REPUBLIC OF BOLIVIA
BOLIVIAN NATIONAL RAILWAYS

RAILWAY REHABILITATION PROJECT, EASTERN LINE

(IPIAS-ROBORE)

Vol. 1. Instructions to Bidders
2. Conditions of Contract
3. General Specifications
4. Technical Specifications
5. Bill of Quantities
6. Basic Designs

Vol. 4 Technical Specifications

January, 1982

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

REPUBLIC OF BOLIVIA

BOLIVIAN NATIONAL RAILWAYS

RAILWAY REHABILITATION PROJECT, EASTERN LINE

(IPIAS-ROBORE)

Vol. 1. Instructions to Bidders
2. Conditions of Contract
3. General Specifications
4. Technical Specifications
5. Bill of Quantities
6. Basic Designs

Vol. 4. Technical Specifications

January, 1982

JAPAN INTERNATIONAL COOPERATION AGENCY

(JICA)

CONTENTS

Technical Specifications

TS 1 SURVEYING

TS 1 SURVEYING

TS 1.01 Scope of Application

The technical specifications for the surveying shall apply to center line survey, profile survey, cross leveling, river surveying and re-surveying. This surveying will not, include the center line restoration survey for partial hand-over and the survey for measurement and payment.

TS 1.02 Survey Engineers (Surveyors)

Surveying work shall be performed by the survey engineers. The survey engineers shall submit personal histories describing their professional qualifications and experiences in surveying to the Engineers for approval prior to the surveying work.
The Contractor shall be responsible for the accuracy of surveying conducted by the survey engineers.

TS 1.03 Data

The Contractorshall carry out the surveying work based upon the basic drawings including the partial topographic map of 1/1,000 scale and topographic map of 1/5,000 scale on which existing lines and proposed new route are indicated using aerial photographs.
Since values of triangulation points and bench marks in the site will be given, center line survey and profile survey shall be carried out with reference to these values.

TS 1.04 Center Line Survey

Center line survey shall be carried out for the existing line between 335 K 300 M of Santa Cruz and 400 K 400 M, the territory of the proposed new line and the territory of the temporary line for the construction indicated on the maps. However, no center line survey is required for a portion of the existing line described above which will become part of the new line.
The Contractor shall establish the center line of tracks shown on the drawings at the site and obtain approval from the Engineer. The center line surveying shall be carried out in accordance with the provisions described below.

(1) Stakes shall conform to the following:
   (a) Stakes shall be main stakes, center stakes and protection stakes. The main stakes and center stakes shall be painted white and marked with codes showing the purpose. All stakes shall be made of wood.
   (b) Main stakes shall conform to Table 1-1.

Table 1-1

Location	Size of stake	Depth of embedment
IP stakes	9 cm x 9 cm x 90 cm	Not less than 80 cm
Begining points and ending points of simple curve	9 cm x 9 cm x 90 cm	Not less than 80 cm

(c) Center stakes shall conform to Table 1-2.

Table 1-2

Location	Interval	Size of stake	Depth of embedment
Center of surveying	20 m	4.5 cm x 4.5 cm x 60 cm	Not less than 40 cm
– DO –	1 km	9 cm x 9 cm x 90 cm	Not less than 70 cm

(d) Protection stakes shall conform to Table 1-3. No stakes are necessary within the track gauge.

Table 1-3

Stakes to be protected	Size of stake	Depth of embedment	Required number of stakes
Main stakes	4.5 cm x 4.5 cm 60 cm	As required	4
Center stakes at 1 km every 1 km	4.5 cm x 4.5 cm 60 cm	– DO –	4

(2) The observation accuracy of auxiliary traversing for center line survey shall conform to Table 1-4.

Table 1-4

Observation value	Observation accuracy
Error in horizontal observation	Less than 15"
Error in double angle	Less than 30"
Constant of vertical angel	Less than 40"
Error of closure in direction angle	Less than 30" x $\sqrt{n}$

(3) When center line survey is completed, the Contractor shall submit (a) table of results of auxiliary traversing and (b) drawings of auxiliary traversing and center line survey to the Engineer.

TS 1.05 Profile Survey

Profile survey means the measurement of altitudes of surveying stations and points of change installed during center line survey as well as the measurement of location of points of change.
Profile survey shall be carried out in accordance with the following provisions:

(1) Surveying shall start from an existing bench mark and the closure shall be made to be this bench mark.

(2) If any existing bench mark is moved for some reason, surveying shall be made with reference to another existing bench mark, its altitude shoult be crrected, and this should be immediately reported to the Engineer.

(3) The accuracy of surveying shall be less than 10 mm $\sqrt{S}$ in terms of error of closure, where S is the measured distance expressed in km.

(4) Profiles shall be made in accordance with the following provisions:
- (a) Scale shall be 1/500 for vertical and 1/2500 for horizontal. However, for the area of a temporary line, use 1/200 for vertical and 1/1000 for horizontal.
- (b) Original drawings shall be made with ink on polyester films but transparent copies made on polyester films are also required.
- (c) Method used in showing the profiles of basic drawings shall be utilized when showing the profiles for the survey.

(5) The following results shall be submitted after the profile survey.
- (a) Field-book of profile survey.
- (b) Original sheets of drawings (drawings shown on polyester film).
- (c) Transparent copies of the original (copies made on polyester film).
- (d) Positive prints (3 sets).

TS 1.06 Cross Leveling

Cross leveling means the measurement ofvertical differences of points changing in the vertical direction normal to the center line from the center stakes on the center line of track, the center points of all structures and the other important points designated by the Engineer.
Cross leveling shall be carried out in accordance with the following provisions:

(1) Approximate locations of the cross leveling shall be as follows:
- (a) Territory of existing line: Portion where the structure is constructed under live line.
- (b) Territories of new line and temporary line: All territories.

(2) The standard width of cross leveling shall be 40 m, and the leveling width at right and left sides of the center line shall be determined by the Engineer.

(3) The accuracy of cross leveling shall be less than 10 cm for the distance and less than 5 cm for the height.

(4) Cross-sectional views shall be made in accordance with the following provisions:
   (a) The scale for the cross sections shall be 1/100 for both vertical and horizontal.
   (b) Drawings shall be made with ink on polyester film with 1-mm grid lines.
   (c) Cross sections shall indicate the standard height, ground height, distance from start point, and center line.

(5) The following results shall be submitted to the Engineer after cross leveling:
   (a) Field-book of cross leveling.
   (b) Original sheets of drawings (polyester film with 1-mm grid lines).
   (c) Positive prints: 3 sets

TS 1.07 River Surveying

River surveying means the profile survey and cross leveling of rivers for obtaining data for the detailed design of clearing and grubbing of river-bed work in accordance with the basic drawings.

