge of curve platforms

Expansion for curve platforms needs to be the sum of the amount of slack (S) and the amount of approach generated by inward tilting of rolling stock (C·h/g) in addition to the amount of carbody displacement at curve (W) for inner rail side platforms, and the amount of carbody displacement at curve (W) minus the amount of separation caused by outward tilting of rolling stock (C·h/g) for outer rail side platforms as shown in Fig. 20.11.

1) Inner rail side platforms of tracks

$K = W + S + C \cdot h/g$ ………………………………………………… (20.11)

2) Outer rail side platforms of tracks

$K' = W - C \cdot h/g$ ………………………………………………… (20.12)

Where

K, K’: Dimension to be expanded (mm)
W: Amount of carbody displacement at curve (mm)
S: Slack (mm)
C: Cant (mm)
h: Platform height (mm)
g: Gauge (mm)

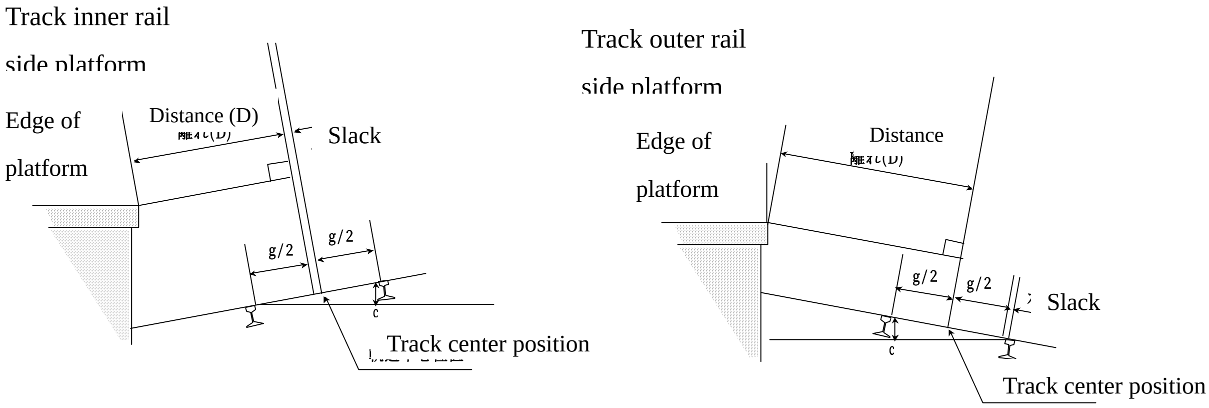


Fig. 20.11 Distance of platforms

In this case, when the calculation results of expansion dimension of outer rail side platforms have negative values, basic dimension for straight lines should apply.
For the calculation formula for the amount of carbody displacement at curve (W), Approximation (20.9) is generally used, but when the radius of curve along the platform is within 300 m for profile or other unavoidable reasons, it is also necessary to take the profile etc. into consideration and examine the calculation formula for the amount of expansion separately.

3. Construction gauge for high-speed railways (Shinkansen)

3.1. Construction gauge width on straight lines

The construction gauge width is 4,400 mm, which was specified giving an allowance of 500 mm to each side of rolling stock gauge, taking the amount of displacement generated by vibrations of rolling stock into consideration and referring to the clearance of conventional railways (400 mm), too. Major values that are considered to influence carbody displacement at curve are the increase in lateral motion of wheelset, the amount of lateral motion to the carbody wheelset, the amount of body tilt caused by rolling, and the amount of car end displacement caused by yawing, and displacement caused by track irregularity. The calculation also shows an allowance of 300 mm or more to the clearance of 500 mm between the rolling stock gauge and the construction gauge, and there is no safety problem when train crews stick their head out of a window to gaze at the vehicle side.

(1) Allowance between the rolling stock gauge width and the construction gauge width

The items taken into consideration for allowance between the rolling stock gauge width and the construction gauge width are as follows:

Major values that are considered to influence carbody displacement at curve are the increase in the amount of lateral motion of wheelset, the amount of lateral motion to the carbody wheelset, the amount of lateral displacement at the carbody shoulder caused by carbody tilt in the case of rolling, the amount of car end displacement caused by yawing, and displacement caused by track crossing.

The above amount of carbody displacement at curve is 200 mm or below in calculation, and this was confirmed by an active duty car test.

4. Facilities installed within the construction gauge

For those that are necessary to be installed within the basic gauge of construction gauge for the purpose of inspections and cleaning of rolling stocks, it is necessary to express these facilities on the construction gauge after confirming the securing of safety, and manage them appropriately with the conditions set during this process such as running speed and the place of the facilities.

[Reference]

2. Allowance outside the construction gauge

(1) Allowance in tunnels

In tunnels, the allowances shown in Fig. 20.9 need to be added outside the construction gauge. The tunnel inner sections are specified taking the maximum amount of cant, radius of curve, construction errors, and others into consideration, but an allowance which is necessary to add electric lamps and electric wires is added outside the gauge for general arched tunnels.

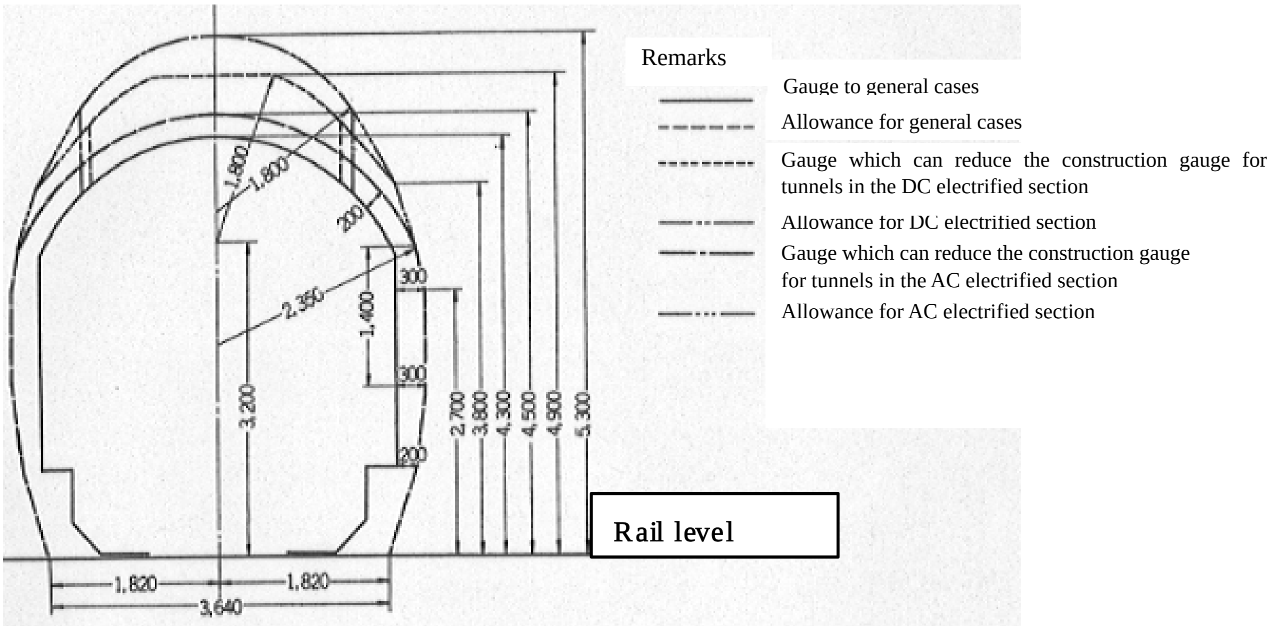


Fig 2.1 Allowance outside the construction gauge in tunnels

(unit: mm)

(2) Allowance generated by cant

When the construction gauge tilts with cant, a dimension which is calculated from Formula (2.1) is added to the upper part of the center line of the construction gauge.

(a) Non-electrified section

$$\Delta h = C \times 1/2 \qquad (2.1)$$

Where

Δh: Dimension to be added

C: Amount of cant

(b) Electrified section a) DC $\Delta h = C$

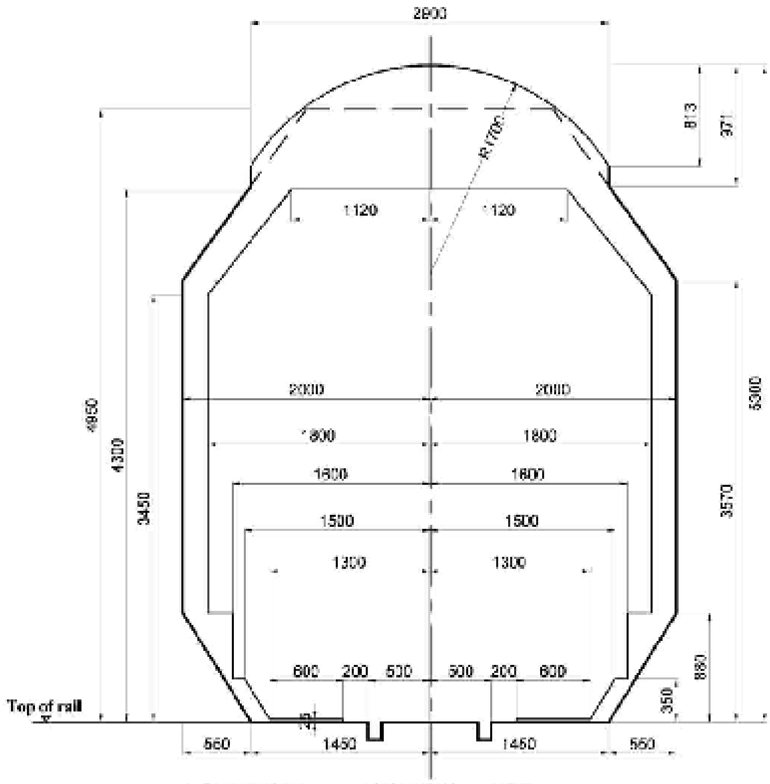
b) AC $\Delta h = C \times 1/2$

[Reference Materials]

Vietnam Railway Specification

For the track facility, Vietnam bridge design standard 22 TCN 272-05 is applied.

The construction gauge are shown herein.



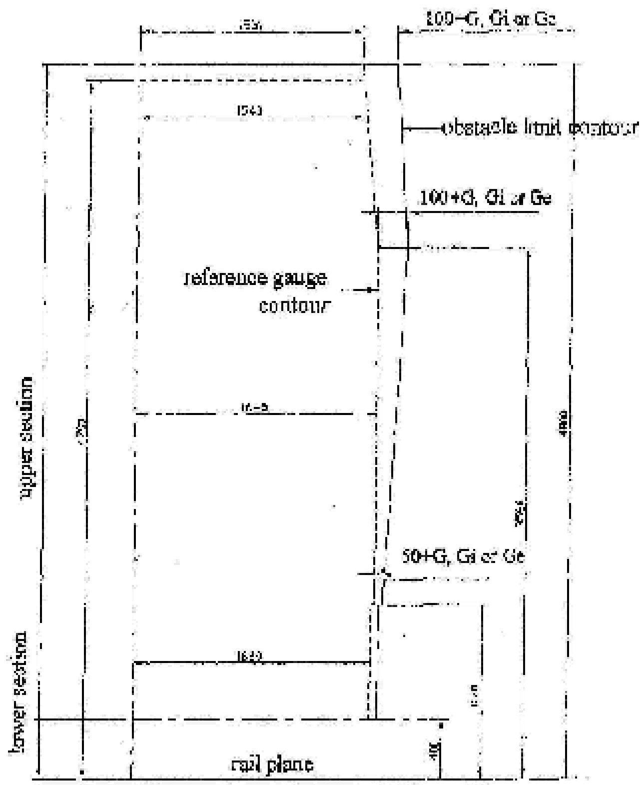
1- Outer envelope: ——— Limite of bridge structure.
2- Inner envelope: ——— Limite of protructive parts of bridge structure.
3. Contructions gauge on curve line must be extented:
- Inside of curve: (24 500/ R) + 4 H (mm)
- Outside of curve: 25 500/ R (mm)
Here. R: Radius of curve (m)
H: Superevelation of rail (mm)

Fig. Contructions Gauge on Straight Line (1000 mm)
(For Bridge Use)

UIC Railway Specification

High Speed Railway

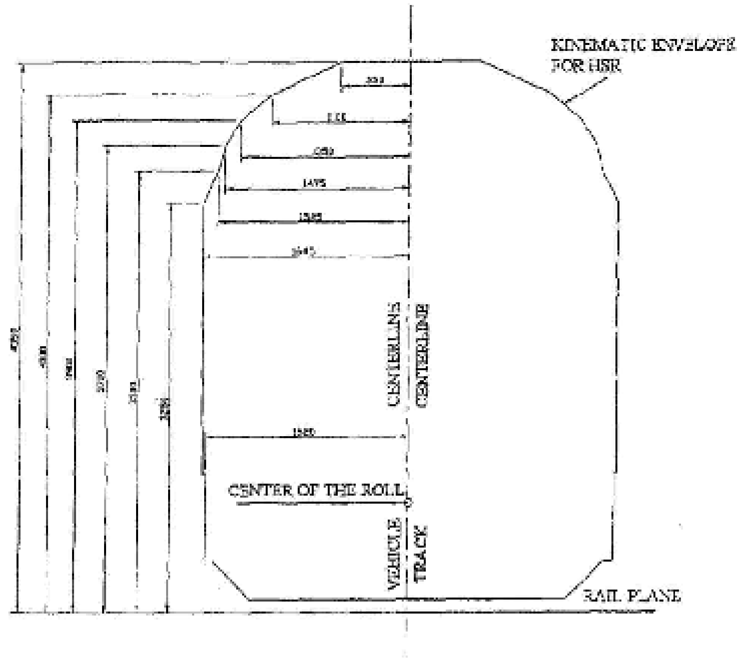
U.I.C. CLEARANCE DIMENSIONS



Dimensions are in millimeters (mm)

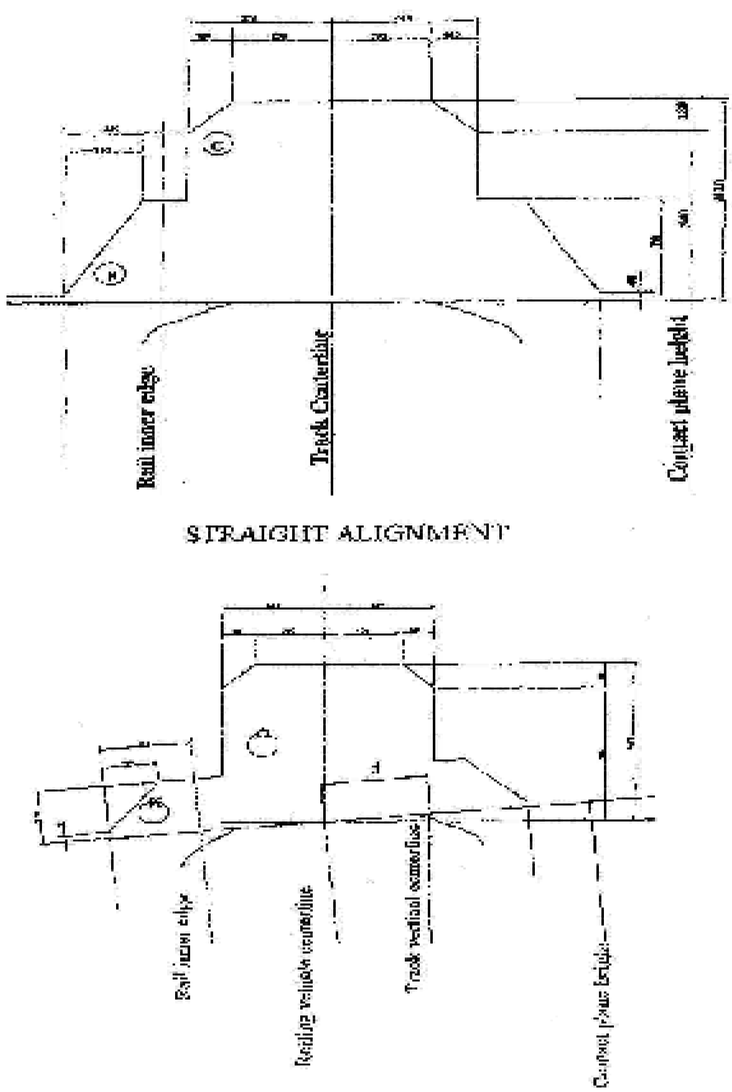
Note : G, Gi & Ge are defined in U.I.C. code 505-1,2,4 & 5.

Kinematic Dimensions of Rolling Stock



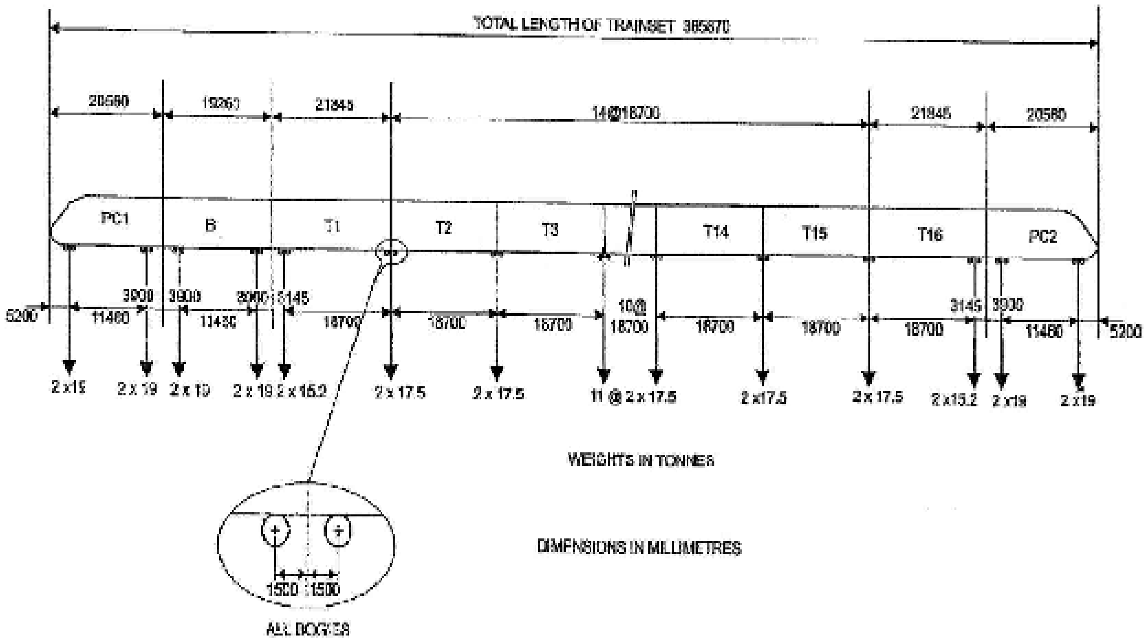
Dimensions are in millimeters (mm)

Electrical Clearances



C = Catenary Insulation Clearance
K = Pantograph Insulation Clearance
d = (Contact plane height x cant) / 1500
Dimensions are in millimeters (mm)

APPENDIX F HIGH SPEED TRAIN LOADINGS



Reference 2 Width of formation level

[Basis for the calculation formula for the amount of widening of formation width (example of normal railways)**]**

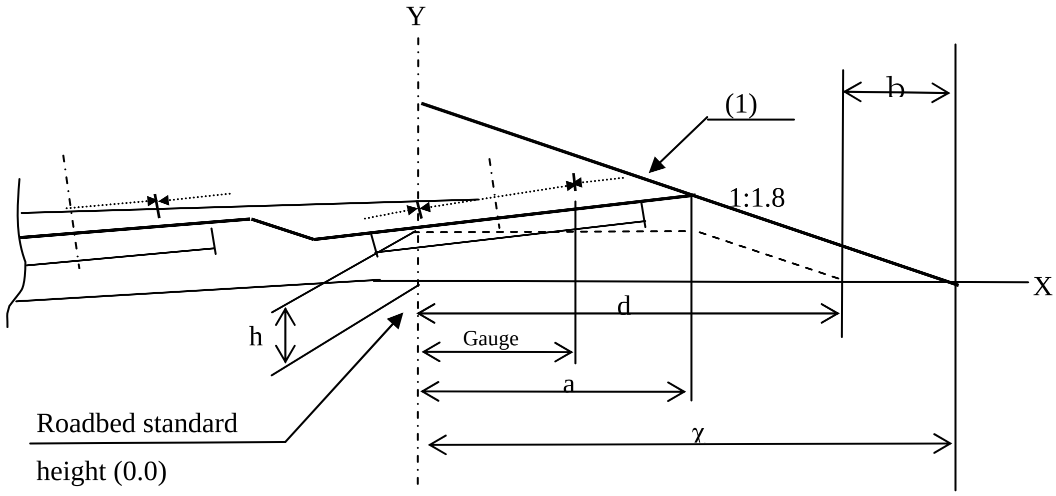


Fig. 23.3 Calculation of the amount of widening of formation width in curve sections

1. Calculation conditions

General conditions are considered as follows:

① Gauge: 1,000 (mm)

② a: 1,450 + gauge/2 = 1450 + 1000/2 = 1,950 (mm)

(3) h: Ballast depth (250) + Cross sleeper thickness (wood: 140) = 390 (mm)

2. Calculation of the amount of widening (b)

From Fig. 21.3, X and Y are expressed by Formula (21.1).

