Typical Standards of Structure

Applicable Technical Standard

1. Design Standards for Railway Stuctures and Commentary
   1) Cut and Cover Tunnel (03/2001)
   2) Concrete Stuctures (04/2004)
   3) Foundation Structures and Earth Retaining Stuctures (06/2000)
   4) Seismic Design (10/1999)
   5) Steel Structures (12/2002)
   6) Steel Concrete Composite Structures (07/2009)
2. "Standard Specifications for Concrete"
   Japan Society of Civil Engineers
3. "Standard Specifications for Tunneling Cut-and-Cover Tunnels"
   Japan Society of Civil Engineers
4. "Guidelines for Road Civil Work and Temporary Structures Work" Japan Road Association

1. Materials used

Materials shall be those listed in Table 1-1.

Table 1-1

Item	Cylinder Strength	Member
Structural concrete	f'ck=24N/mm²	Slab, Wall, Girder
	f'ck=40N/mm²	Diaphragm wall Column,Wall
	f'ck=50N/mm²	CFT
Leveling concrete	f'ck=18N/mm²	–

Item	Material	Member
Reinforcement bar	SD390	All
Structural steel	SS400	
	STK490	CFT
Mechanical coupling	Grade SA or A	

Note: Mechanical coupling shall comply with the grade described in "Standard Specifications for Anchorage and Joint of Reinforcement" Japan society of Civil Engineers.

2. Processing and erection of reinforcement bar

1) The shapes of hooks (bends) of reinforcement bar shall be as per Table 2-1.

Table 2-1

Bend diagram	Bend diagram	Hook	Stirrup and Hoop	Material type
180°	Semi-circle hook 4φ or greater and 6cm or greater	3.0φ or greater	2.5φ or greater	SD390
135°	Acute-angled hook 6cm or greater	3.0φ or greater	2.5φ or greater	SD390
90°	Right-angled hook 12φ or greater	3.0φ or greater	2.5φ or greater	SD390
135° 90°	Width-holding bar Right-angled hook / Acute-angled hook 12φ or greater / 6φ or greater 6cm or greater		2.0φ or greater	SD390

φ: Diameter of reinforcement bar
r: Inner bend radius of reinforcement bar

2) The inner bend radiuses of reinforcement bar shall be as per Tables 2-2 and 2-3.

Table 2-2

Bend angle	Bend diagram	r	Use section
90° or greater		2.5φ or greater	SD390 Stirrup and hoop
		5φ or greater (7.5φ or greater)	Shear bar
		10φ or greater. The values in Table 2-3 shall be set as the standards.	Inner bend radius of main bar along outer angle part of rahmen

φ: Diameter of reinforcement bar
r: Inner bend radius of reinforcement bar
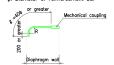( ) shall apply where shear bar is arranged within 2.0φ + 20 mm from the side of a member.

Table 2-3

Diameter of reinforcement bar	Bend radius R	Arch length a
D41	440	691
D38	400	628
D35	370	581
D32	340	534
D29	310	487
D25	270	424
D22	240	377
D19	200	314
D16	170	267
D13	140	220

R: Central bend radius of reinforcement bar

3) The lap joint lengths and anchorage lengths shall be as per Table 2-4.
   Note: The lengths of lap joints for different diameter reinforcement bars shall be decided according to greater diameter of reinforcement bar.
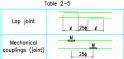
Table 2-4

Joint length and anchorage length of main bar: ℓ		~D29	D32	D35	D38~
	Slab, Wall	40φ	45φ	50φ	55φ
	Girder	~D25 40φ	D29 50φ	D32~35 55φ	

φ: Diameter of reinforcement bar

4) Location of adjoining joints
   For the positions of adjoining joints, Table 2-5 shall be set as the standards.

Table 2-5

Lap joint	25φ
Mechanical couplings (joint)	M / 25φ

φ: Diameter of reinforcement bar

Lap joint shall be applied to the main bar of slab members.
If either condition below 1 or 2 is not satisfied, lap joint length shall be greater or equal to 1.3x ℓ
1. Arranged main bars are greater or equal to 2 times of rebar amount required by calculation.
2. Number of joint in a cross section is less or equal to 50%.
If neither condition above 1 or 2 is not satisfied, lap joint length shall be greater or equal to 1.7x ℓ

5) Covering of reinforcement bar
   Covering of reinforcement bar shall be as per Table 2-6.

Table 2-6

Classification	Covering (mm)
Girder,Column	40
Upper Slab,Lower slab Inner wall	50
Middle slab Intermediate wall	40
Diaphragm wall	75

6) Location of main bar center
   Location of main bar center shall be as per Table 2-7.