The standard length of the profile survey for rivers shall be 150 m, and the interval of cross leveling shall be 10 m with a width of 45 m. The work procedure for the rivers shall be as same as the for cross leveling prescribed above, and detailed instructions given by the Engineer shall be observed.

TS 1.08 Re-Surveying

Re-surveying is performed when changing the route shown in the basic drawings after instructed by the Engineer or requested by the Contractor, or when correcting curves, gradients or locations of structures. Re-surveying shall be carried out by the Contractor in accordance with the instructions given by the Engineer.
If it is necessary to perform large-scale re-surveying and additional surveying as result of a considerable change necessary after the execution of on-site surveying, the Engineer will discuss the matter with the Contractor to determine the period of time and cost for the surveying work.

TS 1.09 Basis of Payment

Cost required for felling of trees and for securing the line of collimation, and costs of compensation for entering or causing damage to the farm lands during surveying shall be included in the unit price of this surveying work.
The surveying shall be deemed to be completed when the results are submitted to and approved by the Engineer.
The Engineer will issue a certificate of completion to the Contractor upon completion of the surveying.
Payment for surveying will be made on the basis of completed amount in the month when the certificate completion is issued with respect to the following item:

Pay item number	Description of work item	Unit of measurement
1	surveying	Lump Sum

TS 2 GEOLOGICAL SURVEY

TS 2 GEOLOGICAL SURVEY

TS 2.01 **Scope of Application**

These technical specifications for the geological survey shall apply to the site reconnaissance, test excavation, boring investigation, and the survey for overall examination of the results and determining the depths of bridge pier and abutament foundation.

TS 2.02 **Survey Engineers**

The Contractor shall submit personal histries describing the professional qualifications and experience in geological surveys of the engineers who perform the survey to the Engineer for approval.

TS 2.03 **Site Reconnaissance**

The Contractor shall survey the areas near the proposed railway bridges shown in Tables 1 and 2 using a plan of 1/1,000 scale to be supplied by the Employer, and indicate the resulsts of the survey including the description of geology, dips in strata and vertical and horizontal distribution on the geological maps of 1/1,000 scale for use as basic information for subsequent test excavation and boring investigation. The Contractor shall prepare a geological map of 1/1,000 scale and submit it to the Engineer for approval.

TS 2.04 **Test Excavation**

This test excavation is to be performed to directly confirm the locations and strengths of the bearing strata for bridge foundations. This excavation work shall be performed in accordance with the provisions described below.

(1) Excavation shall be made to the designated depth, and a level square bottom of 1.0 x 1.0 m minimum shall be formed for each excavation. Approximate locations and depths of excavations are shown in Table 1 but the detailed instructions of the Engineer shall be observed.

Table 1

Kilometerage	Depth of excavation	No. of places
Adjacent area 356 K 307 M	4	2
Adjacent area 359 K 186 M	2	2
– DO –	3	2
Adjacent area 361 K 730 M	4	2
Adjacent area 386 K 780 M	3	3

(2) Confirmation of the bearing strata shall be performed in the presence of the Engineer. The bearing capacity shall be confirmed by visual inspection and the Schmidt

rock test hammer. The Contractor shall take color photographs (8 x 11.5 cm) of each site and submit them after filling to the Engineer.

TS 2.05 **Boring Investigation**

This survey is required to confirm the locations and strengths of bearing strata at several places where test excavation is very difficult to perform. The work shall be performed in accordance with the provisions described below.

(1) Rock boring shall be made in accordance with AASHTO T206 using a sampler of inside with a diameter of 50.8 mm. Cores shall be obtained for the whole portion deeper than 5 m. Approximate locations and depths are shown in Table 2 but the Contractor shall observe the detailed instructions given by the Engineer.

Table 2

Kilometerage	Depth of boring	No. of places
Adjacent area 354 K 950 M	15	2
Adjacent area 355 K 208 M	15	2
Adjacent area 355 K 448 M	10	2
Adjacent area 358 K 155 M	20	2

(2) When a designated depth of boring is reached, the Contractor shall confirm the depth and bearing capacity in the presence of the Engineer, and submit orderly filed boring cores and results of penetration tests to the Engineers.

TS 2.06 **Preparation of Report**

The Contractor shall totally and sufficiently examine the results of site reconnaissance, test excavation and boring investigation, determine the depths of bridge piers and abutment foundations, prepare a report, and submit the report to the Engineer for approval.

TS 2.07 **Basis of Payment**

All costs for delivery of machines, leveling of ground at the site, preparation of report, and other costs required for the geological survey shall be included in the unit price for the geological survey.

The geological survey is deemed to be completed when all geological surveying is done, data and report prescribed in these technical specifications are submitted to the Engineer, and approval by the Engineer is given.

The Engineer will issue a certificate of completion upon the completion of the geological survey to the Contractor.

The payment for the geological survey will be made on the basis of completed amount in the month when the certificate of completion is issued with respect to the following item:

Pay item number	Description of work item	Unit of measurement
2	Geological survey	Lump Sum

TS 3 DETAILED DESIGN

TS 3 DETAIL DESIGN

TS 3.01 **Scope of Application**

The Detailed Design Technical Sepcifications shall apply to the detailed design of railway structures in accordance with the basic design drawings and conditions at the construction site.

Should the basic design drawings be considered not suitable to the local situation, the contractor shall produce an appropriate design after notifying the Engineer of the situation accompanied by data showing the reason why the basic design drawings are not considered suitable.

TS 3.02 **Basic Track Structural Standards**

The basic structural standards for the track shall conform to the following requrements.

(1) **Track Gauge and Slack**

The track gauge shall be 1,000 mm.

The track gauge shall be measured as the shortest distance between rail heads from points within 16 mm from the running suffaces of the rails.

Circular curves below 600 mm in radius shall be allowed slack in accordance with the table below. 5 mm slack can be allowed when deemed necessary even when a circular curve exceeds 600 m in radius.

Table 3-1

Radius of curve (m)	Slack (mm)
R < 200	25
200 ≤ R < 240	20
240 ≤ R < 320	15
320 ≤ R < 440	10
440 ≤ R = 600	5

Slack shall be given by widening the track gauge on the inside of the curve.

The slack tapering-off distance shall be the same for superelevation tapering-off and shall be greater than 5 m if there is no superelevation.

When the slack in the exsiting roadway does not coincide with the values given in the table above, the matter shall be discussed with the Engineer.