$Y = -(1/1.8)x + 390 + (1{,}950/1{,}000)C + (1/1.8) \times 1{,}950$ .... (23.1)

When Y = 0, X is χ, hence

$0 = -(1/1.8)\chi + 1.950C + 390 + (1/1.8) \times 1{,}950$ .... (23.2)

When C = 0 in Formula (21.2), χ is d, hence

$(1/1.8)d = 390 + (1/1.8) \times 1{,}950$ .... (23.3)

Since $\chi = d + b$,

$(1/1.8)b = 1.950C + 390 + (1/1.8) \times 1{,}950 - (390 + (1/1.8) \times 1{,}950)$, from Formula (21.2) and (21.3), hence

$b = 3.510C \approx 3.51C$ .... (23.4)

[Basis for the calculation formula for the amount of widening of formation width (example when G = 1435 mm)**]**

1. Calculation conditions

General conditions are considered as follows:

(1) Gauge: 1,435 (mm)

(2) a: 1,700 + 1,435/2 = 2,418 (mm)

(3) h: Ballast depth + Cross sleeper thickness = 556 (mm)

From Formula (21.2) and (21.3),

$0 = -(1/1.8)\ \chi + (2418/1435)C + 556 + (1/1.8) \times 2418$

$(1/1.8)\ d = 556 + (1/1.8) \times 2418$

$(1/1.8)\ b = 1.685C + 556 + (1/1.8) \times 2{,}418 - (556 + (1/1.8) \times 2{,}418)$, hence

$b = 3.303C \approx 3.03C$

The calculation formula for the amount of widening of formation width in curve sections when a drainage gradient is constructed is based on Formula (21.5).

$b = 3.710\ C$ .... (23.5)

Where

b: Amount of widening (mm)

C: Amount of cant (mm)

The basis for Formula (21.5) is described below:

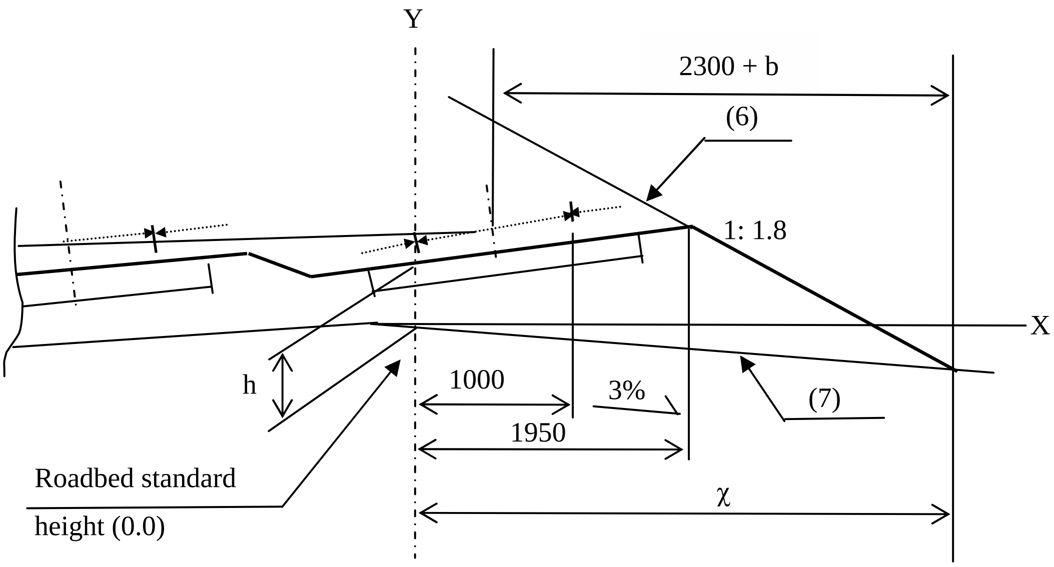


Fig 23.6 Calculation of the amount of widening of formation width in curve sections (drainage gradient: 3%)

Reference materials for formation width

[Basis for the calculation formula for the amount of widening of formation width in curve sections**]**

From Fig. 21.6

$Y = -(1/1.8)X + 390(h) + (1950/1000)C + (1/1.8) \times 1950$ .... (23.6)

$Y = -0.03X$ .... (23.7)

Since (21.6) = (21.7),

$-0.03X = -(1/1.8)X + 1473.5 + 1950C$

$X = 2803 + 3.701C$ .... (23.8)

When C = 0 in Formula (21.8)

$X = 2803$

When $X_0 = X$ (= 2803),

$b = X - X_0 = 2803 + 3.710C - 2803 = 3.710\ C$ .... (23.5)

Referene 3 Structure

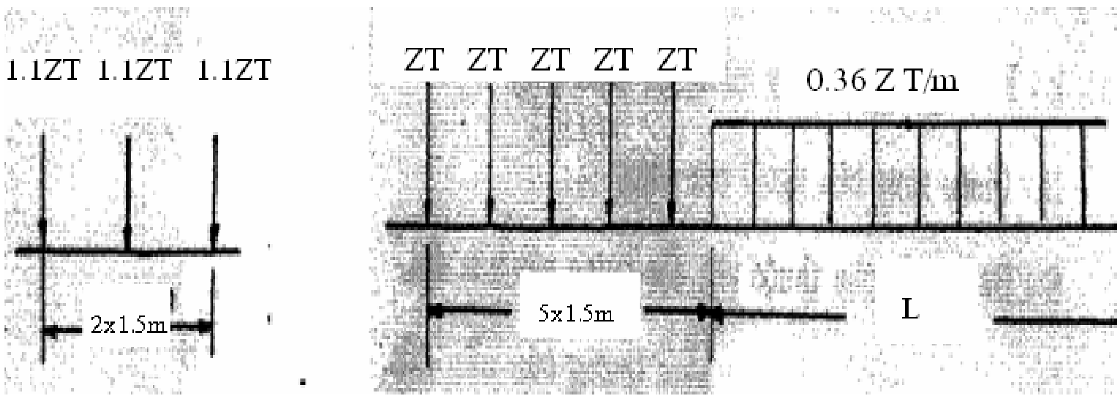
For train loads

Train loads applied to structure design shall be as the following.

1) Sections in which locomotives travel

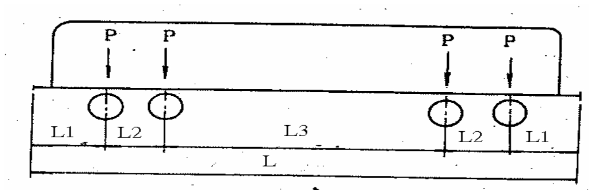
Figures of the standard live loads Z - T

Applied to permanent ways with 1000 mm and 1435 mm gauges



- The left figure shows a special load (exclusive for large locomotives).
- The right figure shows locomotive and car reduced loads.
- By comparing two loads, select the one that has more effect on structures.
- Apply the load of T14-grade (Z = 14 tons) to permanent ways of a 1000 mm gauge.
- As for permanent ways of a 1435 mm gauge, apply the load of T26-grade (Z = 26 tons) to I- and II-grade permanent ways and that of T22-grade (Z = 22 tons) to III-grade permanent ways.
- The Ts shown in the above figures stand for tons.
- The length L shows load arrangement in meters.

2）Sections in which only electric passenger trains travel



L: Carbody length (distance between automatic couplers)

L2: Wheel base

The axle load shall be determined based on a weight obtained from a tare plus a weight of volumes of entrainment of a 300 % occupancy rate of passenger capacity.

Axle load P = (tare + 300 / 100 * passenger capacity * 55 kg) / 4

The following table shows the standard design specifications of electric passenger trains.

Item	Standard value
Carbody length (L)	17 - 20 m
Wheel base (L2)	2.10 - 2.30m
Axle load (P)	14 - 16 t

Reference List of current design standards in Vietnam

Structure type	Design standard name	Constitutive organization and date of enactment
Bridge, channel	Regulations for bridges and channels design based on limit state	Ministry of traffic and transportation 1979-9-19 22TCN 18-79 Note: The Decision No. 3277/2003 dated 3 November 2003 that provides for the expiration date of the above regulations as the end of 2005 has been issued. Regulations for railway bridge design are being prepared at present.
Permanent way	Technical standards for design of 1-gauge-1000-mm railways Technical standards for design of 2-gauges-1435-mm railways	Ministry of traffic and transportation 1976-2-9 1985 TCVN-4117-1985 Ministry of Construction
Tunnel	Design standards for road and railway tunnels (Railway)	National committee for fundamental constructon 1988-2-0TCVN 4527-88
Railway civil engineering in general	1 Standards for construction design of traffic civil engineering and environmental impact assessment in the establishment of an operable project etc. (Railway civil engineering and relations) 2 Design standards for traffic civil engineering in seismic regions (Railway civil engineering and relations)	Ministry of traffic and transportation 1998-3-27 22TCN 242-98 Ministry of traffic and transportation 1995-5-03 22TCN 221-95

2) List of design standards for structures specified in Japan

(1) Design Standards for Railway Structures (Earth Structures)

(2) Design Standards for Railway Structures (Concrete Structures)

(3) Design Standards for Railway Structures (Steel and Compositional Structures)

(4) Design Standards for Railway Structures (Fundamental Structures/Earth-Pressure- Resistant Structures)

(5) Design Standards for Railway Structures (Shield Tunnel)

(6) Design Standards for Railway Structures (Steel-Concrete Hybrid Structures)

(7) Design Standards for Railway Structures (Earth Structures for low maintenance tracks)

(8) Design Standards for Railway Structures (Cut and Cover Tunnel)

(9) Design Standards for Railway Structures (Seismic Design)

(10) Design Standards for Railway Structures (Urban Mountain Tunnel)

(11) Design Standards for Railway Structures (Displacement Limits)

Reference 4 Facilities for the prevention of a disaster 1

1. Purpose of the installation of disaster prevention facilities

It was decided to install facilities according to need to prevent interference with train operation due to a rockfall in cut sections or tunnels entrances, or a fall of car at points near overbridges or roads which may cause a problem to tracks.

2. Outline of specific facilities

2.1 Facilities against rockfall

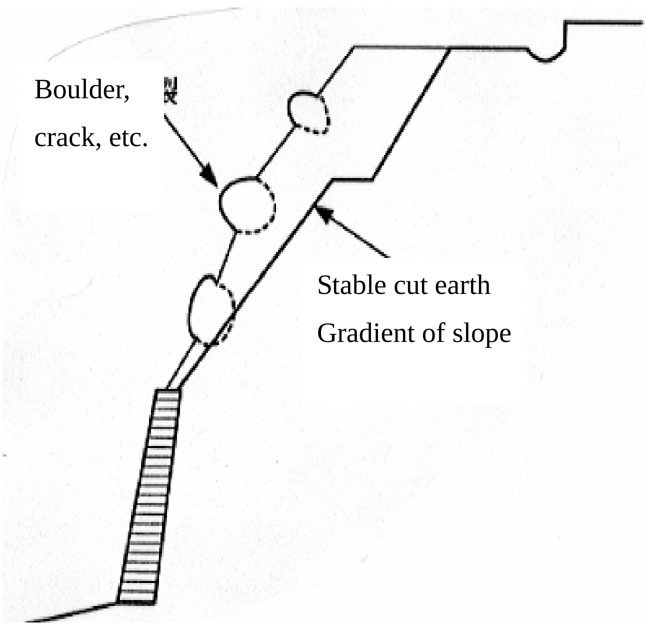
These facilities are broadly classified into hardware measures (rockfall prevention work, rockfall protection work) and software measures (rockfall detecting devices).

When deciding the points to take rockfall measures and selecting prevention work, it is necessary to conduct general inspections for earth structure, or individual inspections if necessary, to understand topography, geological conditions, and others on a broad scale.

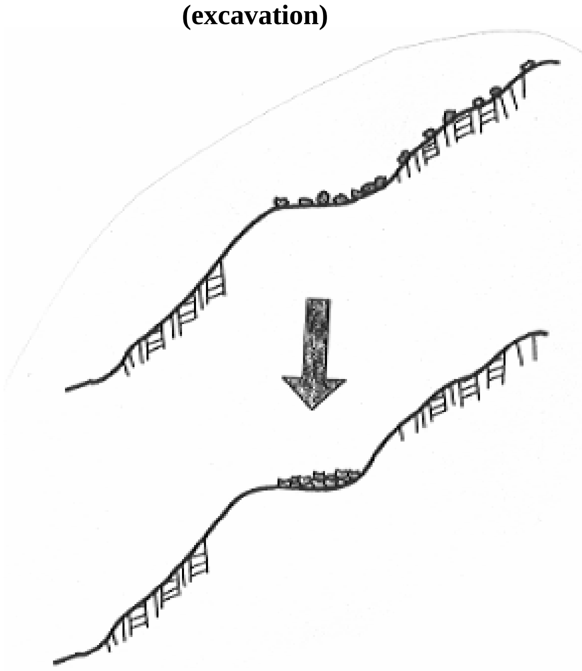
(1) Rockfall prevention work

Prevention work against sources, which take direct measures such as removing rock lumps that may cause a rockfall or fixing them on a slope, includes the following works.

(1) Slope cut (excavation)

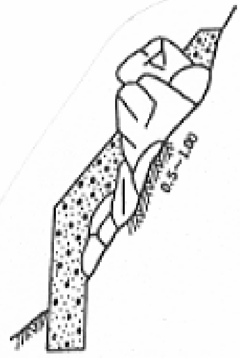


(2) Loose rock trimming (excavation)

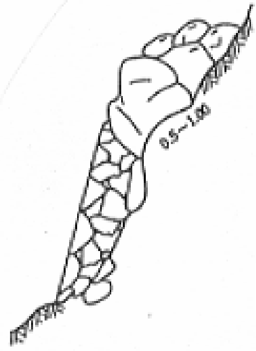


(3) Foot protection work (a method to fix rocks on a slope)

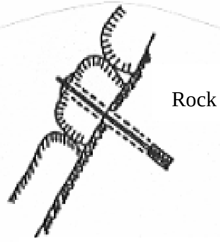
(4) Rock anchor (a method to fix rocks on a slope)



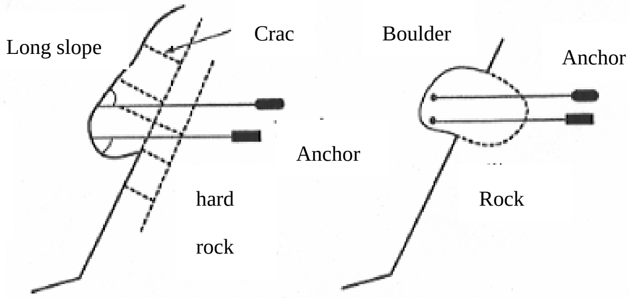
(Concrete foot protection work)



(Masonry foot protection work)



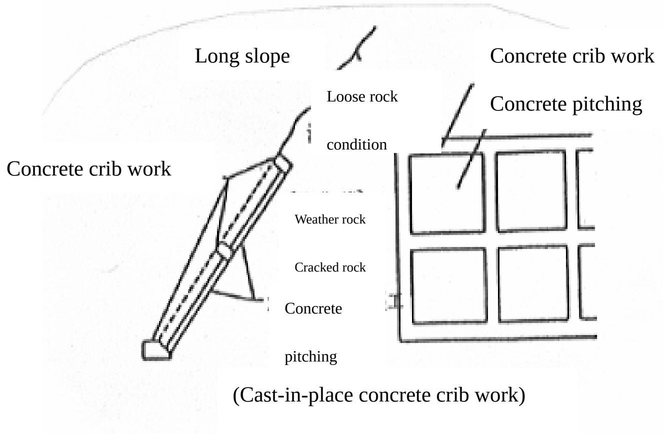
(Rock bolt)



(Rock anchor)

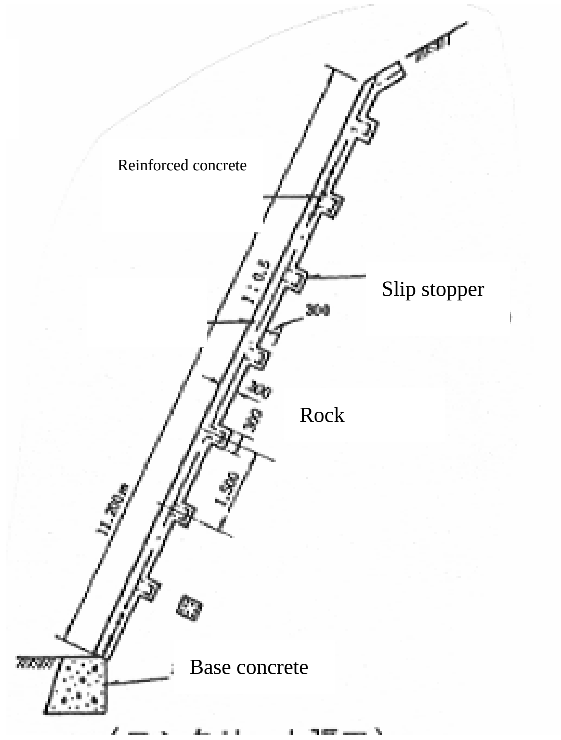
(5) Surface coat (a method to fix rocks on a slope)

a. Cast-in-place concrete crib work

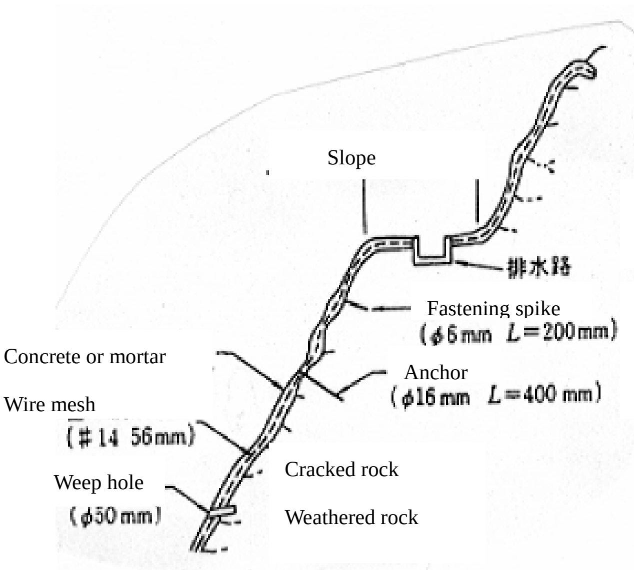


(Cast-in-place concrete crib work)
[Example of combination use of concrete pitching]