Table 2-7

Classification		Location of main bar center (mm)
Upper/Lower Slab Wall	Inside	85
	Outside	85
Middle Slab	Upper	80
	Lower	80
Double Slab		70
Diaphragm Wall	Inside	140
	Outside	140
Inner Wall		80
Upper Slab Girder	Inside	85
	Outside	115 (main rebar of slab is D29,D32)
		110 (main rebar is up to D25)
Lower Slab Girder	Inside	115 (main rebar of slab is D29,D32)
		110 (main rebar is up to D25)
	Outside	115 (main rebar of slab is D29,D32)
		110 (main rebar is up to D25)
Seepage		85

Note: Location of main bar center indicates the length between main bar center and concrete surface.

7) Clearance of reinforcement bar
   The clearance between reinforcement bar shall be equal to or greater than any of the following value, whichever is the greatest.
   a) Beam, Slab and Wall
      1. 20mm
      2. 4/3 times the maximum size of an aggregate
      3. The diameter of reinforcement bar
      When main reinforcement bar in the axial direction is arranged in two or higher tiers, the vertical clearance shall be 20 mm or greater and equal to the diameter of the reinforcement bar.
   b) Column
      1. 40mm
      2. 4/3 times the maximum size of an aggregate
      3. 1.5 times the diameter of reinforcement bar
      When main reinforcement bar in the axial direction is arranged in two or higher tiers, the clearance shall be 40 mm or greater and equal to 1.5 times the diameter of the main reinforcement bar.
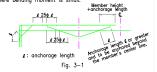
Lap joint shall be applied to the main bar of slab members.

c) Between joints for mechanical couplings
   1. The maximum size of an aggregate

8) Non-contact lap splice
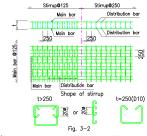   Non-contact lap splice can be applied if the spacings and/or directions of rebar between two members are different.

Fig. 2-1
D: Outer diameter of reinforcement bar

Fig. 2-2

3. Floor slab

1) The bar arrangements and thicknesses of floor slabs shall be as per the section list.
2) Joint and anchorage of reinforcement bar for slab and wall
   a) The anchorage lengths and receiving bar shall be as per Fig. 3-1. Joint shall be arranged in the area where bending moment is small.

Fig. 3-1
ℓ: anchorage length

3) Arrangement and shape of stirrup
   The diameters and intervals of stirrups shall be as per the section list.
   Stirrup shape and hook position shall be as per Fig. 3-2, Fig. 3-3.
   a) In the case of floor slab thickness t>=250

Fig. 3-2
Shape of stirrup
t>250 / t=250(D10)

b) In the case of floor slab thickness t>=200

Fig. 3-3
Shape of stirrup(width-holding bar)(D10)

c) Layout of stirrups and direction and change position of hooks
   1. Upper-end hook: Within L/2 in the center of floor slab span L
   2. Lower-end hook: Within L/4 at each end of floor slab span L
Note: For lower floor slabs, these hook shall be reversed. The floor slab span L shall be a net span.

Fig. 3-4
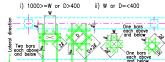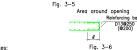1. Upper-end hook   2. Lower-end hook

4) Reinforcing of floor slab opening
   Reinforcing of openings in floor slabs shall be as per special specifications. In the absence of special specifications, the following shall apply.
   a) Procedures for opening reinforcing
      i) 1000>=W or D>400   ii) W or D=<400

Fig. 3-5
W: Size of opening in the longitudinal direction of frame

Fig. 3-6
Area around opening

Notes:
1. If a beam or a structural wall exists around an opening(when the "a" size is 100 mm or smaller), no reinforcing bar shall be required on the beam or wall side.
2. When the opening size W in the longitudinal direction is 100 mm or smaller, no reinforcing bar shall be required.
3. When the opening size W in the longitudinal direction is above 400mm, reinforcing bar in the lateral direction shall be anchored ℓ within the beam.

b) Reinforcing bar list

Table 3-1

Opening size	Reinforcing bar in the longitudinal and lateral directions	Diagonal reinforcing bar
Opening size in the longitudinal direction W=<400 or D=<400	One bar with the same diameter as slab reinforcement bar each above and below	One bar with the same diameter as on the left each above and below
Opening size in the longitudinal direction 400<W=<1000 or 400<D=<1000	Two bars with the same diameter as slab reinforcement bar each above and below	Two bars with the same diameter on the left each above and below

5) Distribution bar
   a) Distribution bar shall be 1/5 or more of main bar and when the reinforcement bar amount varies, it shall be changed at the changed positions of the main bar.
   b) The interval between distribution bar shall be at @250.