(2) **Curves**

The minimum cruve radius on the main roadways shall be greater than 301.6 m.

The minimum curve radius on sidetracks shall be greater than 150 m.

A considerably long tangent should be inserted between adjacent curves on the main roadway. The decision shall be made, however, after consulting with the Engineer.

(3) **Superelevation**

The superelevation in a curve shall be calculated in accordance with the formula given below:

$$C = \frac{GV^2}{127R}$$

where C: Superelevation (mm)
G: track gauge (1,000 mm)
V: train speed (km/h)
R: Radius of curve (m)

The superelevation shall be decided depending on the curve radius and on the train speed through the curve based on the foregoing formula.
The maximum superelevation for the main track shall be 110 mm.
It is assumed that the maximum allowable running speed between Santa Cruz and Columbá on the Eastern Line will be 90 and 70 km/h for ferrobuses and other trains, respectively.
Expect in special instances, the superelevation shall be provided in the curve.
A superelevation shall be tapered-off over a distance greater than 400 times the superelevation.
A superelevation taper-off distance coming to less the 5 m shall be taken as 5 m.

Table 3-2 Superelevation Table

Average Speed (km/h)	Radius of Curve (m)								
	301.6	400	500	600	800	1000	1200	1500	2000
65	110	83	66	55	42	33	28	22	17
70		96	77	64	48	39	32	26	19
75			89	74	55	44	37	30	22
80				84	63	50	42	34	25
85					71	57	47	38	28
90						64	53	43	32

The Engineer shall be consulted when the superelevation of existing track do not match the values given in the above table.

(4) Gradient
The maximum gradient for the main track except in station compounds shall be less than 10/1000. The gradient may be corrected vis-a-vis curve resistance when a gradient section contains a vurve, and the correction can be calculated using the formula below:

$$\text{Maximum gradient in curve} = (10 - \frac{600}{R})\ 0/00$$

R = radius of curve (m)

In principle, the gradients of main track and sidetracks in station compounds shall be level.

(5) **Vertical Curve**

A vertical curve with a radius of greater than 5000 m shall be inserted in sections of a man track containing varied gradients.

A considerably long vertical curve shall be inserted in a sidetrack with varied gradients. The Engineer shall be consulted in this instance.

(6) **Track and Car Clearances**

No buildings or other structures shall be built inside the track clearnace. The track clearnace for a tangent is shown in Figure 3-1. The track clearance for a cruve greater than 800 m in radius shall be the same as that for a tangent, and the width has to be greater for the car deviation on curves with a radius of less than 800 m. The allowance on each side of the track center line shall be calculated by the formula given below:

$$W = \frac{22{,}500}{R}$$

where W: Allowance on each side of the track center line (mm)
R: radius of curve (m)

The tapering-off distance for the this extra allowance shall be 17 m measuring from the end of the circular curve (join between the tangent and curve) or from the end of a circular curve with a smaller radius (between curves). The Enginner shall be consulted regarding existing track.

The track clearance on a cruve shall be banked in line with the superelevation.

Cars shall not be able to move beyond the car clearances shown in Fig. 3-1 in their right positions on a tangent track.

No section of the car shall be able to move out of the clearance calculated by adding the W value on each side of the track center line even if the car's center line deviates from the track center line when the car is in its right position on a curved track.

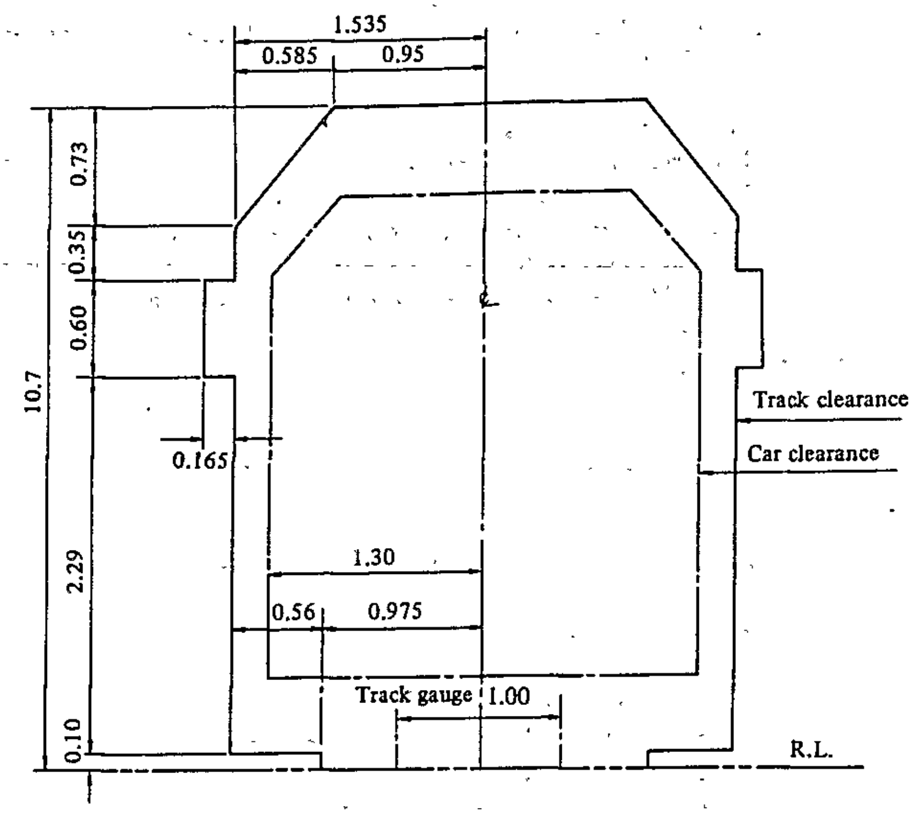


Fig. 3-1 Track and Car Clearances (unit m)

(7) **Formtion Width**

The formation width on a main track shall be 6,000 mm after providing a drainage gradient.

No widening of the embankment will be made regarding the formation width in a cruved section. No widening of the embankment will be made in a high banking section either. The roadbed surface shall have a gradient of 3% from the center line on both sides.