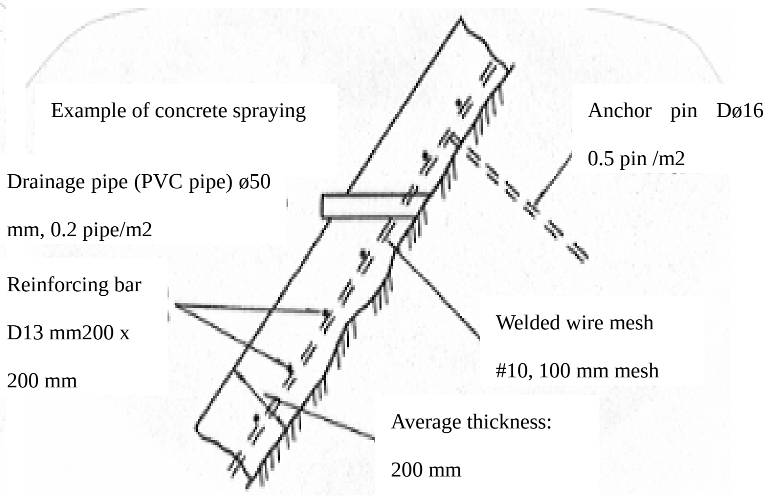
b. Concrete protection work



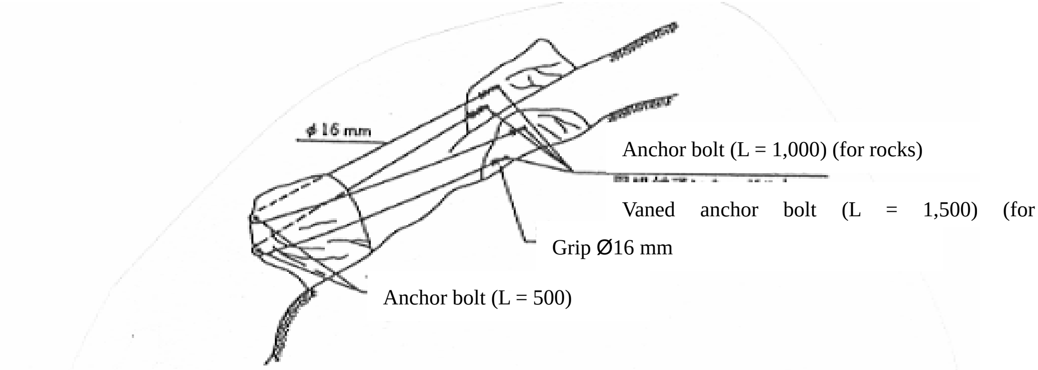
c. Guniting



d. Concrete spraying



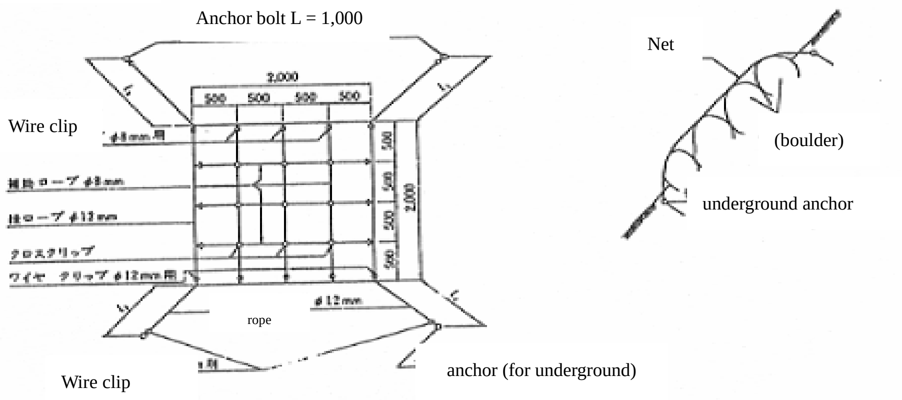
(6) Wire rope hanging



(Rope hanging <wire net>)

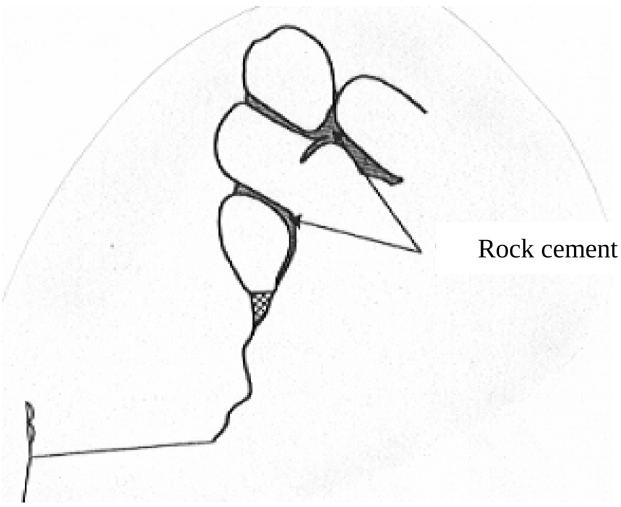
Plan view

Cross sectional view



(Rope netting)

(7) Rock Bonding

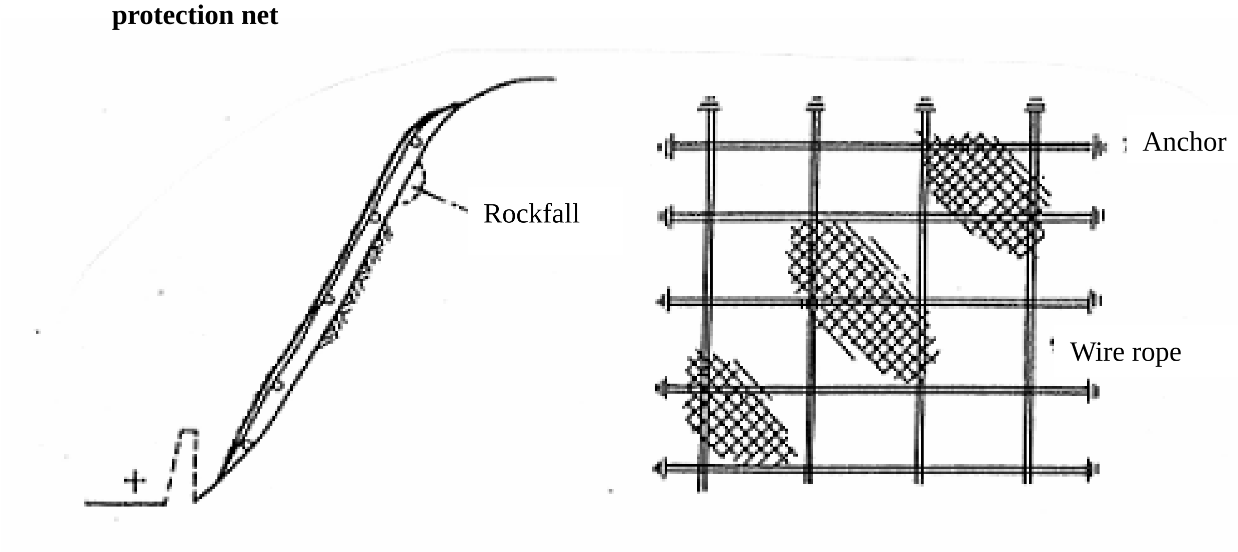


(2) Rockfall protection work

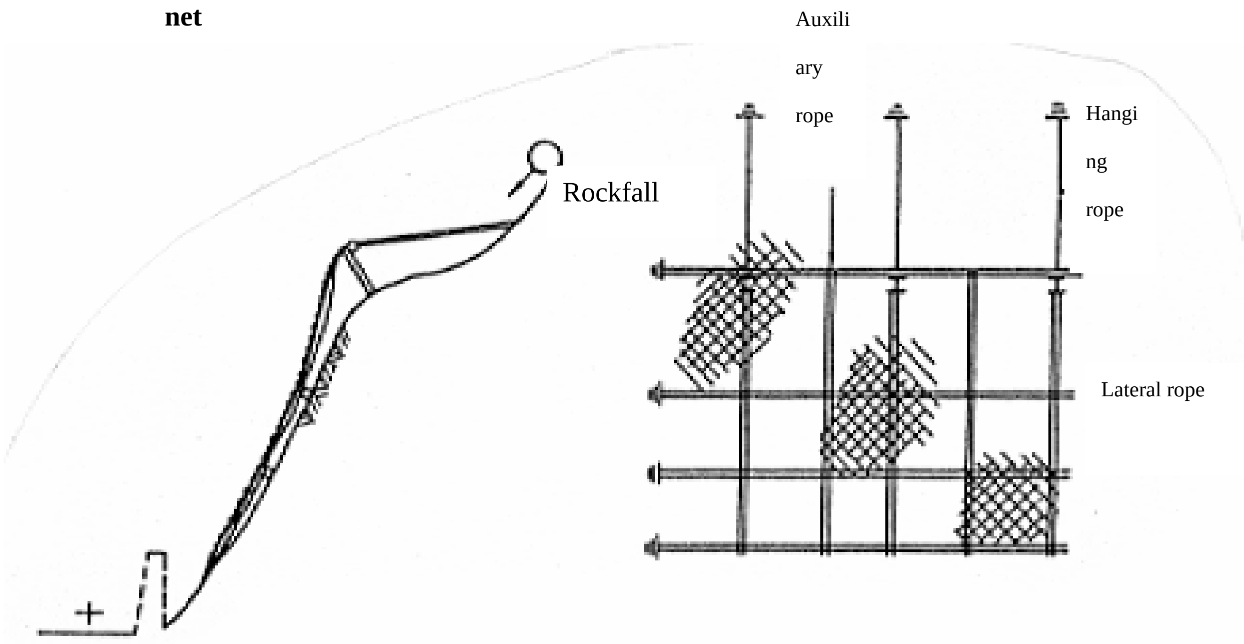
When prevention work against sources cannot be taken, rockfalls are prevented by facilities installed on a slope leading to a track or near the track, and following measures are included.

(1) Rockfall protection net

a. Cover-type rockfall protection net

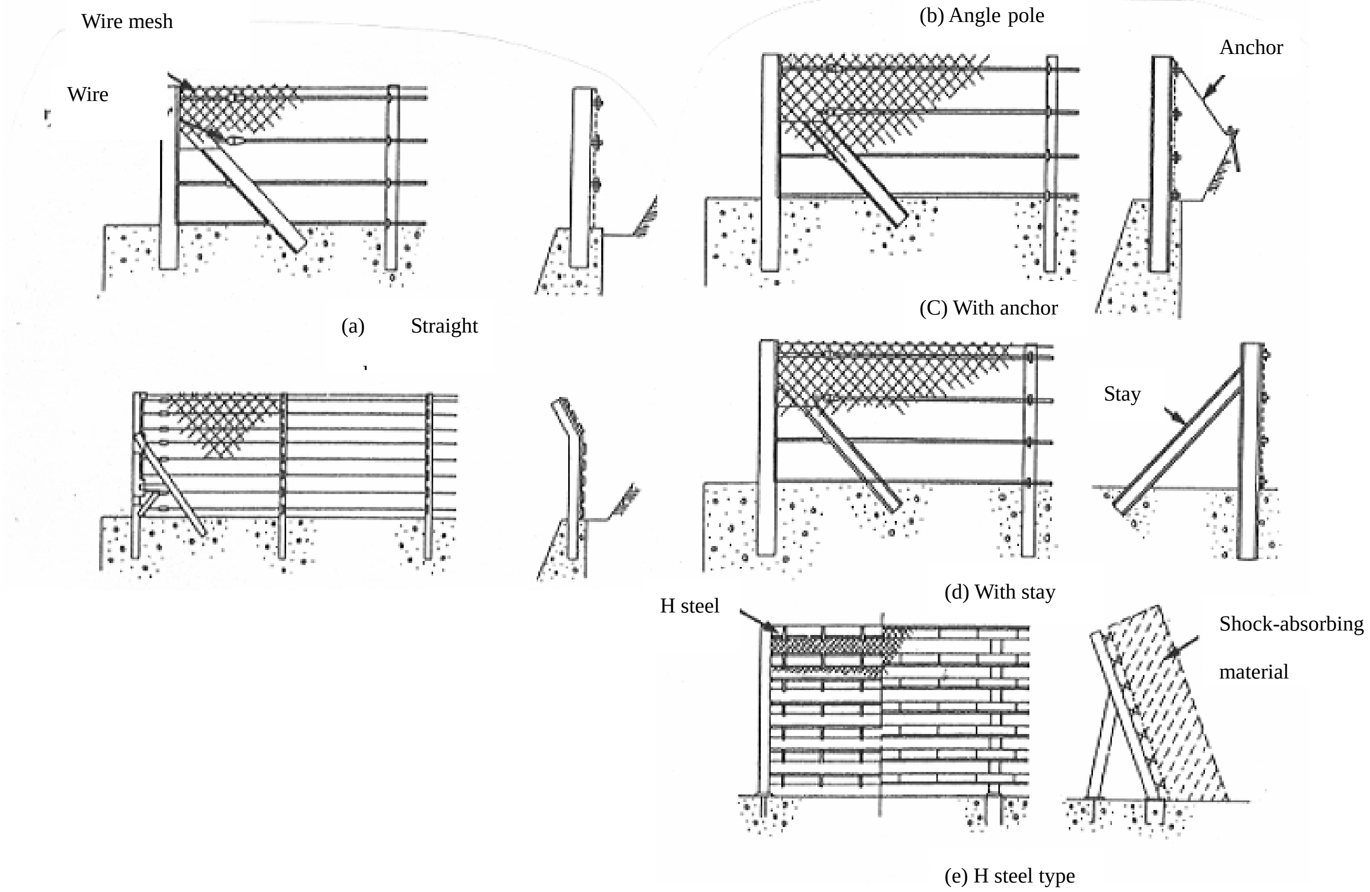


b. Pocket-type rockfall protection net

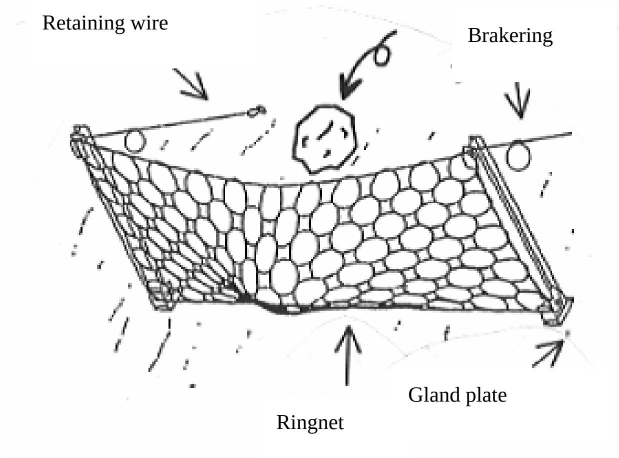


(2) Rockfall protection fence

a. Rockfall protection fence

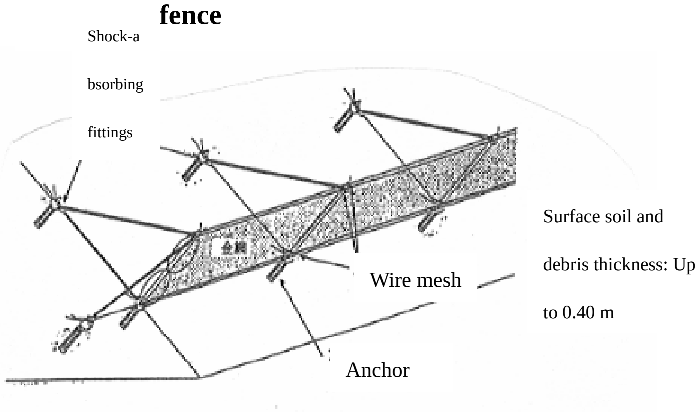


b. Flexible rockfall protection barrier



Flexible rockfall protection barrier (ringnets protection fence)

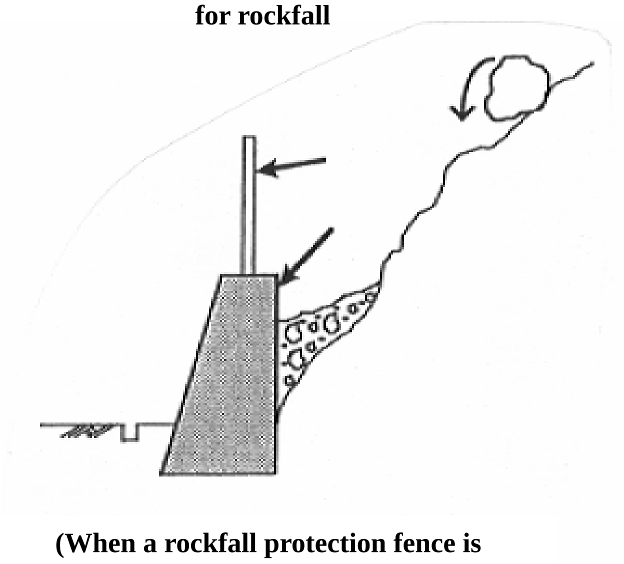
c. Small rockfall protection fence



[Bird's-eye structural drawing] (Support span: 10 m, height: 2 m, one construction block: 30 m on standard) (Type A, for rocks)

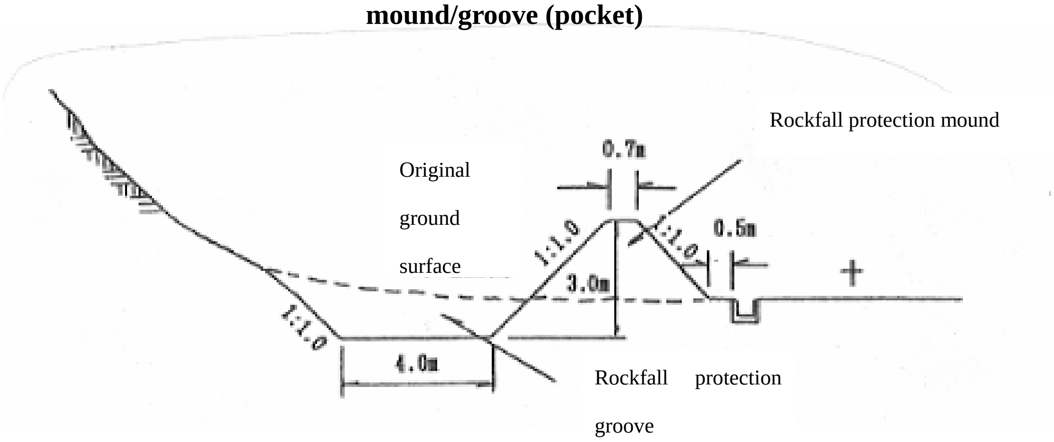
(Small rockfall protection fence <low priced rockfall protection fence>)

(3) Retaining wall for rockfall

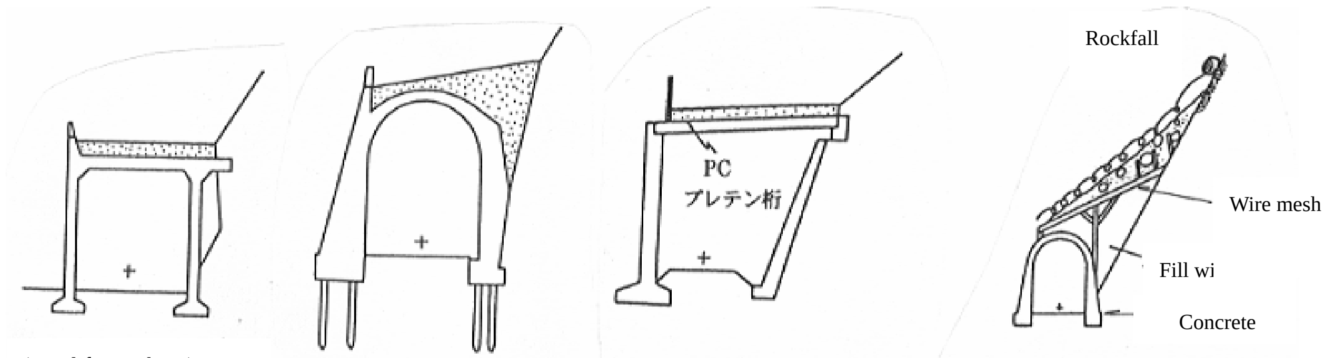


(When a rockfall protection fence is established on the retaining wall)

(4) Rockfall protection mound/groove (pocket)



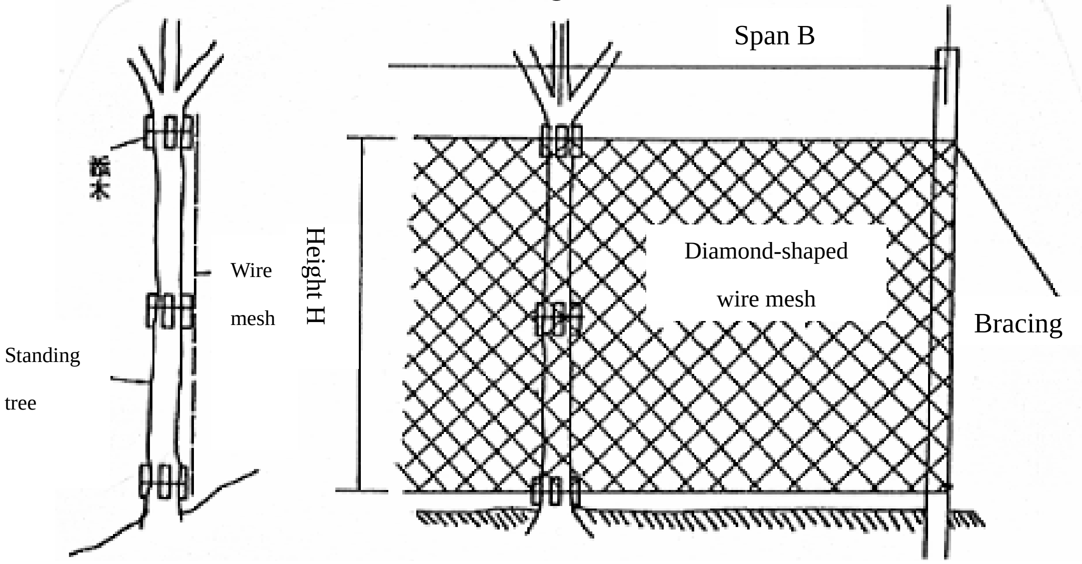
(5) Rockfall protection galleries



(Rigid-frame shape) (Tunnel shape) (PC pretensioned beam) (Prestressed concrete simple beam type)

(Representative rockfall protection galleries)

(6) Fence using standing trees



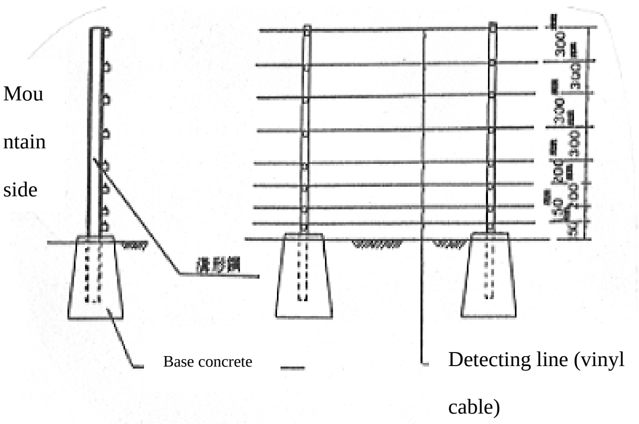
Rockfall detecting devices

Rockfall detecting device is an effective method to stop a train immediately when a rockfall is detected.