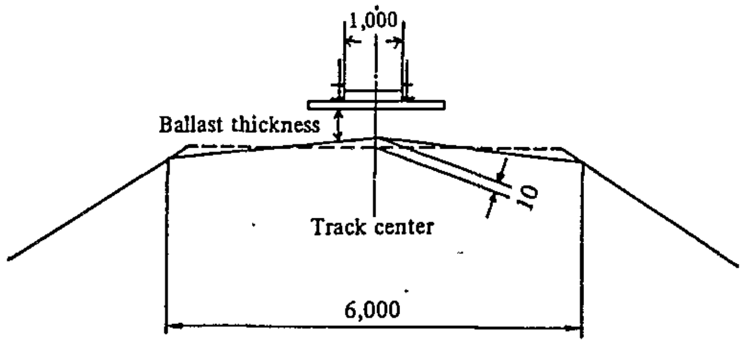


Fig. 3-2 Formation Width (unit mm)

(8) **Gradient of Face of Embankment Slope**

The slope face gradient of 1:1.5 shall be provided over the entire height when the total height of the embankment is below 5 m. A slope face gradient of 1:1.5 shall be provided from the shoulder to a height of 3 m when the total height is greater than 5 m. The slope face gradient shall be 1:1.8 beyond 3 m, and a berm 1.0 m in width shall be provided when the gradient changes from 1:1.8 to 1:1.5. The gradient is expressed by vertical height:horizontal distance.

(9) **Cutting Slope Face Gradient**

In principle, the gradient of a cutting slope face shall be 1:1.2. It shall be designed after studying terrain, geology, spring water, etc. and in conjunction with drainage work.

TS 3.03 **Design Criteria for Railway Structures**

The design criteria for railway structures shall conform to the following requirements. The Engineer shall be consulted when it is not possible to comply with these requirements.

(1) Basic Policy

(a) Prior to undertaking detailed design, such items as proposed use, ease of execution, inspection and maintenance, economy, and suitablility with environment shall be taken into consideration.

(b) In making design calculations, the strength, deformation, stability, and durability of structures shall be studied.

(2) Design Calculations

(a) In principle, design calculations shall be made based on static calculations.

(b) In principle, structural analyses shall be made based on elasticity theory.

(c) Members shall be designed by the allowable stress method.

(d) In the stability analyses the Contractor shall confirm generally the stability of structures against sliding, overturning, bearing capacity of ground and bearing surface of suports and bearing surface of foundations.

(3) Design Loads

(a) Load Types

When designing, the following loads shall be taken into consideration. A seismic load needs not be considered.

(i) Dead load
(ii) Live load
(iii) Impact load
(iv) Centrifugal load
(v) Longitudinal load
(vi) Wind load
(vii) Current pressrue
(viii) Earth pressure
(ix) Temperature change
(x) Other loads, buoyancy, drying shrinkage, erection load, etc.

(b) Dead Load

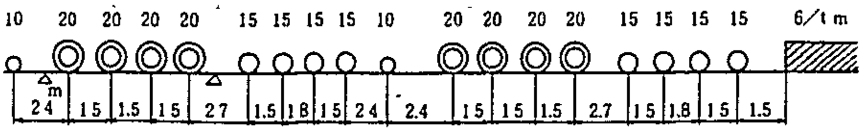
The following unit weights shall be used in principle in calculating dead loads:

Table 3-3 Unit Weight

Material Type	Unit Weight (kg/m³)
Steel, Cast Steel	7,850
Cast Iron	7,250
Reinforced Concrete	2,500
Concrete	2,350
Cement Mortar	2,150
Waterproofing Asphalt	1,100
Stones and Rocks	2,600
Timber	800
Sand, Earth, Gravel	1,600 – 2,000
Ballast	1,900
Track Panel	450 kg/cm
Copper Alloy Bearing	8,500

(c) Live Load

(i) Train Load
The train load for a Cooper E45 is assumed to be as shown in the diagram below, and loading shall be made so that the maximum stress is caused ot members.



NOTE: Dimensions are in meters. Weights are in tons.

Fig. 3-3 Cooper E45

(ii) Live Load on a Walkway of Bridge
The load on a bridge walkway shall to be 300 kg/m².

(d) Impact Load
The impact load from a train load shall be obtained by multiplying the impact coefficient shown below by the train load.

(i) The impact coefficeint for the train load on a steel railway bridge shall be calculated by the formula below:

When $L \leqq 30$ m $\quad i = 0.7 - \dfrac{L^2}{4,000}$

When $L > 30$ m $\quad i = \dfrac{10}{L} + 0.14$

Where L: L is as a rule the length (m) of the base line of the influence line of the same sign that causes a possible maximum train load stress on the structural members under consideration. However, with regard to the web members of the truss except the hip vertical members of a through truss, intermediate posts of a deck truss and diagonal members in sub-panels, L shall be 75% of the bridge span lenth.

i: Impact coefficent

(ii) Inprinciple, the impact coefficient of a concrete sturcture for the train load shall agree with the values given in the table below.

Table 3-4

Span L (m)	0	5	10	20	30	40	50	70	100	Other spans
Impact coefficeint	0.60	0.48	0.43	0.37	0.34	0.32	0.30	0.27	0.24	Value calculated by interpolation method

(iii) Where the surface of concrete structure is covered with the roadbed or filled with other soil material in a thickness of more than one meter, impact coefficient may be decreased to the extent as approved by the Engineer regardless of the requirements as specified in the preceding paragraph.

(e) **Centrifugal Load**

The centrifugal load caused when a train passed a curved track shall be calculated by multiplying the coefficients shwon in the table below by the train load and is considered to affect the track perpendicularly and horizontally at the height from the rail surface given in the table.

Table 3-5

Curve Radius R (m)	Coefficient	Working Hieght from Rail level (m)
$R \leq 1{,}000$ $1{,}000 \leq R$ H 2,000 $2{,}000 \leq R$	0.12 0.08 0	1.8

(f) **Longitudinal Load**

The longitudinal load shall be braking and traciton loads, and the value (large ones) shown in the table below are considered to affect the track in parallel at the height from the rail level given in the table.

Table 3-6

Braking Load	15% of train load
Traction Load	25% of driving wheel axle weight
Height	1.8 m above rail surface

(g) **Wind Load**

(i) In principle, the windload is considered to be from one direction horizontally and perpendicularly to the bridge, and its magnitude shall be as follows:

o When there is no train on the bridge
- Bridge vertical projection plane 300 kg/m^2
- Vertical projection plane of a main truss on the leeward side not covered by the truss floor system . . . . . . 200 kg/m^2

o When there is a train on the bridge
- Bridge vertical projection plane 150 kg/m^2
- Vertical projection plane of a main truss on the leeward side not covered by the truss floor system 100 kg/m^2
- Train vertical projection plane 150 kg/m^2

The vertical projection plane of a train shall be a width 3.6 m above the rail level, and no consideration needs be given to the wind load for the members on the leeward and windward sides of the girders overlapping with the train.

o Regardless of the preceding requirement, the following values may be used as reference by totaling the windward and leeward sides for a through truss up to 80 m in span.

(unit: kg/m)

	Upper Chord	Lower Chord
When there is no train on the bridge	500	600
When there is a train on the bridge	300	800*

* NOTE: Includes the wind load to the vertical projection plane of the train.

The wind load to be considered for members having circular or similar shaped sections shall be 0.6 times the value specified in (i).

(h) **Current Pressure**

The pressure exerted on piers by current shall be as given in the formula shown below, and this pressure is considered to act at a height 0.6 times the water depth from the river bottom.

$$P = KAV^2$$

where P: current pressure (t)

K: coefficient by cross sectional profile of pier (Table 3-7)

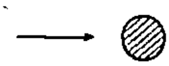
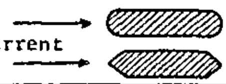
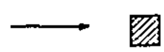
A: Vertical projection area of pier (m^2)

V: Surface velocity (m/sec)

Collision by floating logs and other floating objects

When the effect of collisions by floating logs and other floating objects are considered, a horizontal force of 3 t is estimated to act when the river gradient is greater than 1/300 and 2 t, when the river gradient is below 1/300.

Table 3-7 Relation of Pier Profile with K

Pier Cross-Sectional Profile	K-Value
	0.03
Current 	0.025
	0.05
	0.055

(i) **Earth Pressure**

(i) The active and passive earth pressures shall be ablained based on Coulomb's theories. In general, the properties of earth used in earth pressure calculation shall be as follows:

Table 3-8

Earth Unit Weight	1,600 kg/m²
Internal Friction Angle	33°40 (Ground water level is also the same value.)

When it is judged rational to use the results of a soil test in calculations after obtaining the approval of the Engineer.

(ii) The friction angle between earth and concrete surfaces shall be 1/2 the internal friction angle of the earth.

(iii) The earth pressure acting on structures such as culverts and underground structures whose moving deformation is considered to be very small when subjected to earth pressure shall be computed by the static earth pressure as follows:

$$P = K_o \gamma h$$

where P: earth pressure of depth H (t/m^2)
K_0: earth pressure coefficient = 0.5
γ: earth unit weight (t/m^3)
h: earth depth (m)

(iv) Loaded Load as Surcharge
Train loads shall be handled as loaded loads by the formula shown below:

$$q = \frac{P}{a x b}$$

where q: Reduced uniformly distributed load (t/m^2)
P: train load 20 t
a: axial distance 1.50 (m)
b: lateral distribution width of train load (m)
(distribution is generally considered to be 1:0.5)

(j) Temperature Change and Drying Shrinkage

(i) Temperature change
Temperature change shall be determined in accordance with the engineer's instructions, and the linear expansion coefficients shall be based on the values given below.

Expansion coefficeint	per degree
Steel	1.2×10^{-5}
Concrete	1.0×10^{-5}

(ii) **Drying Shrinkage of Concrete**

The following values shall be made standards regarding the drying shrinkage to be used in structural analysis of statically indeterminate structures.

Reinforced concrete structures (per deg) 15×10^{-5}

(k) Other Loads

(i) Frictinal Resistance at Bearings

Table 3-8

Type of Bearing	Types of material in contact	Coefficient of Firction
Sliding Bearing	Steel and Steel Steel and cast iron	0.25 0.20
Bearing Plates	Steel and Phosphorus bronze	0.10
Roller or Rocker Bearings	Steel and Steel	0.10

The loads which fixed and movable supports bear shall be as follows:

$$\text{Fixed Bearing } T = \Sigma T - \frac{\mu R}{2} \geqslant \frac{\Sigma T}{2}$$

where T: longitudinal load supported by Fixed Bearing
ΣT: total longitudinal load
μ : coefficient (based on foregoing table)
R: movable support reaction

$$\text{Movable bearing } T = \mu R \leqslant \frac{\Sigma T}{2}$$

where T: longitudinal load supported by the movable bearing
ΣT: total longitudinal load
μ : coefficent (based on foregoing table)
R: movable support reaction

TS 3.04 **Detailed Design of Reinforced and Plain Concrete**

Detailed design of reinforced and plain concrete shall be made in accordance with the following requirements.

(1) Allowable Unit Stress

(a) **Reinforcing Bars**

The standard allowable tensile unit stress of reinforcement shall be the values given in the table below:

Table 3-10

(Unit: kg/cm^2)

Reinforcement Type	GRADE60
Allowable Tensile Unit Stress	1,690

NOTE: The basic allowable compressive unit stress of reinforcement conforming to ASTM A615, A616, and A617 are to be the same values as the foregoing allowable tensile unit stresses.

(b) **Reinforced Concrete**

The standard allowable unit stress for reinforced concrete shall be decided in principle based on the design strength of $\sigma 28$. The standard all allowable unit stress of concrete shall be as specified below.

(i) The standard allowable bending compressive unit stress (including cases when an axial force is accompanied) shall be the values given below:

$$\sigma ca \leqq \frac{\sigma 28}{3}$$

(ii) The standard allowable shearing unit stress shall be less than the values given in the table below:

Table 3-11 (Unit kg/cm²)

Method of Calculation of Diagonal tensile reinforcement bars		incase when $\sigma_{28} = 180$	in case when $\sigma_{28} = 210$
When calculation is not conducted for diagonal tention bars, τa_1	Beams	6	6.5
	Slab	8	8.5
When calculation is conducted for diagonal tension bars (excluding cases accompanied by the effects of torsion), τa_2		17	18.5

(iii) The standard allowable bond unit stress shall be less than the values shown in the table below. These values shall be decreased for reinforcing bars exceeding 32 mm in diameter.

Table 3-12

(Unit kg/cm²)

Type of reinforcement	in case when $\sigma_{28} = 180$	in case when $\sigma_{28} = 210$
Deformed Bars	14	150.0

(iv) The standard allowable unit bearing pressrue σca' shall be the value shown below:

- o When loaded over the entire surface, the formula given below shall be used:

$$\sigma ca' \leqq 0.3\sigma ca$$

- o When loaded partially, gross area of the concrete surface is assumed to be A and the area subjected to the bearing pressure, A', and the formula given below shall be used.

$$\sigma ca' \leqq (0.25 + 0.05 \frac{A}{A'}) \sigma_{28}$$

When the section to be subjected to bearing pressure is sufficiently reinforced, the standard allowable bearing unit stress shall be decided within a range for which the safety factor in a test is greater than 3.