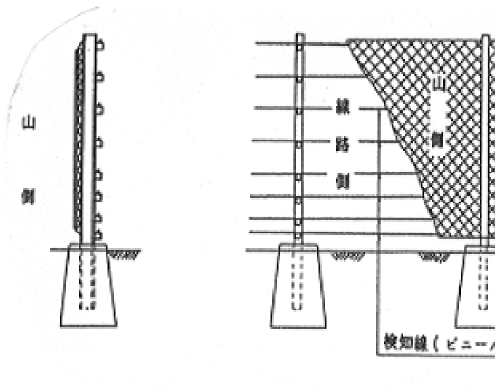
In general, it is used when various types of hardware measures cannot be taken, constructed hardware measures are not enough, or temporary safety measures are necessary when the construction of hardware measures requires a long period.

The detecting method includes “breaking system” which issues an alarm when the detecting line breaks when a rockfall etc. hits the line and “tilting system” which incorporates an inclinometer at the detection part and issues an alarm when the detector inclines at a certain angle or above when it is hit with a rockfall etc.

In addition to these systems, there are sensors which detect voltage fluctuations by deformation of the sensor cable and those using optical fiber.



(Breaking system: Detecting line independent system)



(Breaking system: Protection work joint use system)

Reference 5 Facilities for the prevention of a disaster 2

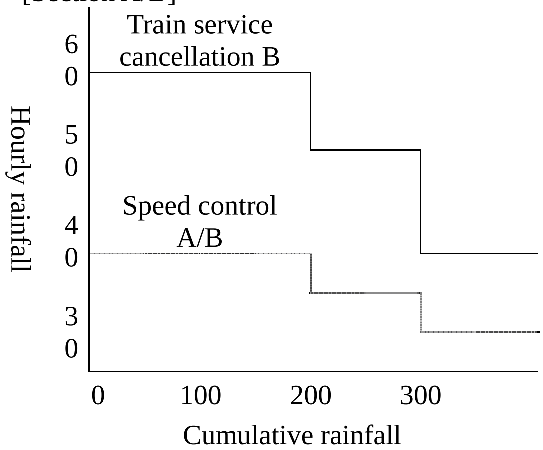
The standard values when operation control or other measures are taken are shown in Table 30.1 to 4.

1. Example of operation controls under rainfall

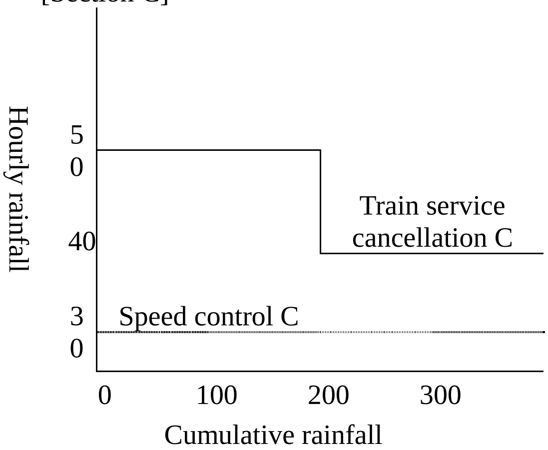
Table 30.1 Standard values for operation control etc.

Classifica-tion of operation control sections	Types of operation control	Standard values		
		Cumulative rainfall: Less than 200 mm	Cumulative rainfall: 200 mm or more and less than 300 mm	Cumulative rainfall: 300 mm or more
A	Speed control	Hourly rainfall: 40 mm or more	Hourly rainfall: 35 mm or more	Hourly rainfall: 30 mm or more
B	Speed control	Hourly rainfall: 40 mm or more	Hourly rainfall: 35 mm or more	Hourly rainfall: 30 mm or more
	Train service cancellation	Hourly rainfall: 60 mm or more	Hourly rainfall: 50 mm or more	Hourly rainfall: 40 mm or more
C	Speed control	Hourly rainfall: 30 mm or more		
	Train service cancellation	Hourly rainfall: 50 mm or more	Hourly rainfall: 40 mm or more	

[Section A/B]



[Section C]



· Hourly rainfall: Rainfall for the nearest one hour measured every 15 min. (four times every hour at 0, 15, 30, and 45 minutes)

· Cumulative rainfall: Total cumulative rainfall after the measurement was started when it had not rained for 48 hours.
(Rainfall is measured every 15 minutes just like hourly rainfall.)

2. Example of operation controls by wind speed

Table 30.2 Example of wind speed standard values during operation control

Types of controls	Wind speed (m/s)	
	General control	Early control
Operation stop	30 −	25 −
Slowing down (25 km/h)	25 − 30	25 − 25
Surveillance	20 − 25	15 − 20

3. Example of controls in times of earthquake

○ JR's example

The standard values of operation control in times of earthquake are specified as in Table 1.3.

Table 30.3 Example of standard values for operation control etc.

(Unit: gal)

	Conventional line	
	Ordinary section	Section with seismic design
Signal	25	25
Speed control	40	80
Operation stop	80	120

○ Examples of private railways

The handling of operation when an earthquake occurs is specified in Table 30.4.

Table 30.4 Example of the handling of operation when an earthquake occurs

	− Less than 10 gal	10 or more and less than 50 gal	50 or more and less than 100 gal (Warning I)	100 or more and less than 150 gal (Warning II)	150 gal or more (Warning III)
When an earthquake occurs	All trains should be operated carefully when informed of the occurrence of an earthquake.	All trains should be operated carefully when informed of the occurrence of an earthquake. The station master should inspect tracks and structures near the station.	All trains should stop immediately when informed of the occurrence of an earthquake. The station master should inspect tracks and structures near the station. Each engineering department should inspect tracks and structures.	All trains should stop immediately when informed of the occurrence of an earthquake. The station master should inspect tracks and structures near the station. Each engineering department should inspect tracks and structures.	Contact lines of all lines stop automatically by the movement of the seismograph. All trains should stop immediately when informed of the occurrence of an earthquake. Each engineering department should inspect tracks and structures. The station master should patrol crossings and stations, and be on guard.

Resumption of operation		The train should be operated carefully at 45 km/h or below.	After confirming that there is no problem in the operation of trains from the above inspection by the station master, the train should be operated carefully at 25 km/h or below during the first section, and appropriate speed control should be made according to the conditions. (Follow the request of operation control from each engineering department, if any.)	After confirming that there is no problem in the operation of trains from the above inspection by the station master, the train should be operated carefully at 15 km/h or below during the first section, and then speed control between 25 and 50 km/h should be made. (Follow the request of operation control from each engineering department, if any.)	After the station master confirms that there is no problem in the operation of trains and obtains approval from each engineering department, the train should be operated carefully at 15 km/h or below during the first section, and then speed control between 25 and 50 km/h should be made. (Follow the request of operation control from each engineering department, if any.) When it is absolutely necessary to move the stopping train before approved by each engineering department, the station master must confirm that there are no obstacles in the section where the train is moved and obtain approval of the transport section chief.
Normal operation		After the station master and crews confirm that there are no abnormalities in the tracks and structures.	After the above speed control is taken.	After approved by each engineering department.	After approved by each engineering department.

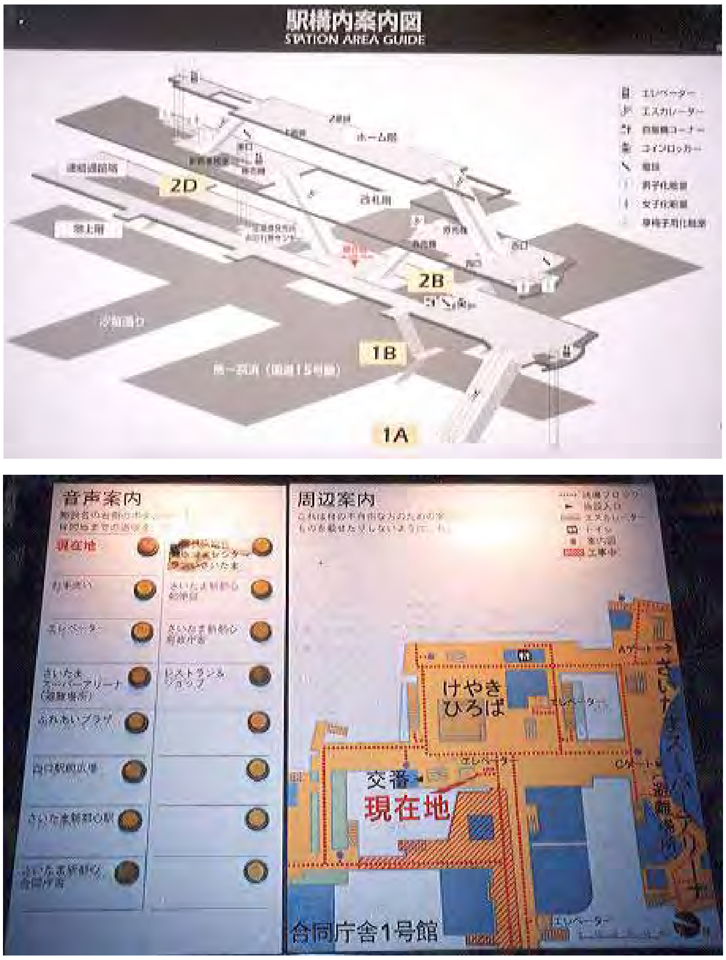
Reference６　Station facilities

Equipment to provide passengers with helpful information

The equipment to provide passengers with helpful information means the equipment for appropriately guiding passengers to station facilities to be used by them, such as guidance signs (photograph 37.1), location signs (photograph 37.2), guide signs (photograph 37.3) and control sign (photograph 37.4).

Photograph 37.1　Examples of guidance signs

Photograph 37.2　Examples of location signs

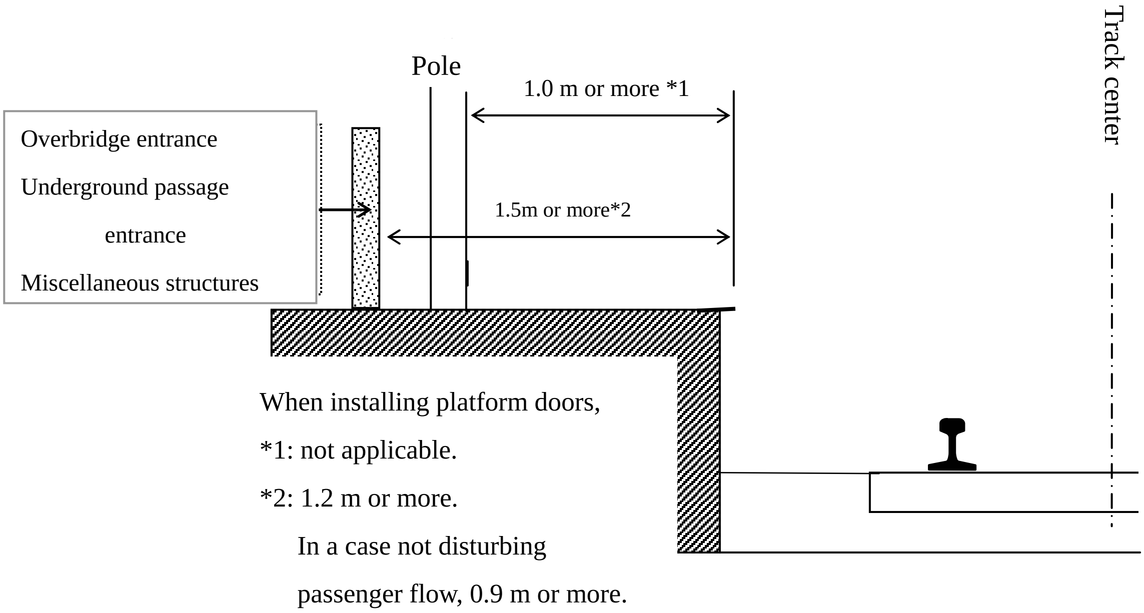


Photograph 37.3   Examples of guide signs

Photograph 37.4   Example of control sign

: Reference 7 Platform 1

Figure 38.1 Distance between platform edge and structure



Photograph 38.2 Falling protection fence at the location other than track side

Photograph 38.3　Emergency train stop button

Photograph 38.4　Falling detection mat

Photograph 38.5　Example of platform fence

Photograph 38.6 Example of platform doors

Reference 8 Platform 2

1. Calculation of platform width

1.1. Conventional railway (except for Shinkansen)

To calculate the platform width, there are various assessment formulas using the parameters including simultaneous maximum volume of entrainment and detrainment, actual situation of passenger flow and passenger flow speed, etc. These formulas provide different calculation results. For such the purpose, following official notices and papers have been used until now.

(a) "Required width for platform", engineering paper No. 45, March 1938.

(b) "On the design of passenger facilities in track saving electric railcar station", Shigeru Ito, August 1947.

(c) Interim report of section meeting for assessing the priority of improvement works", Platform Section, Facility Bureau, October 1955.

(d) "Investigation on formulas to calculate the scale of passenger facilities", Business information of Tokyo Third Engineering Office, (No. 9, No. 10), November 1980, November 1981.

In this case, as an example we mention the widely applied formula (1.1) to calculate the priority of improvement works proposed by the head office, Japan National Railways, described in above (c).

Required width： $B = B_1 + B_2 + \gamma$ .... (1.1)

Where,

B_1: Gathering width (width occupied due to gathering of passengers at each car door, and calculated by assuming that all passengers gather at each door in semicircular pattern on the average.)

B_2: Flow width (width occupied by passengers walking on platform after getting off a train.)

γ: Margin width due to pole width and the factors such as refuge from train

Refuge width (from opposite platform edge to warning white line): 0.8 m

Pole width: average 0.3 m

Bench width: Single sided 0.6 - 1.1m, Double sided 1.1 - 1.4m } Average 1.1 m

But, for the platform in front of main building, this parameter should be 2 m.

Above values should be taken into account depending on the considered situation.

(a) B_1: In a case of PC, DC;

$$B_1 = 0.44\,k \left(\frac{P_a}{N} \right)^{1/2}$$

In a case of EC;

$$B_1 = 0.2\,k \left(\frac{P_a}{N} \right)^{1/2}$$

(b) B_2: In a case of PC, DC;

$$\begin{cases} \frac{P_b}{N} \text{ When } < 2LN,\ B_2 = \frac{2P}{3L} \\ \frac{P_b}{N} \text{ When } > 2LN,\ B_2 = \frac{4N}{3} \end{cases}$$

In a case of EC;

$$\begin{cases} \frac{P_b}{N} \text{ When} < 6.4LN,\ B_2 = \frac{2P_b}{3LN} \\ \frac{P_b}{N} \text{ When} > 6.4LN,\ B_{2,} = \frac{13N}{3} \end{cases}$$

When <6.4LN,
When > 6.4LN,

Where:

PC: Passenger car
DC: Diesel car
EC: Electric car

} Abbreviation of each train

P: Volume of entrainment and detrainment determining maximum width of platform ($P = P_a + P_b$)

P_a: Maximum volume of entrainment per train (in a case of electric car station, 30 minutes average volume of entrainment at rush hour per electric car)

P_b: Volume of detrainment in above case

N: Number of passenger cars

L: Length per car

Fundamental assumptions for above assessment formula are as follows.

(a) Passengers equally distribute at each car door and the gathering of passengers forms a semicircular pattern as shown in Figure 1.1.

(b) Volume of entrainment and detrainment shows equal distribution pattern.

(c) For passengers getting off, Formula (1.2) is applied.

$$\text{Passage width} = \frac{\text{Passing volume}}{\text{Crowd speed} \times \text{Crowd density}} \quad \cdots\cdots \quad (1.2)$$

From (1.2), the passage width required to pass a constant passing volume on a platform becomes minimum when the product of crowd speed and crowd density becomes maximum.

(d) In a case that two electric trains arrive at the same time, required widths should be summed up.

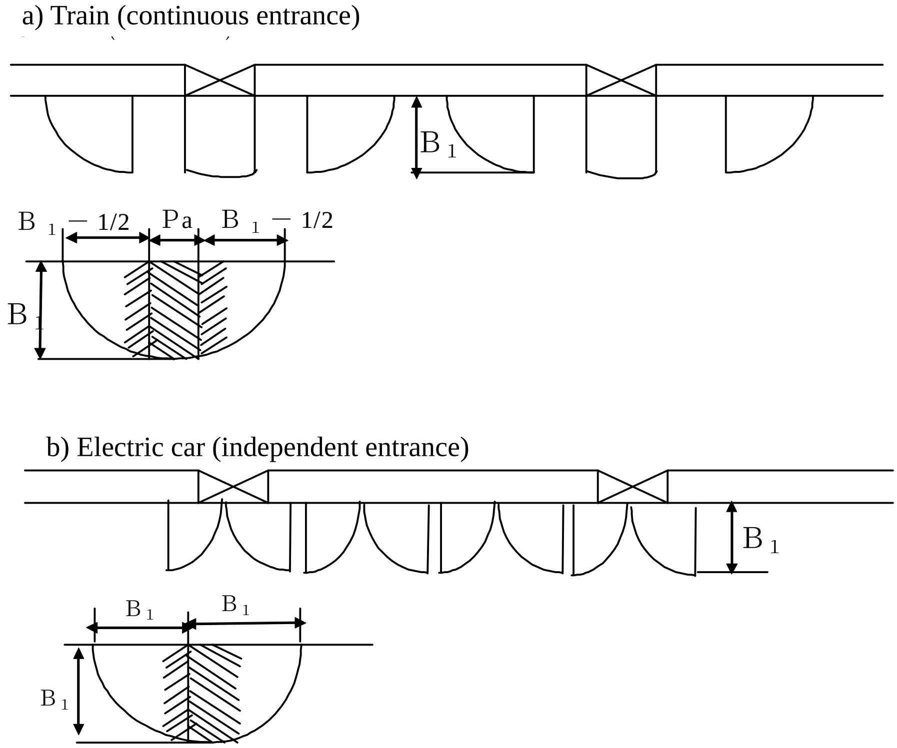


Figure 1.1　Gathering pattern of passengers

Where, the values to be substituted into the assessment formula are shown in Table 1.1.