(c) **Allowable Unit Stress in Plain Concrete**

In principle, the standard allowable unit stress of plain concrete shall be decided based on a design strength of σ_{28}.

(i) The standard allowable compressive unit stress (including cases where an eccentric axial load is to be applied) shall be the value given below:

$$\sigma ca = \frac{\sigma_{28}}{4}$$

$$\leqq 55 \text{ kg/cm}^2$$

(ii) The allowable bending tensile unit stress σta shall be the value given below. In this instance, σ_{28}' shall be the concrete design tensile strength.

$$\sigma_{ta} \leqq \frac{\sigma_{28}'}{7} \leqq 3 \text{ kg/cm}^2$$

where $\sigma_{28}' = \dfrac{\sigma_{28}}{10}$

(iii) The standard bearing pressure unit stress $\sigma ca'$ shall be the values given in the following paragraphs:

o When loaded over the entire surface, the formula given below shall be used. The standard allowable bearing pressure unit stress can be increased to 70 kg/cm^2 particularly when the bearing pressure strength is increased by placing spiral reinforcement bars or other materials.

$$\sigma ca' \leqq 0.3\, \sigma_{28}$$

$$\leqq 60 \text{ kg/cm}^2$$

o When loaded in over only part of the sections, the formula given below shall be used assuming gross area of the concrete surface to be A and the area to be subjected to bearing pressure to be A'.

$$\sigma ca' \leqq (0.25 + 0.05 \frac{A}{A'}) \times \sigma_{28}$$

$$\leqq 120 \text{ kg/cm}^2$$

(d) **Allowable Unit Stress for Combinations Loads**

The allowable unit stresses to be used in design calculations shall be the values obtained by multiplying the standard unit stresses shown in (3) (a), (b), and (c) by the coefficeints given in the table below, according to the type of structure and load combination.

Table 3-13

	Combinations	Coefficient α
Shoe and Bearing Surface	Dead load + train load + (impact) + centrifugal load	1.0
	Dead load + train load + (impact) + braking load, or tracion load	1.15
Abutment	Dead load + earth pressure	1.0
	Dead load + train load + (impact) + earth pressure	1.0
	Dead load + train load + (impact) + braking load or traction load + earth pressure	1.15
Pier	Dead load + train load + (impact) + centrifugal load	1.0
	Dead load + train load + (impact) + braking load or traction load	1.15
	Dead load + train load + (impact) + centrifugal load + wind load + [current pressure]	1.25
Culvert	Dead load + train load + (impact) + earth pressure + [water pressure]	1.0
Retaining wall	Dead load + [train load] + earch pressure	1.0

NOTE: The loads in ( ) shall be considered when it gives a marginally combination. combinations of loads in [ ] shall be considered when necessary.

(2) General Design

(a) This project will use the following three types of concrete.

Table 3-14

σ28 Strength (kg/m²)	Application
210	Abutment, piers, box culverts, U-sheped retaining walls
180	Open Drainage retaining walls, and other structures that are not so important
160	Leveling concrete

(b) Calculation Assumotions in Structural Analysis

(i) **Moment of Inertia**

– Moment of inertia used in calculating statically indeterminate stress in general may be obtained on gross concrete section neglecting reinforcement.

– Moment of inertia used in calculating the deformation caused by a temporary load shall be calculated on gross section of a member taking into consideration the effects of reinforcement. In this instance, the cross sectional area of a reinforcement shall be considered as a concrete cross sectional area of the value obtained by multiplying the actual cross sectional area by Young's modulus ration given in the table below.

Table 3-15 Young's Modulus Ratio

σ28 (kg/cm²)	180	210
n	8.8	8.3

σ : Design strength based on 28 days compressive strength.

(ii) **Young's Modulus for Reinforcement**
Young's modulus for reinforcement shall be $Es = 21 \times 10^6$ kg/cm².

(iii) **Young's Modulus for Concrete**
Young's modulus Ec for concrete for a temporary load used in concrete design calculations shall be based on the values given in Table 3-16.

Table 3-16 Young's Modulus for Concrete

$\sigma 28$ (kg/cm²)	180	210
Ec (kg/cm²)	2.4×10^5	2.6×10^5

σ : Design strength based on 28 days compressive strength.

(iv) **Poisson's Ratio for Concrete**

Poisson's ratio for concrete shall generally be taken as 1/6, and the ratio between Young's modulus and the shearing elasticity coefficient shall be 2.3

(v) **Compression and Bending**

o Calculation of Bending Unit stress

Assumption in unit stress calculations

In calculations of a cross section area or unit stress, the tensile stress of concrete is usually neglected, and the longitudinal strain is considered to vary in proportion to the distance from the neutral axis in the cross section.

In calculation on cross sections or unit stress, Young's moduli for reinforcement and concrete shall be taken as

$Es = 2.1 \times 10^6$ kg/cm² and $Ec = 1.4 \times 10^5$ kg/cm² ($n = Es/Ec = 15$).

When reinforcement do not cross a design cross section of a member perpendicularly, the value calculated by multiplying the sine of the angle, which the reinforcement makes with the cross section, by the bar cross sectional area shall be considered as the effective cross section area of the reinforcement for the stress that work vertically on the cross section.

o The reinforcement and concrete unit stresses on a memeber that is subjected to a bend and axial force shall not exceed the allowable unit stresses described in TS 3.04 (1).

(vi) **Shearing unit stress caused by a bend**

o When the effective depth is constant:

$$\tau = \frac{S}{b_0 jd} = \frac{S}{b_0 z}$$

where
- τ: shearing unit stress (kg/cm²)
- S: shearing strength (kg)
- b_0: width of member cross section (cm)
- $z=jd$: distance from working point of the total compressive stress to the centroid of the tensile bar cross section (cm)

o When the effective depth of the member changes:

$$\tau = \frac{S_1}{b_0 jd} = \frac{S_1}{b_0 z}$$

where

$$S_1 = S - \frac{M}{d}(\tan\alpha + \tan\beta)$$

M: bending moment (kg.cm)

d: effective depth of cross section under consideration (cm)

α: angle at which the lower surface of the member makes a horizontal line (Fig. 3-4)

β: angle at which the upper surface of the member makes a horizontal line (Fig. 3-4)

α and β become positive and negative, respectively, when the inclinations of the member upper and lower surfaces increase and decrease their effectoive depth, as the absolute values of the bending moment increases.