Table 1.1　Values for the formula to assess platform width

(Platform Engineering Association, Japan National Railways)

	Unit	Train	Electric car
Getting on and off speed	Persons／sec	0.8	1.6
Gathering density at car door	Persons／m^2	3.33	4.0
Flow speed	m／sec	0.8	1.0
Flow density	Persons／m^2	1.5	1.5
Flow volume	Persons／m／sec	1.2	1.5
Waiting density	Persons／m^2	1.25	

However, currently when applying the assessment formula to a commutation station with large volume of users, following issues may be pointed out.

(a) While it is assumed that gathering of passengers forms a semicircular pattern at car door, several stations currently carry out lined-up getting on.

(b) Although the distribution of passengers on a platform extremely concentrates at entrance and exit of stairway, conventional formula handles this distribution as uniform.

(c) 0.8 m^2 per person when most crowding condition may be deemed as too standardized treatment.

On the other hand, also the factors such as interrelation among volumes of entrainment and detrainment or operation head, etc. may contribute. Hence, by taking above issues into account, the assessment formula for metropolitan commutation station has bee newly proposed as shown in Table 1.2. Where, the new assessment formula uses the values such as getting on and off speed of passengers, flow speed, flow density and flow volume at platform and stairway, etc. shown in Table 1.3.

The table shows also the values from existing investigation papers. As obvious from these, all the values are similar with each other except for some ones.

Table 1.2

Formula to calculate required platform width of metropolitan commutation station (draft)

(Investigation Section, Tokyo Third Engineering Office)

Platform condition	Calculation formula
1. Platform, at which passengers mainly get on. (Up train platform of suburb station, etc.)	$L = 0.012(P_{nj} + P_{kj}) + 3.0$ L: Required width (m) Pnj: Entrainment volume per up electric car per stairway (rush hour 30 minutes average per electric car) Pkj: Entrainment volume in down electric car in above case 3.0: Margin width (flow margin 1.50 m, platform edge margin 0.8×2 = 1.6)
2. Platform, at which passengers mainly get off. (Up train platform of transfer station near metropolis, etc.)	$L = \frac{PKK}{1.52t} + 5.6$ L: Required width (m) Pkk j: Detrainment volume per electric car per stairway (rush hour 30 minutes average per electric car) t: Stairway discharge time Operation interval 5 minutes or more 150 s 〃 3 – 5 minutes 120 s 〃 less than 3 minutes 100 s 5.6: Margin width (1.0 for passenger in stairway, stairway wall thickness 0.30×2 = 0.6 m, from stairway side wall to platform edge 2.0×2 = 4.0 m)
3. Platform, at which both the volumes of entrainment and detrainment are large. (Platform at metropolitan terminal station, etc.)	$L_1 = 0.012(P_{nj} + P_{kj}) + 3.0$ (National railway) $L_2 = 0.005(P_{nj} + P_{kj}) + 0.012 P_{kj} 0.028 P_{nk} + 2.30$ $L_3 = 0.005(P_{nj} + P_{kj}) + 0.028(P_{nk} + P_{kk}) + 1.50$ (Middle destance railway) $L_2 = 0.005(P_{nj} + P_{kj}) + 0.012 P_{kj} 0.028 P_{nk} + 2.30$ $L_3 = 0.005(P_{nj} + P_{kj}) + 0.021(P_{nk} + P_{kk}) + 1.50$ } L: Required width (m) (maximum one of L_1 - L_3) Pnj: Detrainment volume per electric car per stairway (rush hour 30 minutes average per electric car)

Table 1.3

Comparison of values for the formulas to calculate platform and stairway width

Investigation item			Unit	Improve-ment Engineering association	Dr. Ito	Investi-gation Section, Tokyo Engineering Office	Investi-gation Section, Osaka Engineering Office	Investigation Section, Tokyo Third Engineering Office	Platform Engineering Association
Getting on speed			Persons /sec	1.4	1.4	1.6	1.2	1.17	1.6
Getting off speed			〃	1.4	1.4	1.9	1.5	2.53	1.6
Gathering density at car door 【Gathering area】			Persons /m^2 【m^2 /person】	4.0 【0.25】	4.0 【0.25】	4.0 【0.25】	7.7 【0.13】	4.10〜6.13 【0.28〜0.15】	4.0
Platform	Flow speed		m/sec	1.0	1.1	0.84	0.84	1.17	1.0
	Flow density		Persons /m^2	1.25	1.20	1.75	2.10	1.23	1.5
	Flow volume		Persons /m・sec	1.25	1.32	1.47	1.59	1.44	1.5
Passage	Flow speed		m/sec		0.75	0.60	1.07	1.29	
	Flow density		Persons /m^2		2.0	2.40	2.0	1.20	
	Flow volume		Persons /m・sec		1.50	1.40	2.14	1.55	
Stairway	Down Step	Flow speed	m/sec	0.60	0.64	0.53	0.53	0.58	
		Flow density	Persons/ m^2	2.86	2.50	2.70	3.0	2.62	
		Flow volume	Persons /m・sec	1.72	1.60	1.43	1.59	1.52	
	Up step	Flow speed	m/sec	0.60	0.60	0.38	0.52		
		Flow density	Persons /m^2	2.86	2.50	2.90	2.80		
		Flow volume	Persons /m・sec	1.72	1.50	1.12	1.46		

1.2 Shinkansen

(1) Assumptions for calculation

(a) For the volumes of entrainment and detrainment, we could consider the value obtained from the volumes of entrainment and detrainment at each station calculated from transportation volume assumption by taking fluctuation into account, and the case that passenger capacity gets off and then passenger capacity gets on, although rare when group passengers get on and off. Therefore, we took also the values when passenger capacity gets on and off into account.

(b) For the standard values to be substituted into the assessment formula, we assumed as follows by referring to the measured values from the investigations of the improvement engineering association and Tokyo Engineering Office, etc.

Getting off speed	0.7 Persons／sec
Crowd speed of passengers getting off	0.7 m／sec
Crowd density of passengers getting off	1.43 Persons／m^2
Crowd speed of passengers getting off at stairway	0.45 m／sec
Crowd density of passengers getting off at stairway	2.5 Persons／m^2
Crowd speed of passengers getting off and walking around stairway	0.7 m／sec
Crowd density of passengers getting off and walking around stairway	1.9 Persons／m^2
Gathering density at car door	3.5 Persons／m^2
Average door interval	12.5 m

(2) Assessment formula for platform width

(a) Width required for the gathering of passengers and the flow of passengers getting off

$$B_1 = 0.438\sqrt{\frac{S_1}{N_n}} + 0.028\frac{S_2}{N} + B_1' \quad \cdots\cdots (1.3)$$

Where,

B_1: Required width

S_1: Volume of entrainment per car　　S_2: Volume of detrainment per car

N: Number of connected cars　　n: Number of doors per car (two doors)

First term indicates the width required for the gathering of passengers, which is calculated by assuming that all passengers get on via each car door on the average and gather at each car door in a semicircular pattern.

Second term indicates the width required for the flow of passengers getting off, which is calculated by assuming that all passengers get off via each car door on the average.

Third term B_1' indicates the width required for the line of sight of station personnel, shed pillar width and bench, etc., which is assumed as 1.3 m and 2.6 m for an opposite platform and an island platform, respectively.

(b) Required width of the section around stairway

$$B_2 = B_w + B_s + B_s' + B_2' \quad \cdots\cdots (1.4)$$

Where,

B_2: Required width (m)

B_w: Wind refuge width for train

B_s: Stairway width $B_s´$: Width for side wall of both sides of stairway 0.5m

$B_2´$: Safety passing width of waiting passengers

First term B_w is set at 2.5 m in a case that a high speed train (250 km/h) runs on the track along a platform and at 1.5 m in a case that such the high speed train does not run..

Fourth term B_2’ indicates the safe passing width for passengers waiting in the section not corresponding to stairway, which is assumed as 1 m and 2 m for an opposite platform and an island platform, respectively.

Reference 9 Passenger ways

1. Width of passenger ways

In principle, the width of passenger ways should be calculated based on the number of passengers. In this case, we considered that the minimum may be the width allowing at least two persons to pass each other since the width occupied by a walker is about 0.6 m (Construction data book: Architectural Institute of Japan). However, for a case that a wheelchair and walker pass each other, separate consideration will be required (photograph 37.1)

Width of two walkers	0.6m × 2 ＝ 1.2 m
Margin to prevent contact when passing each other	0.1 m
Margin to prevent contact with wall	0.1m × 2 ＝ 0.2 m
	Total 1.5 m

Photograph Example of passenger passage

Photograph Example of passenger passage

Photograph Example of passenger stairway

(Width of step: about 1.5 m)

[Reference]

1. Passenger passage, etc. with consideration to facilitate smooth movement

1.1. Slope (photograph 1.1)

For slope, handrail shall be provided for its both sides to assure the safe and easy movement of persons of advanced age and physically handicapped persons. If its side is not bounded by a wall, “rising edge” should be provided to prevent potential trouble that wheelchair may come off.

Photograph 1.1. Example of slope

1.2. Elevator and escalator

For elevator and escalator, careful consideration should be given to assure safe and easy movement of various physically handicapped persons. Elevators may be effective for persons of advanced age or pregnant women as well as for physically handicapped persons. Therefore, the railway operator must install elevator, which can be utilized by physically handicapped person alone. In addition, the railway operator should assure space in front of elevator and escalator to prevent any crossing with the line of flow that general passengers walk (photograph 1.2).

1.3. Non-slip measure for passenger passage, stairway and slope

The railway operator must use anti slip material or provide non-slip measure for passenger passage, stairway and slope to prevent trouble such as fall of passengers (photographs 1.3 and 1.4).

1.4. Guidance blocks for persons with visual handicap

The guidance blocks for persons with visual handicap include the linear blocks, which form the line of flow for guiding persons with visual handicap in a route from entrance / exit as a boundary with public ways to train door via ticket barrier (photograph 1.2) and the dotted blocks, which are placed at locations requiring alarm to persons with visual handicap, who continue movement. The guidance blocks for persons with visual handicap are most effective measure to guide such the persons. Therefore, the railway operator shall arrange the blocks so as to assure easy walking by taking the layout of passenger facilities into account.

Photograph 1.2. Example of elevator and guidance blocks

Photograph 1.3. Example of anti slip floor material

Photograph 1.4. Example of non-slip measure at step edge

Reference10　Facilities for underground stations etc. 1

Intermediate ventilation and longitudinal ventilation systems

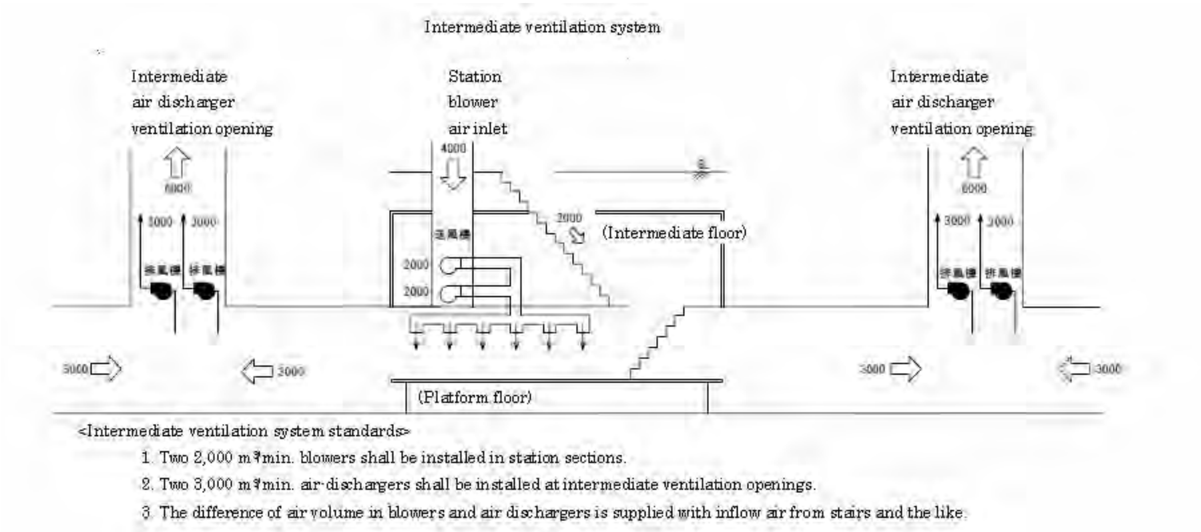
Intermediate ventilation and longitudinal ventilation systems are adopted as standard ventilation systems.

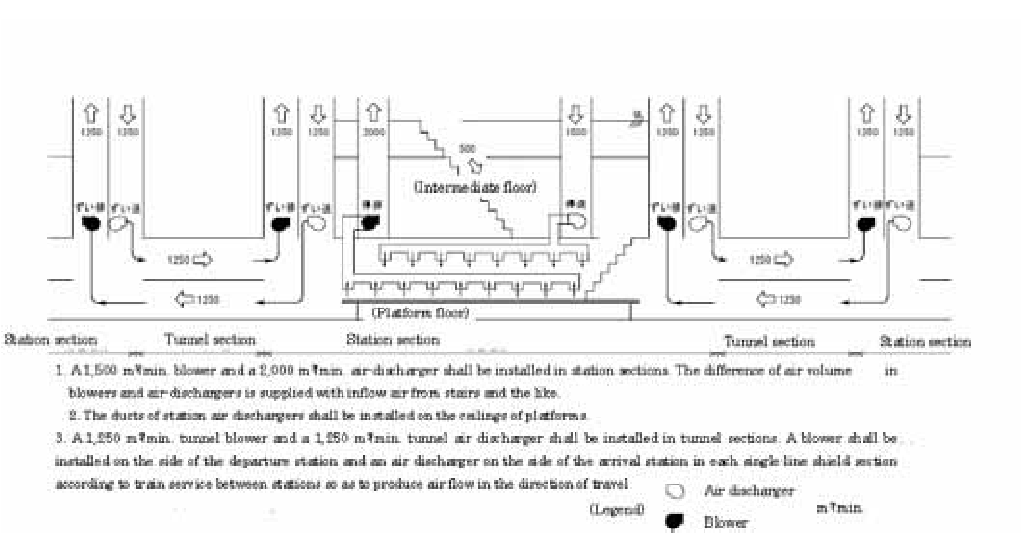
1. Intermediate ventilation system

The intermediate ventilation system is a system of ventilating stations and tunnels as a unit by introducing fresh air taken in through ground air-inlet towers into station sections by use of blower machines installed at stations and discharging hot air in tunnel sections through ground air-outlet towers by use of air-discharging machines installed at the middle of tunnels.

2. Longitudinal ventilation system

The longitudinal ventilation system is a system of ventilating stations and tunnels separately: ventilating stations by use of blowers and air dischargers installed in station sections and tunnels by use of tunnel blowers and tunnel air dischargers installed at each end of stations for producing air flow in the direction of travel.





Reference 11　Facilities for underground stations,etc.2

Disaster control room

Underground stations are available to the general public and have a special characteristic that they are situated underground. In case that a disaster such as fire occurs, considering the characteristics of underground stations, station attendants shall conduct (1) a report to the fire service, operating command center and others, provision of information about fire to passengers, operation of fire control facilities such as smoke control facilities and monitoring of the operating state of fire control facilities; (2) initial fire control operations; and (3) emergency evacuation guidance for passengers and rescue operations. Disaster control rooms shall be established for controlling information gathering, communications and command issues, information broadcasting for passengers, operation of fire control facilities and monitoring of the operating state of fire control facilities in an intensive way so as to cope with disasters including fires appropriately. Station attendants shall provide regular services.

Disaster control rooms can control and monitor such facilities as receivers used in automatic fire alarm facilities, communication and broadcasting facilities, operating state monitoring boards used in fire control facilities, operation monitoring boards used in smoke control facilities, boards for monitoring the operating state of fire protection doors, fire shutters or the like. (See Photographs 40.1 to 4)

Disaster control rooms should be established as an annex to station offices, in which station attendants always work, because there is a need to take various measures in the initial stages. If disaster control rooms are established separately from station offices, the exclusive attendants shall work in the rooms at any time during the operating hours of railway stations.

“Fire shutters or the like” mean remote-controlled fire shutters and ITV or the like installed at the places necessary for fire control. Although underground stations are required to have an instruction manual pertaining to the measures that attendants shall take in the case of fire, education and training for attendants and cooperative framework with the fire service, there are some cases, for stations that have some adjacent underground railways or the like, that the managers of stations and underground malls and fire control managers establish a joint fire control conference to conduct fire control jointly and prepare and submit a “joint fire control plan” to the fire service.

Reference　Automatic fire alarm facilities ①

Automatic fire alarm facilities are warning facilities to discover fire early and enable an early report, early fire fighting and early evacuation by detecting heat, smoke, etc. at the time of fire with detecting devices (Photographs 409.5 to 40.6) and issuing a warning automatically and composed of detectors, receivers, transponders, transmitters, display lamps, sound devices, wiring and the like.

In automatic fire alarm facilities, when a detecting device detects a fire or a person operates a transmitter, a fire signal is transmitted to a receiver and then sectional sound automatically rumbles to notify the occurrence of fire to people in a station; besides, a fire display lamp lights up in concurrence with the rumble of the sound and a sectional display lamp lights up to indicate at what place (in which precaution area) a fire occurs.

Automatic fire alarm facilities have detecting devices composed of a smoke detector, heat detector and others and press-button and telephone transmitters.

Receivers of automatic fire alarm facilities shall be provided for disaster control rooms in which station attendants always work.

Photo 40.5 An example of a smoke detector

Photo 40.6 An example of a heat detector

"Investigative commission on measures against fires in underground railways" installed advanced automatic fire alarm facilities to improve fire prevention safety. The commission stated that for underground stations situated deeply, large-scale stations, etc., in which evacuation and fire fighting activities are difficult, it is effective to install an advanced type of automatic fire alarm facilities that detect the surroundings temperature and smoke concentration around each detector, have a function to display caution marks at an early stage of a fire and can identify operating detectors.

Besides, it also stated that it is effective to project the state of fires on a screen in the disaster control room automatically (in conjunction with automatic fire alarm facilities) by using ITVs to detect fires or the like early.

Automatic fire alarm facilities ②

Places at which the detectors of automatic fire alarm facilities should be installed are sitting rooms, stands, substations, power distributing stations, machine rooms, warehouses, etc. that have combustibles and the possibility of occurrence of fire.

The detectors of automatic fire alarm facilities shall be installed at the places that are easy to perceive the occurrence of fire effectively such as ceilings based on the characteristics of the detectors according to the structure of the places, the kind of combustibles or the like.

The provisions of Article 21, paragraphs (2) and (3) of the Order for Enforcement of the Fire Service Act and Articles 23 and 24-2 of the Ordinance for Enforcement of the Fire Service Act shall be applied as the technical standards for the installation and maintenance of automatic fire alarm facilities.

Although places at which the detectors of automatic fire alarm facilities shall be installed as provided for in the conventional standards were those except platforms, concourses, passages (including stairs and ramps) and stands (limited to those that are movable), the current standards adopted the expression that the detectors of automatic fire alarm facilities shall be installed at the places that have the possibility of occurrence of fire because there was a case that the detectors were installed at the places which do not necessarily have a need to install detectors.