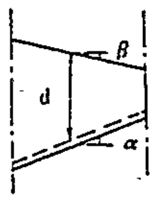


Fig. 3-4 Beam Whose Effective depth Changes

The shearing unit stress shall not exceed the allowable unit stress τa_1 given in TS 3.04 (1) when no calculations for diagonal tensile reinforcement are made.

The shearing unit stress shall not exceed the allowable unit stress given in TS 3.04 (1) when making calculations for diagonal tension reinforcement.

(3) Structural Details

The structual details of reinforcement shall meet the following requirements:

(a) Clear Distance between Reinforcing Bars

The clear distance between parallel reinforcing bars shall be greater than 2 cm, greater than 4/3 times the dimensions of coarse aggregate, and greater than the reinforcing bar diameter.

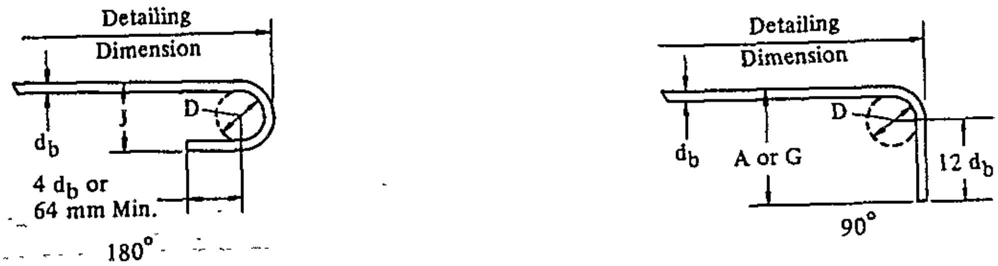
Where parallel reinforcement is placed in two or more layers, the clear distance between layers shall be greater than 2 cm and greater than the reinforcing bar diameter.

(b) Minimum Bend Diameter of Reinforcing Bars

(i) The minimum bend diameter of reinforcing bars shall conform to Table 3-17 and Figure 3-5 (a).

Table 3-17

Reinforcing Bar	Bar Dia D Other than Stirrups and Hoops	Stirrup and Hoop Dia D
#3 ... #5	6 x db	4 x db
#5 – #8	6 x db	8 x db
#8 – #11	8 x db	8 x db



STIRRUP AND TIE HOOKS

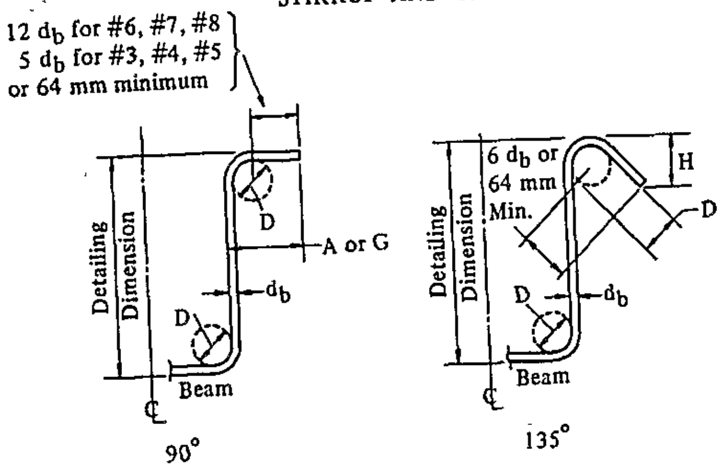


Fig. 3-5 (a)

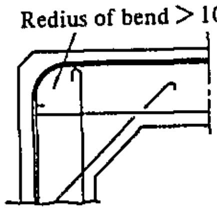
(ii) Bend Diameter of Bent-up Bar
Unless otherwise instructed, the bend diameter of a bent-up bar shall be the same as the minimum bend diameter described in (5) (a) (ii). (See Fig. 3-5 (b)).

(iii) The bend radius of reinforcing bars along an outside member connecting sections of a rigid-framed structure shall be greater than 10 times the reinforcing bar diameter. (Fig. 3-5 (c)).

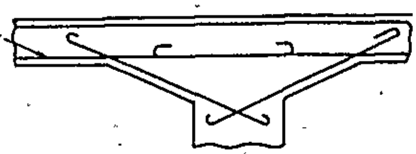
(c) **Reinforcing Bars Along Inside of Haunches and Others**

In principle, reinforcing bars along the insides of member connecting sections of rigid framed and haunches shall be other straight reinforcing bars along haunches, instead of tensile bars bent from a slab or beam. (See Figure 3-5 (d)).

(b)



(c)



(Bars inside of Haunches)

(d)

Fig. 3-5

(d) **Length of Reinforcing Bar Splices**

(i) Reinforcing bars shall be spliced according to the ACI standard unless otherwise instructed by the Engineer.

(ii) **Reinforcing Bar Splice Position**

- Splices shall be made in a section with the least stress on the reinforcing bars whenever possible.
- Do not concentrate reinforcing bar splices in one location.

(e) **Minimum Concrete Cover for Reinforcement**

Minimum concrete cover for reinforcement shall be normally 5 cm however, it shall be decided after consulting with the Engineer considering the importance of the structure, environmental conditions at site, and other factors which might adversely affect concrete reinforcement.

TS 3.05 **Detailed Design of Retaining Walls**

The detail design of retaining walls shall meet the following requirements:

(1) Design Policy for Retaining Walls
The position of retaining walls shall be decided so as to minimize the earth pressure. The design shall consider the execution method and economical efficiency and shall be appropriate to the situation at the construction site.

(2) Study of Soil
A study of the safety of the bearing soil against earth pressure load on the rear shall be made for the soil of retaining walls in addition to the load on the walls.

(3) Embedment Depth of Retaining Wall Foundations
The embedment depth shall be decided after considering the soil condition, bearing strength, required design conditions, environment and meteorological conditions, and other factors.

(4) Drainage Work
An appropriate drainage system shall be installed on retaining walls in order to drain water from the rear earth. Where no drainage system can be installed, the effects of water pressure shall be considered.

(5) Handling of Surcharge Load
When designing a retaining wall, the necessary surcharge load shall be considered. Even when no surcharge load is considered necessary for a design consideration, a surcharge load of 1 t/m^2 shall be considered.

(6) Earth Pressure Acting on Retaining Walls
The earth pressure acting on a retaining wall shall be considered to be a Coulmob's earth pressure meeting the following requirements:

(a) Assumption in Earth Pressure Calculation

(i) For Stability Calculation and Floor Slab Design (See Fig. 3-6)

- When $\ell/h \geq 0.1$, the vertical plane passing through the tip of the rear floor slab shall be taken as the virtual rear plane, and the earth pressure considered to act on this virtual rear plane.