The conventional standards prescribed that automatic fire alarm facilities shall be installed at fixed stands. The facilities were not necessarily installed at movable stands placed in platforms, concourses, passages, etc. for the reason that the position was not fixed and others. However, movable stands have not few combustibles and are enlarged according to the needs of the users. In fact, movable stands are seldom moved. Because early fire detection is important for the prevention of expansion of fire and speedy evacuation, induction or the like, the current standards prescribe that the detectors of automatic fire alarm facilities shall be also installed at simple-type stands.

When a fire occurs at a stand, information that the stand in question is the place of occurrence of fire shall be indicated on the sectional window of the receivers of fire alarm facilities; however, this shall not apply to the case that the place of occurrence of fire can be identified by existing section.

In tunnels, because detectors do not detect the occurrence of fire at the said place effectively due to air flow caused by the travel of trains, the installation of automatic fire alarm facilities is not required as in the past.

Automatic fire alarm facilities shall have emergency power supply in preparation for a blackout.

Reference Fire control facilities

5(1)② Interior fire hydrant facilities

Although fire fighting is possible with the fire extinguisher in ① in the initial stage of fire, interior fire hydrant facilities shall be installed because there is a need to pour a large amount of water in preparation for a case that flames reach the ceiling and fire fighting with fire extinguishers becomes difficult. Interior fire hydrant facilities are used for the initial fire control prior to the arrival of a fire brigade to afire site and provided for by Article 11, paragraphs (3) and (4) of the Order for Enforcement of the Fire Service Act. Interior fire hydrant boxes shall be installed, on every floor, at places within 25 m in the horizontal distance from each section of a floor to a hose connector for the No. 1 fire hydrant and within 15 m for the No. 2 fire hydrant (Fig. 40.1).

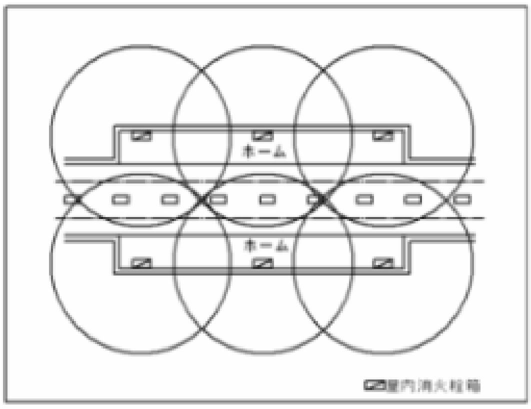


Fig. 40. 1 An example of installation of interior fire hydrant boxes in a platform

When installing interior fire hydrant boxes in a relative-type platform, it is desirable to arrange them every platform.

Water sources shall be exclusive for fire control facilities and the tank capacity of 5.2 m^3 (130 liters/min. x 2 places x 20 min.) or more for the No. 1 fire hydrant and 2.4 m^3 (60 liters/min. x 2 places x 20 min.) or more for the No. 2 fire hydrant shall be secured. Pressurized water supply facilities shall be installed at a place partitioned with noninflammable material so as to be convenient for inspections and in little danger of being damaged by disaster including fire.

Hoses shall conform to the provisions of a ministerial ordinance that provides for the technical specifications of hoses for fire fighting and two No.1 fire hydrants of 40 mm in aperture and 15 m or more in length shall be provided. Besides, hoses of 30 mm in aperture and 30 m in length for the easy-to-handle-type No. 1 fire hydrant and of 25 mm in aperture and 20 m in length for the No. 2 fire hydrant shall be provided (Photo. 40.7 to 40.9).

Interior fire hydrant facilities need to be equipped with emergency power supply.

Photo. 40.7 An example of th e No.1 fire hydrant

Photo. 40.8 Easy-to-handle-type No. 1 fire hydrant

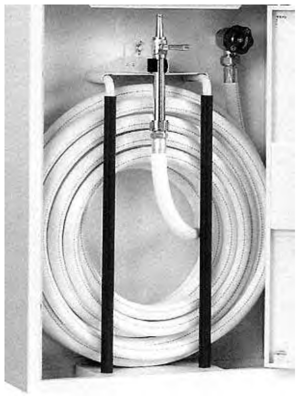


Photo. 40.9 An example of the N o. 2 fire hydrant

Although conventional interior fire hydrant facilities required a person who perform fire f ighting by training a nozzle to flame and who opens a valve and holds a hose, the adoptio n of easy-to-handle-type No.1 fire hydrants and No.2 fire hydrants which allow a person to c onduct fire fighting by him- or herself.

These fire hydrants have a characteristic of allowing a person to conduct fire fighting by him- or herself because the hoses of the fire hydrants are not transformed due to water pre ssure and have a water shutoff device at their heads.

5(1)③ Sprinkler facilities

In case of fire in the sitting room of an underground station, it is assumed that smoke tha t occurs at a fire source fills to the sitting room ant the like. It is also assumed that there is a case that smoke prevents a fire brigade from entering into the room and conducting effective fire fighting against the fire source. For this reason, sprinkling by sprinklers is more effective than watering by fire fighting hoses (Photo. 40.10).

Photo. 40.10 An example of sprinkler heads

Connection sprinkling facilities or sprinkler facilities with water supply outlets shall be installed in places except platforms, conco urses, passages (including stairs and ramps), rooms pertaining to operation security, substatio ns, electricity rooms and machine rooms based on the provisions of Article 12, paragraphs (2) and (3) and Article 28-2, paragraphs (2) and (3) of the Order for Enforcement of the Fire Se rvice Act. As for substations and electricity rooms, there is a case of the installation of fire c ontrol facilities such as inert gas fire control facilities and powder fire control facilities etc. in a substation and an electricity room in consideration of the influence by watering at the tim e of occurrence of fire.

Here, these facilities shall not be installed in operation command places, electric power com mand places, signal operation places and disaster control rooms that have equipment that ma y break down or make electric leakage due to water in platforms, concourses and sitting roo ms which have little combustibles as a rule and if a disaster control room is established in p arallel with a stationmaster's office or a station office (or both of them), it is needed to coordi nate with the fire services concerned regarding the installation. There is a case that complem entary measures to arrange fire extinguishers or the like for these places are taken.

Water sources shall be exclusive for fire control facilities and the volume of water shall be 1.6 m3 (80 liters/min. x 20 min.) x the number of pieces according to the kind of sections an d heads. The radiation quantity of 10 normal closed-type heads in the sitting rooms of statio ns and 8 pieces of highly-sensitive-type heads shall be secured. Pressurized water supply facil ities shall be installed at places partitioned with noninflammable material so as to be conveni ent for inspections and in little danger of being damaged by disaster including fire. Also, spri nkler facilities shall have emergency power supply.

Photo 40.11 An example of a sprinkler installed in a convenience-store-type stand

Because convenience-store-type stands have blind spots for shopkeepers which make it difficult to detect fire early and more combustibles than simple-type stands, they shall be provided with sprinklers with water supply outlets from a viewpoint of the prevention of fire expansion (Photo. 40.11).

It is effective to provide simple-type stands with sprinklers in the same way as convenience-store-type stands so as to have good effect as an initial fire fighting facility in case of fire.

In the “Investigative commission on measures against fires in underground railways,” package-type fire control facilities was considered as those that improve fire prevention safety. The commission stated that it is effective to install a package-type fire control facility in simple-type stands for early fire control and prevention of expansion of damage. This can be retrofitted relatively easily, is a automatic fire control device to discharge water down below by detecting heat and has wet and powder types. However, when it is installed in simple-type stands, attention should be paid regarding the positions of detectors and goods arrangement. Besides, for the powder-type device, powder emitted for fire fighting is often misidentified as smoke.

5(1)④ Connected water pipes

Connected water pipes are used by fire brigades for fire fighting at fire sites. The water di scharge outlets of connected water pipes installed in stations shall be provided at places considered as necessary for fire fighting in platforms, concourses and passages every floor and within 50 m in the horizontal distance from each section of a floor to a hose connector.

Photo. 40.12 An example of a water discharge outlet mounted on a fire hydrant box

The structure shall be based on the provision of Article 29, paragraph (2) of the Order for Enforcement of the Fire Service Act. Provided, however, that a water discharge outlet is mounted on a fire hydrant box, that water is effectively supplied from a water supply outlet placed on the ground and that the effectiveness in fire fighting is acknowledged, it can be treated as it has the same function as a case that a connected water pipe is installed at a said part.

Water supply outlets shall be mounted at a position at which they are easily distinguished from a point on the road around an entrance and water can be supplied effectively from a fire engine. Although water discharge outlets shall be mounted in water discharge outlet housing boxes, the combined use with interior fire hydrant boxes is possible. The coupling metal fittings of the hose connector shall be of the No. 65 socket. It is desirable to make coordination with the fire services concerned prior to installation (Photo. 40.12 to 40.14).

Photo. 40.13 An example of water supply outlets mounted at an entrance

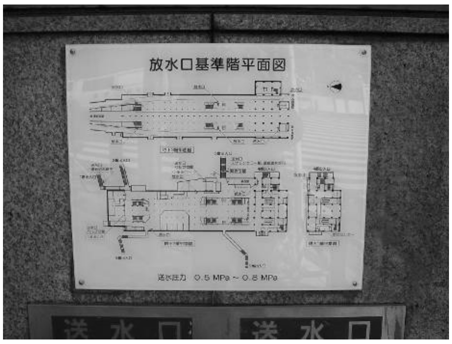


Photo. 40.14 An example of a guide map of water discharge outlets near water supply outlets

5(2) Inter-station connected water pipes

In case of a fire in a running train, although the train shall travel to the next station without stopping as a rule, in preparation for fire fighting in case of a sudden stop in the middle of a tunnel, connected water pipes shall be provided between stations.

In the case that the distance between water discharge outlets of connected water pipes installed in the platform of an adjacent station is over 500 m, connected water pipes shall be ins talled. The water discharge outlets of connected water pipes between stations shall be set in the intervals of 500 m or less and the structure shall be based on the provision of Article 29, paragraph (2) of the Order for Enforcement of the Fire Service Act. Besides, it is desirable make coordination with the fire services concerned prior to installation.

【Reference】

A reference case of the inspection of fire control facilities, ascertainment of operations or the like

Fire control facilities of underground stations and tunnels are composed of various facilities and it is necessary to conduct the ascertainment of operations according to the content of each facility. The purpose of the ascertainment of operations is to implement appropriate maintenance and management and keep facilities available.

As for the ascertainment of operations of each facility, in the case that fire prevention facilities based on the provision of Article 17-3-3 of the Fire Service Act are inspected on the basis of "Guidelines for the forms of reports on the periods, methods and results of inspections implemented according to the types of fire prevention facilities or the like or special fire prevention facilities or the like and the contents of inspection based on the provisions of the Ordinance for Enforcement of the Fire Service Act" (Announcement of the Fire-Defense Agency No. 9 dated May 31, 2004), the results may be used.

The inspections of fire prevention facilities or the like based on Announcement of the Fire-Defense Agency No. 9 mean those in the case that equipment inspection is implemented biannually and general inspection is implemented annually.

Also, many facilities for fire prevention sections established for the prevention of expansion of fire and for evacuation and guidance shall be installed in the whole station building and it is needed to conduct inspections of the following facilities at minimum in order to make inspections effective and efficient.

① Fire prevention doors that are installed in two-directions evacuation paths, entrances for fire brigades or the like and in parallel with fire shutters. Besides, those that close automatically in conjunction with detectors at the state of opening all the time.

② Fire prevention and smoke prevention dampers that open and close automatically in conjunction with detectors and ventilating and smoke discharging facilities.

③ Fire shutters that are installed in two-directions evacuation paths, entrances for fire brigades or the like and close automatically in conjunction with detectors at the state of opening all the time.

④ Hanging walls against smoke that descend automatically in conjunction with detectors.

⑤ Emergency lighting.

⑥ Evacuation passages (stairs) in the section used as two-directions evacuation paths and entrances for fire brigades.

As for other fire prevention facilities without inspection standards, it is desirable to make efforts conduct inspections of them by establishing voluntary standards or the like.

【Reference】

A case of the ascertainment of operations of fire control facilities

Facility section interpretation standard prescription	Facility name	Operation ascertainment item	Inspection period (within)
Fire prevention section 2(1)③ 4(5)①	Fire prevention door	Operations of the opening and closing of doors by manual operation and appearance and fitting without any abnormity	1 year
		There shall not be any obstacle to closure and evacuation in the surroundings of fire prevention doors.	
		Closing automatically from open condition by door closers etc. in the case of constant closure.	
		Closing automatically in conjunction with detectors etc., in the case of constant open and closing automatically in case of a fire.	
2(1)③ 4(5)①	Fire shutter	Appearance and fitting without any abnormity and opening/closing without any obstacles.	1 year
		Opening and closing shall be done easily by manual operation, in manually operative and constantly closing shutters.	
		The stoppage operation in opening and closing and intermediate positioning shall be performed easily with a push button, handle, chain, etc., in the case of electromotion shutters that are constantly opening.	
		Closing automatically in conjunction with detectors etc., in the case that it closes automatic in case of fire.	
		Rumbling during closure, in the case that there is a sound device for closure and in the case that it closes automatically in case of a fire.	
4(5)②	Two-steps shutter	In conjunction with detectors, descending one step automatically from the height of the floor surface to that of a prescribed value and to the floor surface by manual operation in the second step.	1year
		The opening and closing operations shall be produced normally by the site operation or the remote control from a disaster control room. Also, the surveillance of the action condition from a disaster control room shall be produced.	
2(1)③ 4(6)②·④	Fire and smoke prevention dumper	Fitting conditions, dumper main bodies and automatic closure devices without any abnormal condition such as transformation, dirt, corrosion, damage, etc.	1year
		In the case of closing automatically by a temperature fuse, appearance without abnormality such as the change of color of temperature fuse, adhesion of oil and fat, transformation, adhesion of dirt. Also, there shall not be the corrosion of any fuse device.	
		In the case of automatic closure by a temperature fuse, closing and returning actions by manual operation without abnormality.	
		In the case of automatic open and closure in conjunction with fire signals, air conditioning machines, etc., operations in conjunction with these signals.	
	Fireproof processing of cable penetration parts	Without abnormality in fitting conditions such as damages, omission etc. of fireproof boards and heatproof seal material. Without openings etc. in penetration parts.	Every time of refurbishmen t

Disaster control room facilities 3(1)	Central disaster prevention surveillance facilities	Functions such as fire display, alarm and tunnels, platform smoke discharging machines, recovery control etc. of every station by the central disaster prevention surveillance facilities of operation command rooms etc. shall be normal. (Inspection cycle column * : Inspection cycles of facilities based on Announcement of the Fire-Defense Agency No. 9)	6 months* 1 year
3(1) 4(1)①	Map-type disaster prevention surveillance disk	By the disaster prevention surveillance disks of station disaster control rooms, functions such as fire display, operation, alarm and gearing action settings inside a said station building shall be normal.	6 months 1 year
3(1)	Shutter control disk	Function such as condition surveillance, remote control, etc. of each shutter inside the said station building by the shutter control disk that was installed in a station disaster control room shall be normal.	1 year
	Elevator machine control disk	By elevator machine control disk installed in a station disaster control room, Function such as condition surveillance, remote control, etc. of each elevator facility shall be normal.	1 year
3(1) 4(2)①(ｲ)	Broadcasting facilities	Broadcasting shall be produced normally in the various points in a station building from a the station disaster control room.	1 year
	Emergency broadcasting facilities	Equipment and general inspections based on Announcement of the Fire-Defense Agency No. 9.	6 months 1 year
3(1)	I T V Surveillance facilities	The positions, picture angles and monitor pictures of the surveillance camera that was established in the various points in a station building shall be normal.	1 year
Warning facilities 3(1) 4(1)②	Automatic fire alarm facilities	Equipment and general inspections based on Announcement of the Fire-Defense Agency No. 9.	6 months 1 year
Report facilities 3(1) 4(2)①(ｱ)	Adjacent communication building telephone	Equipment inspections based on Announcement of the Fire-Defense Agency No. 9.	6 months
	Command telephone	Telephone communications normally and mutually done with command telephones in a disaster control room and operation command place.	1 year
	Railroad telephone	Telephone calls shall be produced normally and mutually with the railroad telephone exclusive use in operation command places, electric power command places and various points in stations.	1 year
4(2)①(ｳ)	Radio communication back-up facilities	Equipment inspections based on Announcement of the Fire-Defense Agency No. 9.	6 months
4(2)②	Train radio	Telephone calls shall be produced normally and mutually between trains and operation command places by train radio.	1 year
	Railway line telephone	Telephone calls shall be produced normally and mutually between railway line telephones in operation command places and tunnels.	1 year
Evacuation guidance facilities 4(3)①(ｱ)	Two-directions evacuation passages	There shall not be obstacles to the evacuation of passengers.	1 year

4(6)⑦・⑧			
3(2) 4(3)①(ｲ)	Emergency lighting	There shall not be unillumination in emergency lighting.	1 year
		There shall be the illuminance over the prescription value in the standard floor surface.	
		Automatical and prompt lighting in the case of power failure.	
4(3)①(ｱ)	Automatic gate	There shall not be obstruction in evacuation, in the case that automatic gates are part of a evacuation passage. （Simultaneous opening etc.）	1 year
	Escalator （if it is part of a passage）	Stopping normally, in the case that it interlocks in conjunction with detectors or fire shutters.	1 year
		The condition surveillance and also operation of each escalator by the elevator machine control disk that was installed in the station disaster control room shall be normal. Also, for what is equipped with a step depression prevention function device, the function shall be normal even if a legal loading load is exceeded.	
4(3)①(ｳ)	Evacuation exit guiding lamp and passage guiding lamp	Equipment inspections based on Announcement of the Fire-Defense Agency No. 9.	6 months
4(3)②(ｱ)	Tunnel lighting	There shall not be abnormality in appearances such as stains, damages, etc. and unillumination.	1 year
		Lighted promptly by emergency power supply, in case of a power failure.	
4(3)②(ｲ)	Evacuation mark in the tunnel	There shall not be abnormality in appearances such as omission, transformation, stain, damage, etc. The characters entered shall be read clearly.	1 year
		Attached in a proper position.	
7	Evacuation mark in the station building	There shall not be abnormality in appearances such as omission, transformation, stain, damage, etc. The characters entered shall be read clearly.	1 year
		Attached in a proper position.	
Smoke discharging facilities 4(4)①	Smoke discharging facilities in tunnels	There shall not be abnormality in appearances such as stain, damage, corrosion etc., abnormal sound and other functions.	1 year
		The operation and condition surveillance from the said station disaster control room or central disaster prevention surveillance facilities shall be normal.	
	Smoke discharging facilities in stations	Equipment and general inspections based on Announcement of the Fire-Defense Agency No. 9.	6 months 1 year
4(3)①(ｱ) 4(4)②	Hanging wall against smoke	There shall not be abnormality in fitting conditions and appearances such as damage.	1 year
		There shall not be operational obstacles in the surroundings of hanging walls in the case of a mobile type.	
		Manual winding up operation with handles, chains, etc. in the case of a mobile type shall be produced easily in the case of a mobile type.	

		A hanging wall shall be set in normal condition in the case of a mobile type.	
		Descending normally, in the case that hanging walls descend automatically in conjunction with smoke detectors etc. in the case of a mobile type. Also, returning shall be produced normally.	
		The function of the condition surveillance and remote control etc. of each hanging wall against smoke shall be normal by the disaster prevention surveillance disk that was installed in the station disaster control room.	
Others 4(6)①	Air inhalator	There shall be the necessary number of inhalators at proper places.	1 year
		There shall not be air leaking and abnormality in pressure gauge and appearances.	
		The gas cylinder pressure shall be in a prescribed value. Also, the air inhalator shall work normally.	
4(6)⑤･⑥	Emergency outlet facilities	Equipment inspections based on Announcement of the Fire-Defense Agency No. 9.	6 months
Fire control facilities 5(1)①	Fire extinguisher	Equipment inspections based on Announcement of the Fire-Defense Agency No. 9.	6 months
5(1)②	Interior fire hydrant facilities	Equipment and general inspections based on Announcement of the Fire-Defense Agency No. 9.	6 months 1 year
5(1)③	Connectedprinkling facilities or sprinkler facilities with water supply outlets	Equipment and general inspections based on Announcement of the Fire-Defense Agency No. 9.	6 months 1 year
5(1)④	Connected water pipe	Equipment inspections based on Announcement of the Fire-Defense Agency No. 9.	6 months 1 year
Emergency power supply 3(3)	Concentration-type emergency	The prescribed amount of fuel shall be secured.	1 year
		The transmission function to the necessary station or load shall be normal in case of a power failure.	
		Other equipment and general inspections based on Announcement of the Fire-Defense Agency No. 9.	6 months 1 year
	Emergency voluntary generator set	Equipment and general inspections based on Announcement of the Fire-Defense Agency No. 9.	6 months 1 year
	Storage battery facilities	Equipment and general inspections based on Announcement of the Fire-Defense Agency No. 9.	6 months 1 year

Reference 12　Facilities for underground stations,etc,3

An example of evacuation safety checking

5.1 Calculation of the evacuation completion time

As for an underground station whose structure is that the platform is on the second basement and ticket gate on the first basement, it is necessary to calculate the evacuation completion time regarding the routes passing through each ticket gate. An example of the calculation of evacuation completion time in the case that the number of evacuating persons is set as 3,000 which correspond to the getting-on rate of 200% in the train whose capacity is 1,500 is shown below.

(1) From train entrances to platform stairs

The last evacuating person requires substantial time until he or she gets off the train and the time T_1 is fixed on the basis of the number of passengers and train entrances and a horizontal outflow coefficient and calculated as the following:

T_1 (Retention time) ＝Q(Number of evacuating persons)／ (N (Horizontal outflow coefficient) ×B (Number of entrances x Width of an entrance))

Since the number of entrances x width of an entrance is 52.0 m as shown in ④ of the calculation sheet, T_1 is 38.5 seconds as shown on the right hand of the calculation sheet. The accumulation time that the last evacuating person takes to reach the bottom of the platform stairs after the beginning of the evacuation is calculated by adding the maximum travel time $t_{1(max)}$ in the platform to T_1. Since the $t_{1(max)}$ is 75.0 seconds by dividing 75.0m, the maximum distance from a train entrance to the bottom of platform stairs (the lower line of ⑤ in the calculation sheet), by the average horizontal walk speed 1.0m/sec, the accumulation time calculated by adding $t_{1(max)}$ toT_1 is 113.5 seconds.

On the other hand, since retention occurs immediately after the first evacuating person's reaching the bottom of the platform stairs due to subsequent evacuating persons below the platform stairs, the time T_2 that the last person takes to reach the said place is calculated from the number of passengers, width of platform stairs and stair outflow coefficient as follows:

T_2 (Retention time) ＝Q(Number of evacuating persons)／ (N (Stair outflow coefficient) ×B (Width of platform stairs))

Since the widths of platform stairs are 4.5 m (stairs 3.5 m and an escalator 1.0 m) in the route to the ticket gate A and 5.0 m (stairs 4.0 m and an escalator 1.0 m) in the route to the ticket gate B, T_2 is 242.9 seconds as shown on the right hand of the calculation sheet. Since the time that the first evacuating person takes to reach the bottom of the platform stairs at the ticket gate is the minimum travel time $t_{1(min)}$, that is, 3.0 seconds, calculated by dividing 3.0 m, the minimum distance from the entrance of train to the bottom of the platform stairs (the upper line of ⑤ in the calculation sheet) by the average horizontal walk speed 1.0/sec, the accumulation time that the last evacuating person takes to reach the bottom of the platform stairs after the beginning of evacuation is 245.9 seconds by adding T_2 to $t_{1(min)}$.

Here

$T_1 + t_{1(max)}$ ：113.5 sec ＜ $t_{1(min)} + T_2$ ：245.9 sec

Since the evacuation time that the last evacuating person takes to reach the bottom of the platform stairs is determined by retention time not at the train entrance but at the bottom of the platform stairs, the time is $t_{1(min)} + T_2$：245.9 seconds （4.1 minutes）.

(2) From the bottom of platform stairs to the ticket gate

Hereafter, the evacuation time to the ground is calculated separately for the routes passing through the ticket gates A and B.

① Ticket gate A route

The accumulation time that the last evacuating person takes to reach the ticket gate A passing through the bottom of the platform stairs after the beginning of the evacuation is calculated by adding the maximum travel time t_2：34.0 seconds on platform stairs (or an escalator) and the maximum travel time t_3：7.5 seconds on the concourse in the latch from the top platform stair to the ticket gate A to 245.9 seconds calculated in (1), that is, 287.4 seconds.

On the other hand, it is necessary to adopt the number of passengers who use this evacuation route for the calculation of the time T_3 that the last evacuating person takes to reach the ticket gate A. The percentage of passengers who use this evacuation route is, according to the ratio of N x B:

$$(4.5 \times 1.3) \div ((5.0+4.5) \times 1.3) = 0.47$$

Therefore, T_3 in this evacuation route is 242.9 seconds as shown on the right hand of the calculation sheet. Since the time that the first evacuating person takes to reach the ticket gate A is 44.5 seconds calculate by adding t_2 and t_3 to $t_{1(min)}$, in the light of retention at the ticket gate A, the accumulation time that the last evacuating person takes to reach the ticket gate A after the beginning of evacuation is calculated as 287.4 seconds by adding T_3 to 44.5 seconds.

Here

$t_{1(min)} + T_2 + t_2 + t_3$ ：287.4 sec ＝ $t_{1(min)} + t_2 + t_3 + T_3$ ：287.4sec

Therefore, the retention at the ticket gate A is solved at the time when the last person reaches the ticket gate A and the accumulation time at this point is 287.4 seconds.

② Ticket gate B route

The accumulation time that the last evacuating person takes to reach the ticket gate B passing through the bottom of platform stairs after the beginning of evacuation is calculated by adding the maximum travel time t_2 : 30 seconds on platform stairs (or an escalator) and the maximum travel time t_3 : 43 seconds on the concourse in the latch from the top platform stair to the ticket gate B to 245.9 seconds calculated in (1), that is, 318.9 seconds.

On the other hand, the percentage of passengers who use this evacuation route is:

$1.0 - 0.47 = 0.53$

Therefore, the time T_3 that is the last evacuating person takes to reach the ticket gate B is, in this evacuation route, 438.6 seconds as shown on the right hand of the calculation sheet. Since the time that the first person takes to reach the ticket gate B is, by adding t_2 and t_3 to $t_{1(min)}$, 76.0 seconds, in the light of retention at the ticket gate B, the accumulation time that the last evacuating person takes to reach the ticket gate B after the beginning of evacuation is calculated as 514.6 seconds by adding T_3 to 76.0 seconds.

Here

$$t_{1(min)} + T_2 + t_2 + t_3 \text{ : } 318.9 \text{ sec} < t_{1(min)} + t_2 + t_3 + T_3 \text{ : } 514.6 \text{ sec}$$

Therefore, since the evacuation time of the last evacuating person to reach the ticket gate B is determined by retention time not at the bottom of the platform stairs but at the ticket gate B, the time is 514.6 seconds.

As a result, the evacuation time of the last evacuating person toreach the ticket gate in this station is 514.6 seconds (8.6 minutes) in the ticket gate B route.

(3) From the ticket gate to the ground

① Ticket gate A route

The accumulation time that the last evacuating person takes to reach the bottom of the exit stairs passing through the ticket gate A after the beginning of the evacuation is calculated by adding the travel time from the ticket gate A to the bottom of the farthest exit stairs t_4 : 63.5 seconds to 287.4 seconds calculated in (2), that is, 350.9 seconds.

On the other hand, the time T_4 that the last evacuating person takes to reach the bottom of the exit stairs is 206.2 seconds as shown on the right hand of the calculation sheet, based on the number of passengers who use this evacuation route, the sum of the minimum widths of three exits and the escalator and a stair outflow coefficient. Since the time that the first evacuating person takes to reach the bottom of the exit stairs is 108.0 seconds by adding t_2, t_3 and t_4 to $t_{1(min)}$, in the light of retention at the bottom of the exit stairs, the accumulation time that the last evacuating person takes to reach the bottom of the exit stairs after the beginning of evacuation is 314.2 seconds by adding T_4 to 108.0 seconds.

Here

$$t_{1(min)} + t_2 + t_3 + T_3 + t_4 : 350.9 \text{ sec} > t_{1(min)} + t_2 + t_3 + t_4 + T_4 : 314.2 \text{ sec}$$

Therefore, the evacuation time of the last evacuating person to the bottom of the exit stairs is determined by the retention time not at the bottom of the exit stairs but at the ticket gate A and is 350.9 seconds.

Finally, the accumulation time that the last evacuating person takes to reach the ground after the beginning of the evacuation is calculated by adding the travel time on the exit stairs t_5: 37.0 seconds to the accumulation time to the bottom of the exit stairs 350.9, that is, 387.9 seconds.

② Ticket gate B route

The accumulation time that the last evacuating person takes to reach the bottom of the exit stairs passing through the ticket gate B after the beginning of the evacuation is calculated by adding the travel time from the ticket gate B to the bottom of the farthest exit stairs t_4: 60.5 seconds to 514.6 seconds calculated in (2), that is, 575.1 seconds.

On the other hand, the time T_4 that the last evacuating person takes to reach the bottom of the exit stairs is 238.2 seconds as shown on the right hand of the calculation sheet, based on the number of passengers who use this evacuation route, the sum of the minimum widths of three exits and the escalator and a stair outflow coefficient. Since the time that the first evacuating person takes to reach the bottom of the exit stairs is 136.5 seconds by adding t_2, t_3 and t_4 to $t_{1(min)}$, in the light of retention at the bottom of the exit stairs, the accumulation time that the last evacuating person takes to reach the bottom of the exit stairs after the beginning of evacuation is 374.7 seconds by adding T_4 to 136.5 seconds.

Here

$$t_{1(min)} + t_2 + t_3 + T_3 + t_4 : 575.1 \text{ sec} > t_{1(min)} + t_2 + t_3 + t_4 + T_4 : 374.7 \text{ sec}$$

Therefore, the evacuation time of the last evacuating person to the bottom of the exit stairs is determined by the retention time not at the bottom of the exit stairs but at the ticket gate A and is 575.1 seconds.

Finally, the accumulation time that the last evacuating person takes to reach the ground after the beginning of the evacuation is calculated by adding the travel time on the exit stairs t_5: 59.0 seconds to the accumulation time to the bottom of the exit stairs 575.1, that is, 634.1 seconds.

As a result, the evacuation time of the last evacuating person to reach the ground in this station is 634.1 seconds (10.6 minutes) in the ticket gate B route.

5.2 The number of evacuating persons and evacuation completion time by assumed fire

Because the evacuation completion time used for the checking of evacuation safety is different in the number of evacuating persons and evacuation completion time by assumed fire, the evacuation time calculations as explained above require to be done several times.

The number of evacuating persons and evacuation places estimated by assuming this station to be a common one in the three major metropolitan areas is shown in Table 40.17. The evacuation completion time used for the checking of evacuation safety is as shown in Table 40.17 based on the calculation sheet.

Table 40．17 The number of evacuating persons and evacuation completion time by assumed fire

Assumed fire		Number of evacuating persons (Getting-on rate):%	Evacuation place corresponding to evacuation completion time used for checking	evacuation completion time：min	Remark
Vehicle	Usual	200	Evacuation place (concourse)	4.7	Ticket gate A
	Large source	275	Evacuation place (concourse)	6.2	Ticket gate A
Platform stand	Usual	275	Evacuation place (concourse)	6.2	Ticket gate A
	Large source	275	Evacuation place (concourse)	6.2	Ticket gate A
Concourse stand	Usual	75	Evacuation place (concourse))	6.0	Ticket gate B
	Large source	75	Evacuation place (concourse)	6.0	Ticket gate B

5.3 Checking of evacuation safety

The result of checking the evacuation safety of this station in each assumed fire based on the evacuation completion time by assumed fire is as follows.

(1) Usual fire

1) Vehicle fire

Assuming that evacuation completion time t = 4.7minutes, fire point block volume V = 1,155 m^3, the amount of ventilation of smoke discharging facilities per fire point block volume Ve = 95.9 m^3/min, smoke concentration Cs is as follows:

$$Cs = 21 \cdot (1 - e^{-Ve \cdot t / V}) / Ve$$
$$= 21 \times (1 - e^{-95.9 \times 4.7 / 1,155}) / 95.9$$
$$= 0.071 < 0.1 \quad (OK)$$

2) Platform stand fire

Assuming that evacuation completion time t = 6.2 minutes, fire point block volume V = 1,155 m^3, the amount of ventilation of smoke discharging facilities per fire point block volume Ve =95.9 m^3/min, smoke concentration Cs is as follows:

$$Cs = 2.1 \cdot (Ve \cdot t - V + V \cdot e^{-Ve \cdot t / V}) / Ve^2$$
$$= 2.1 \times (95.9 \times 6.2 - 1,155 + 1,155 \times e^{-95.9 \times 4.7 / 1,155}) / (95.9)^2$$
$$= 0.030 < 0.1 \quad (OK)$$

3) Concourse stand fire

Based on evacuation completion time t = 6.0 minutes, required smoke dispersion volume Vo is:

$V_o = 10.5 t^2$

$= 10.5 \times (6.0)^2$

$= 378.0$

On the other hand, since there is no smoke discharging facility in this station, assuming that the floor area of concourse is 1,050 ㎡ and height of the ceiling of concourse is 2.8 m, smoke dispersion volume is:

$V = 1{,}050 \times (2.8 - 2)$

$= 840.0 > 378.0$ (OK)

(2) Large source fire

1) Vehicle and platform stand fire

Assuming that evacuation completion time t = 6.2 minutes;

Area in railroad track right angle direction cross-section area in a platform floor at a height of 2.0 m or more from the platform floor surface except the parts in which smoke does not disperse such as stairs or columns A_E = 31.63 ㎡;

Vehicle cross-section area at a height of 2.0 m or more from the platform floor surface Av' = 2.02 ㎡;

The entire length of platform floor L = 210.0m;

The amount of ventilation of smoke discharging facilities of the entire platform Ve = 1,007.0 m^3/min;

Railroad track right angle direction cross-section area in fire point block volume calculation A_o = 68.70 ㎡; and

Vehicle cross-section area (including the part under the floor) Av = 10.50 ㎡,

the ratio of the effective amount of discharged smoke to the effective volume on the platform floor Ve' is:

$Ve' = Ve \times (A_E - Av') / (A_o - Av)$

$= 1{,}007 \times (31.63 - 2.02) / (68.70 - 10.50)$

$= 512.3 > 300.0$ (Vs: the amount of emitted smoke or the like)

and the time that smoke and gas caused by a train fire due to large fire source take to fall to a height from the floor surface that brings about obstacles to evacuation to the bottom of smoke layer minus 2.0 m t_o (min) $= \infty$ (OK)

2) Concourse stand fire

Because this station does not have facilities for discharging smoke in the concourse, the time that smoke and gas caused by a train fire due to large fire source take to fall to a height from the floor surface that brings about obstacles to evacuation to the bottom of smoke layer minus 2.0 m t_o (min) is as follows:

$t_o = V' / (V_s - Ve')$

$= 840.0 / 300.0$

$= 2.8 \leqq$ evacuation completion time = 6.0 minutes (OUT)

As remedial measures, enlargement of the smoke-dispersion volume of concourse and the introduction of smoke discharging facilities to the concourse may be effective. If smoke discharging facilities are introduced, the required ventilation volume of facilities Ve (m^3/min) will be as follows:

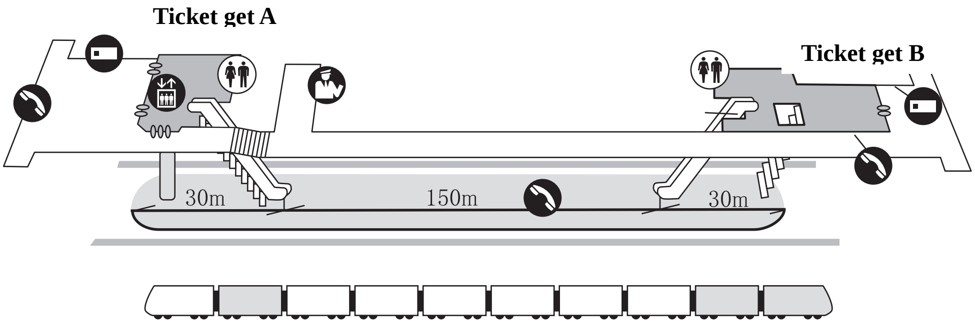
Based on $6.0 = 840.0 / (300.0 - Ve \times (2.8 - 2.0) / 2.8)$,

$Ve = (300.0 \times 6.0 - 840) \times 2.8 / (0.8 \times 6.0)$

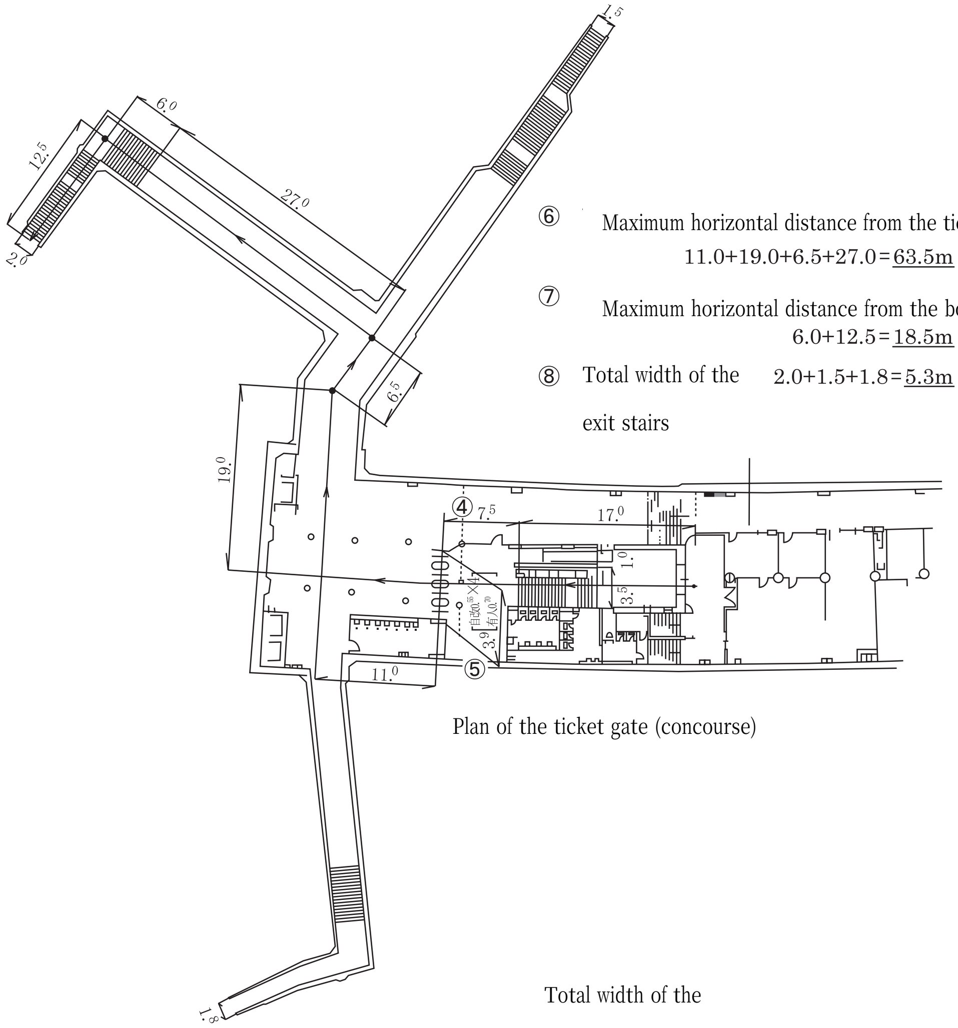
$= 560.0 (m^3/min)$

By shortening evacuation completion time through the enlargement of the width of ticket gate B, which is the largest retention point, it is possible to decrease the expanded amount of smoke-dispersion volume and the ventilation volume of smoke discharging facilities.

The station yard of * station**



*** station Ticket gate A



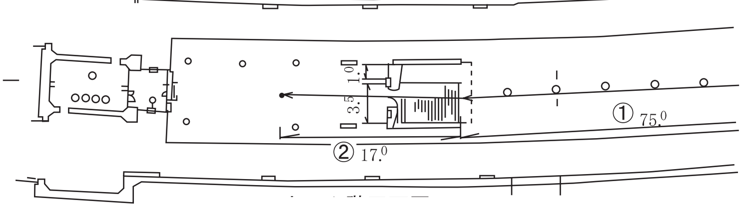
⑥ Maximum horizontal distance from the ticket gate A to the bottom of the exit
11.0+19.0+6.5+27.0=63.5m

⑦ Maximum horizontal distance from the bottom to the exit stairs
6.0+12.5=18.5m

⑧ Total width of the exit stairs 2.0+1.5+1.8=5.3m

Plan of the ticket gate (concourse)

③ Total width of the platform stairs 3.5+1.0=4.5m



Plan of the platform

Caluculation of evacuation time (〇〇Line, ☆☆station, ticket A route)

1. Forms of trains and stations

(1)Train capacity	(Corresponding to 10 cars)	1,500.00	Parson
(2)Getting-on rate		200.00	%
(3)Width of a door	(Par a point)	1.30	m
(4)Total width of doors on the entire train		52.00	m
(5)Distance from a drop-off to the bottom of platform stairs	(Minimum)	3.00	m
	(Maximum)	75.00	m
(6)Number of platform stairs		3.00	Place
(7)Width of platform stairs(Side of ticket A)	(Including Es total)	4.50	m
(8)Distance of the platform stairs(side of ticket A)	(Minimum)	17.00	m
(9)Distance of the top platform stairs to the ticket get(side of ticket A)	(Maximum)	7.50	m
(10)Number of ticket gates		2.00	Place
(11)Width of a ticket gate A	(Total)	3.90	m
(12)Distance from the ticket gate A to the exit atairs	(Maximum)	63.50	m
(13)Number of exit stairs		3.00	Place
(14)Width of the exit stairs	(Including Es total)	5.30	m
(15)Distance of the exit stairs	(Muximum)	18.50	m

2. Capacity to act of the public — B class

Average horizontal walk rate	1.00	m/s
Average stairs walk rate	0.50	m/s
Average outflow coefficient	1.50	Pason/m/s
Stair outflow coefficient	1.30	Pason/m/s

3. Calculation of evacuation time

Train entrance	Retention time T1=	1500 × 2 ÷ 1.5 ÷ 52.00	= 38.5 ″
↓			
Platform	Travel time	t1(min)= 3.0 ÷ 1.0	= 3.0 ″
↓		t1(max)= 75.0 ÷ 1.0	= 75.0 ″
↓			
Bottom platform stair	Retention time T2=	1500 × 2 ÷ 1.3 ÷ 9.5	= 242.9 ″
↓			
Stairs on the side of ticket gate A	Travel time	t2= 17.0 ÷ 0.5	= 34.0 ″
↓			
Concourse A	Travel time	t3= 7.5 ÷ 1.0	= 7.5 ″
↓			
Ticket gate A	Retention time T3=	1500 × 2 × 0.47 ÷ 1.5 ÷ 3.9	= 242.9 ″
↓			
Passenger	Travel time	t4= 63.5 ÷ 1.0	= 63.5 ″
↓			
Bottom exit stair	Retention time T4=	1500 × 2 × 0.47 ÷ 1.3 ÷ 5.3	= 206.2 ″
↓			
Exit stairs	Travel time	t5= 18.5 ÷ 0.5	= 37.0 ″
↓			
Groud			

(Evacuation time of the last person)

Passing through the bottom platform stair	T1+t1(max)	= 113.5 ″
	ti(min)+T2	= 245.9 ″ : 4.1 ′
Passing through the top platform stair	245.9+t2	= 279.9 ″ : 4.7 ′
Passing through the ticket gate A	245.9+t2+t3	= 287.4 ″ : 4.8 ′
	t1(min)+t2+t3+T3	= 287.4 ″
Passing bottom exit stair	287.4+t4	= 350.9 ″ : 5.8 ′
	t1(min)+t2+t3+t4+T4	= 314.2 ″
Reaching the ground	350.9+t5	= 387.9 ″ : 6.5 ′

→ Ticket gate B route

Caluculation of evacuation time (○○Line, ☆☆station, ticket B route)

1. **Forms of trains and stations**

(1)Train capacity	(Corresponding to 10 cars)	1,500.00	Parson
(2)Getting-on rate		200.00	%
(3)Width of a door	(Par a point)	1.30	m
(4)Total width of doors on the entire train		52.00	m
(5)Distance from a drop-off to the bottom of platform stairs	(Minimum)	3.00	m
	(Maximum)	75.00	m
(6)Number of platform stairs		3.00	Place
(7)Width of platform stairs(Side of ticket B)	(Including Es total)	5.00	m
(8)Distance of the platform stairs(side of ticket B)	(Minimum)	15.00	m
(9)Distance of the top platform stairs to the ticket get(side of ticket B)	(Maximum)	43.00	m
(10)Number of ticket gates		2.00	Place
(11)Width of a ticket gate B	(Total)	2.40	m
(12)Distance from the ticket gate B to the exit atairs	(Maximum)	60.50	m
(13)Number of exit stairs		2.00	Place
(14)Width of the exit stairs	(Including Es total)	5.10	m
(15)Distance of the exit stairs	(Muximum)	29.50	m

2. **Capacity to act of the public** — B class

Average horizontal walk rate	1.00	m/s
Average stairs walk rate	0.50	m/s
Average outflow coefficient	1.50	Pason/m/s
Stair outflow coefficient	1.30	Pason/m/s

3. **Calculation of evacuation time**

Train entrance	Retention time T1=	1500 × 2 ÷ 1.5 ÷ 52.00	= 38.5 "
↓ Platform	Travel time	t1(min)= 3.0 ÷ 1.0	= 3.0 "
↓		t1(max)= 75.0 ÷ 1.0	= 75.0 "
Bottom platform stair	Retention time T2=	1500 × 2 ÷ 1.3 ÷ 9.5	= 242.9 "
↓ Stairs on the side of ticket gate B	Travel time	t2= 15.0 ÷ 0.5	= 30.0 "
↓ Concourse B	Travel time	t3= 43.0 ÷ 1.0	= 43.0 "
Ticket gate B	Retention time T3=	1500 × 2 × 0.53 ÷ 1.5 ÷ 2.4	= 438.6 "
↓ Passenger	Travel time	t4= 60.5 ÷ 1.0	= 60.5 "
Bottom exit stair	Retention time T4=	1500 × 2 × 0.53 ÷ 1.3 ÷ 5.1	= 238.2 "
↓ Exit stairs	Travel time	t5= 29.5 ÷ 0.5	= 59.0 "
↓ Groud			

(Evacuation time of the last person)

Passing through the bottom platform stair	T1+t1(max)	= 113.5 "	
	ti(min)+T2	= 245.9 "	4.1 '
Passing through the top platform stair	245.9+t2	= 275.9 "	4.6 '
Passing through the ticket gate B	245.9+t2+t3	= 318.9 "	
	t1(min)+t2+t3+T3	= 514.6 "	8.6 '
Passing bottom exit stair	514.6+t4	= 575.1 "	9.6 '
	t1(min)+t2+t3+t4+T4	= 374.7 "	
Reaching the ground	575.1+t5	= 634.1 "	10.6 '

→ Ticket gate A route

Caluculation of evacuation time (○○Line, ☆☆station, ticket A route)

1. Forms of trains and stations

(1)Train capacity	(Corresponding to 10 cars)	1,500.00	Parson
(2)Getting-on rate		275.00	%
(3)Width of a door	(Par a point)	1.30	m
(4)Total width of doors on the entire train		52.00	m
(5)Distance from a drop-off to the bottom of platform stairs	(Minimum)	3.00	m
	(Maximum)	75.00	m
(6)Number of platform stairs		3.00	Place
(7)Width of platform stairs(Side of ticket A)	(Including Es total)	4.50	m
(8)Distance of the platform stairs(side of ticket A)	(Minimum)	17.00	m
(9)Distance of the top platform stairs to the ticket get(side of ticket A)	(Maximum)	7.50	m
(10)Number of ticket gates		2.00	Place
(11)Width of a ticket gate A	(Total)	3.90	m
(12)Distance from the ticket gate A to the exit atairs	(Maximum)	63.50	m
(13)Number of exit stairs		3.00	Place
(14)Width of the exit stairs	(Including Es total)	5.30	m
(15)Distance of the exit stairs	(Muximum)	18.50	m

2. Capacity to act of the public — B class

Average horizontal walk rate	1.00	m/s
Average stairs walk rate	0.50	m/s
Average outflow coefficient	1.50	Pason/m/s
Stair outflow coefficient	1.30	Pason/m/s

3. Calculation of evacuation time

Train entrance	Retention time T1=	1500 × 2.75 ÷ 1.5 ÷ 52.00	= 52.9 ″
↓ Platform	Travel time	t1(min)= 3.0 ÷ 1.0	= 3.0 ″
↓		t1(max)= 75.0 ÷ 1.0	= 75.0 ″
↓ Bottom platform stair	Retention time T2=	1500 × 2.75 ÷ 1.3 ÷ 9.5	= 334.0 ″
↓ Stairs on the side of ticket gate A	Travel time	t2= 17.0 ÷ 0.5	= 34.0 ″
↓ Concourse A	Travel time	t3= 7.5 ÷ 1.0	= 7.5 ″
↓ Ticket gate A	Retention time T3=	1500 × 2.75 × 0.47 ÷ 1.5 ÷ 3.9	= 334.0 ″
↓ Passenger	Travel time	t4= 63.5 ÷ 1.0	= 63.5 ″
↓ Bottom exit stair	Retention time T4=	1500 × 2.75 × 0.47 ÷ 1.3 ÷ 5.3	= 283.6 ″
↓ Exit stairs	Travel time	t5= 18.5 ÷ 0.5	= 37.0 ″
↓ Groud			

(Evacuation time of the last person)

Passing through the bottom platform stair	T1+t1(max)	= 127.9 ″	
	ti(min)+T2	= 337.0 ″	5.6 ′
Passing through the top platform stair	337.0+t2	= 371.0 ″	6.2 ′
Passing through the ticket gate A	337.0+t2+t3	= 378.5 ″	6.3 ′
	t1(min)+t2+t3+T3	= 378.5 ″	
Passing bottom exit stair	378.5+t4	= 442.0 ″	7.4 ′
	t1(min)+t2+t3+t4+T4	= 391.6 ″	
Reaching the ground	442.0+t5	= 479.0 ″	8 ′

→ Ticket gate B route

Caluculation of evacuation time (○○Line, ☆☆station, ticket B route)

1. Forms of trains and stations

(1)Train capacity	(Corresponding to 10 cars)	1,500.00	Parson
(2)Getting-on rate		275.00	%
(3)Width of a door	(Par a point)	1.30	m
(4)Total width of doors on the entire train		52.00	m
(5)Distance from a drop-off to the bottom of platform stairs	(Minimum)	3.00	m
	(Maximum)	75.00	m
(6)Number of platform stairs		3.00	Place
(7)Width of platform stairs(Side of ticket B)	(Including Es total)	5.00	m
(8)Distance of the platform stairs(side of ticket B)	(Minimum)	15.00	m
(9)Distance of the top platform stairs to the ticket get(side of ticket B)	(Maximum)	43.00	m
(10)Number of ticket gates		2.00	Place
(11)Width of a ticket gate B	(Total)	2.40	m
(12)Distance from the ticket gate B to the exit atairs	(Maximum)	60.50	m
(13)Number of exit stairs		2.00	Place
(14)Width of the exit stairs	(Including Es total)	5.10	m
(15)Distance of the exit stairs	(Muximum)	29.50	m

2. Capacity to act of the public — B class

Average horizontal walk rate	1.00	m/s
Average stairs walk rate	0.50	m/s
Average outflow coefficient	1.50	Pason/m/s
Stair outflow coefficient	1.30	Pason/m/s

3. Calculation of evacuation time

Train entrance	Retention time T1=	1500 × 2.75 ÷ 1.5 ÷ 52.00	=	52.9 "
↓				
Platform	Travel time	t1(min)= 3.0 ÷ 1.0	=	3.0 "
↓		t1(max)= 75.0 ÷ 1.0	=	75.0 "
↓				
Bottom platform stair	Retention time T2=	1500 × 2.75 ÷ 1.3 ÷ 9.5	=	334.0 "
↓				
Stairs on the side of ticket gate B	Travel time	t2= 15.0 ÷ 0.5	=	30.0 "
↓				
Concourse B	Travel time	t3= 43.0 ÷ 1.0	=	43.0 "
↓				
Ticket gate B	Retention time T3=	1500 × 2.75 × 0.53 ÷ 1.5 ÷ 2.4	=	603.1 "
↓				
Passenger	Travel time	t4= 60.5 ÷ 1.0	=	60.5 "
↓				
Bottom exit stair	Retention time T4=	1500 × 2.75 × 0.53 ÷ 1.3 ÷ 5.1	=	327.5 "
↓				
Exit stairs	Travel time	t5= 29.5 ÷ 0.5	=	59.0 "
↓				
Groud				

(Evacuation time of the last person)

Passing through the bottom platform stair	T1+t1(max)	= 127.9 "	
	ti(min)+T2	= 337.0 "	5.6 '
Passing through the top platform stair	337.0+t2	= 367.0 "	6.1 '
Passing through the ticket gate B	337.0+t2+t3	= 410.0 "	
	t1(min)+t2+t3+T3	= 679.1 "	11.3 '
Passing bottom exit stair	679.1+t4	= 739.6 "	12.3 '
	t1(min)+t2+t3+t4+T4	= 464.0 "	
Reaching the ground	793.6+t5	= 798.6 "	13.3 '

→ Ticket gate A route

Caluculation of evacuation time (○○Line, ☆☆station, ticket A route)

1. Forms of trains and stations

(1)Train capacity	(Corresponding to 10 cars)	1,500.00	Parson
(2)Getting-on rate		75.00	%
(3)Width of a door	(Par a point)	1.30	m
(4)Total width of doors on the entire train		52.00	m
(5)Distance from a drop-off to the bottom of platform stairs	(Minimum)	3.00	m
	(Maximum)	75.00	m
(6)Number of platform stairs		3.00	Place
(7)Width of platform stairs(Side of ticket A)	(Including Es total)	4.50	m
(8)Distance of the platform stairs(side of ticket A)	(Minimum)	17.00	m
(9)Distance of the top platform stairs to the ticket get(side of ticket A)	(Maximum)	7.50	m
(10)Number of ticket gates		2.00	Place
(11)Width of a ticket gate A	(Total)	3.90	m
(12)Distance from the ticket gate A to the exit atairs	(Maximum)	63.50	m
(13)Number of exit stairs		3.00	Place
(14)Width of the exit stairs	(Including Es total)	5.30	m
(15)Distance of the exit stairs	(Muximum)	18.50	m

2. Capacity to act of the public — B class

Average horizontal walk rate	1.00	m/s
Average stairs walk rate	0.50	m/s
Average outflow coefficient	1.50	Pason/m/s
Stair outflow coefficient	1.30	Pason/m/s

3. Calculation of evacuation time

Train entrance	Retention time	T1= 1500 × 0.75 ÷ 1.5 ÷ 52.00	=	14.4 "
Platform	Travel time	t1(min)= 3.0 ÷ 1.0	=	3.0 "
		t1(max)= 75.0 ÷ 1.0	=	75.0 "
Bottom platform stair	Retention time	T2= 1500 × 0.75 ÷ 1.3 ÷ 9.5	=	91.1 "
Stairs on the side of ticket gate A	Travel time	t2= 17.0 ÷ 0.5	=	34.0 "
Concourse A	Travel time	t3= 7.5 ÷ 1.0	=	7.5 "
Ticket gate A	Retention time	T3= 1500 × 0.75 × 0.47 ÷ 1.5 ÷ 3.9	=	91.1 "
Passenger	Travel time	t4= 63.5 ÷ 1.0	=	63.5 "
Bottom exit stair	Retention time	T4= 1500 × 0.75 × 0.47 ÷ 1.3 ÷ 5.3	=	77.3 "
Exit stairs	Travel time	t5= 18.5 ÷ 0.5	=	37.0 "
Groud				

(Evacuation time of the last person)

Passing through the bottom platform stair	T1+t1(max)	=	89.4 "	
	ti(min)+T2	=	94.1 "	: 1.6 '
Passing through the top platform stair	94.1+t2	=	128.1 "	: 2.1 '
Passing through the ticket gate A	94.1+t2+t3	=	135.6 "	: 2.3 '
	t1(min)+t2+t3+T3	=	135.6 "	
Passing bottom exit stair	135.6+t4	=	199.1 "	: 3.3 '
	t1(min)+t2+t3+t4+T4	=	185.3 "	
Reaching the ground	199.1+t5	=	236.1 "	: 3.9 '

→ Ticket gate B route

Caluculation of evacuation time (〇〇Line, ☆☆station, ticket B route)

1. Forms of trains and stations

(1)Train capacity	(Corresponding to 10 cars)	1,500.00	Parson
(2)Getting-on rate		75.00	%
(3)Width of a door	(Par a point)	1.30	m
(4)Total width of doors on the entire train		52.00	m
(5)Distance from a drop-off to the bottom of platform stairs	(Minimum)	3.00	m
	(Maximum)	75.00	m
(6)Number of platform stairs		3.00	Place
(7)Width of platform stairs(Side of ticket B)	(Including Es total)	5.00	m
(8)Distance of the platform stairs(side of ticket B)	(Minimum)	15.00	m
(9)Distance of the top platform stairs to the ticket get(side of ticket B)	(Maximum)	43.00	m
(10)Number of ticket gates		2.00	Place
(11)Width of a ticket gate B	(Total)	2.40	m
(12)Distance from the ticket gate B to the exit atairs	(Maximum)	60.50	m
(13)Number of exit stairs		2.00	Place
(14)Width of the exit stairs	(Including Es total)	5.10	m
(15)Distance of the exit stairs	(Muximum)	29.50	m

2. Capacity to act of the public — B class

Average horizontal walk rate	1.00	m/s
Average stairs walk rate	0.50	m/s
Average outflow coefficient	1.50	Pason/m/s
Stair outflow coefficient	1.30	Pason/m/s

3. Calculation of evacuation time

Train entrance	Retention time	T1=	1500 × 0.75 ÷ 1.5 ÷ 52.00	≒ 14.4 "
↓				
Platform	Travel time	t1(min)=	3.0 ÷ 1.0	≒ 3.0 "
↓		t1(max)=	75.0 ÷ 1.0	≒ 75.0 "
↓				
Bottom platform stair	Retention time	T2=	1500 × 0.75 ÷ 1.3 ÷ 9.5	≒ 91.1 "
↓				
Stairs on the side of ticket gate B	Travel time	t2=	15.0 ÷ 0.5	≒ 30.0 "
↓				
Concourse B	Travel time	t3=	43.0 ÷ 1.0	≒ 43.0 "
↓				
Ticket gate B	Retention time	T3=	1500 × 0.75 × 0.53 ÷ 1.5 ÷ 2.4	≒ 164.5 "
↓				
Passenger	Travel time	t4=	60.5 ÷ 1.0	≒ 60.5 "
↓				
Bottom exit stair	Retention time	T4=	1500 × 0.75 × 0.53 ÷ 1.3 ÷ 5.1	≒ 89.3 "
↓				
Exit stairs	Travel time	t5=	29.5 ÷ 0.5	≒ 59.0 "
↓				
Groud				

(Evacuation time of the last person)

Passing through the bottom platform stair	T1+t1(max)	≒ 89.4 "	
	ti(min)+T2	≒ 94.1 "	1.6 '
Passing through the top platform stair	94.1+t2	≒ 124.1 "	2.1 '
Passing through the ticket gate B	94.1+t2+t3	≒ 167.1 "	
	t1(min)+t2+t3+T3	≒ 240.5 "	4.0 '
Passing bottom exit stair	240.5+t4	≒ 301.0 "	5.0 '
	t1(min)+t2+t3+t4+T4	≒ 225.8 "	
Reaching the ground	301.0+t5	≒ 360.0 "	6.0 '

→ Ticket gate A route