- In this instance, earth between the wall and virtual rear plane shall be considered part of the wall.

- When $\ell/h < 0.1$, the earth pressure is considered to act on the rear plane of the structure.

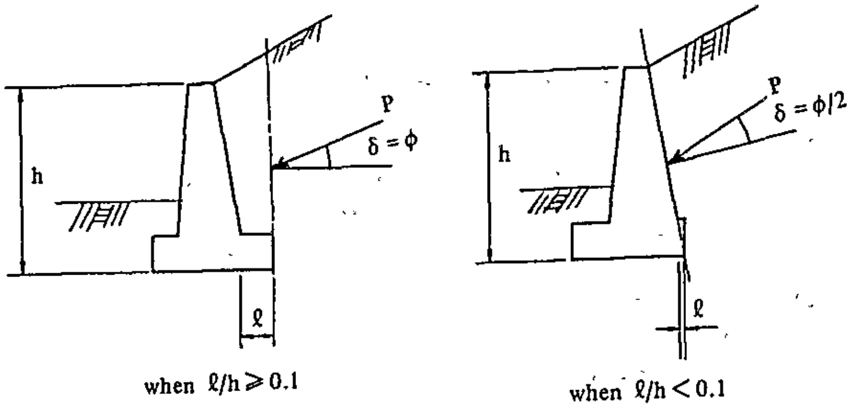


Fig. 3-6

(ii) For Wall Design (See Fig. 3-7)

o Earth pressure is considered to act on the wall rear plane.

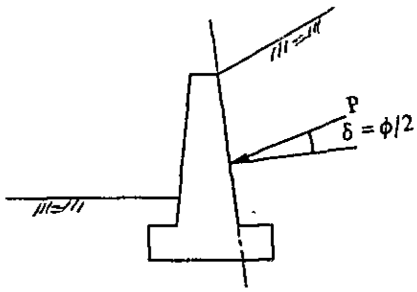


Fig. 3-7

(7) Structural Details
(a) An expansion joint shall be installed for each interval below 20 m in wall length.
(b) Weep-holes 5 cm in diameter shall be provided at intervals of 1.5 m to 3.0 m for good draining.

TS 3.06 **Detailed Design of Box Culverts**

The detiled design of box culverts shall conform to the following requirements.

(1) Box Culvert Design in General
The shapes and dimensions of box culverts shall be decided after taking the required cross sections, condition of foundation ground, embankment profiles, execution

methods, etc. into consideration.

(2) **Load Acting on Box Culverts**
The loads acting on box culverts shall be decided after taking the properties of the foundation ground at the sites, embankment profiles, execution methods, shapes and dimensions of the box culverts, relations and positions with the ground, and other factors into consideration.

(3) **Vertical Earth Pressure Acting on Upper Surfaces of Box Culverts**
The vertical earth pressure acting on upper surfaces of box culverts shall be calculated based on the formula given below:

$$P = \gamma h$$

where P: earth pressure for height h (t/m^2)
γ: earth unit weight (t/m^3)
h: earth depth (m)

(4) **Effects of Train Load Working on Upper Surfaces of Box Culverts**
The effects of the train loads working on the upper surfaces of box culverts shall be distributed as shown in Table 3.17.

Table 3-17

(Unit: t/m^2)

Earth Covering	1 m	2 m	3 m	4 m	5 m	10 m
Single Track	5.3	3.6	2.8	2.3	1.7	0.7

NOTE: The table is for a Copper E45.

(5) **Earth Pressure Working on Sides of Box Culverts**
The earth pressure working on box culvert sides shall be static earth pressure.

(6) **Ground Reaction Used in Design Calculations of Longitudinal Directions of Box Culverts**
The ground reactions to be used in design calculations of the bending moments, shearing, etc. in the longitudinal direction of culverts which are expected to settle considerably shall be calculated after taking the rigidity of the box culverts and ground reaction coefficients into consideration.
When the foundation ground and support methods for box culverts markedly differ in the culvert longitudinal direction, a study of settlement shall also be made.

TS 3.07 Detailed Design of Foundation

Detailed design of foundations shall conform to the following requirements.

(1) Foundations in General

(a) Sufficient studies shall be made in advance regarding the terrain, geology, environmental conditions, and other items required for design prior to designing the foundations.

(b) A foundation type meeting the following requirements and offering economical advantage should be selected.

- o Terrain and geological conditions
- o Characteristics of structures
- o Environment

(c) The foundations shall safely support the structures and shall be designed so as not to cause detrimental displacement.

(2) Stability of Foundations

(a) Foundation Design Conditions
The foundations shall sefely support superstructures and shall be designed so as to ensure adequate protection and safety against breaking, slipping, and overturning of the ground. The foundations shall be designed taking the complexity of the ground, calculation accuracy, working conditions, and material durability into consideration.

(b) Calculation of Allowable Bearing Capacity of Soil
In the design of the allowable beanng capacity of soil for the foundation ground, a study of the allowable bearing capacity before breaking of the foundation ground in accordance with the equation given below shall be made.

Allowable Bearing Capacity

$$Qa = 1/F\,[\alpha CNc + \beta\gamma_1 BN\gamma + \gamma_2 Df(Nq-1)] + \gamma_2 Df \ (t/m^2)$$

where Qa: allowable bearing capacity (t/m^2)

C: ground cohesion under foundation load surface (t/m^2)

γ_1: ground unit weght under foundation load surface (t/m^2)
(In case of the foundation which is situated under the ground water level, unit weight of submerged ground is applied)

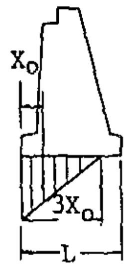
γ_2: average unit weight of ground above foundation load surface (t/m^2)
(In the portion under the ground water level, the unit weight of submerged ground is applied.)

d, β: coefficients determined by foundation shape (See Table 3-18)

N_c, N_γ, N_q: Bearing force coefficients (See Table 3.19)

D_f: Effective embedment depth from the lowest ground surface close to the foundation to foundation load surface (m)

B: Minimum width of foundation load surface (m). Diameter when the shape is circular. $B = 2\ X_0$ when the load deviates from the center as shown in Fig. 3-8.



F_s: safety factor

Normal time	3.0
Normal time + temporary time	2.0
Normal time + flood time	1.5

Fig. 3-8

Table 3-18 Shape Coefficient

Shape of Foundation Load Surface	Continius	Square	Rectangle	Circle
α	1.0	1.3	$1 + 0.3\frac{B}{L}$	1.3
β	0.5	0.4	$0.5 - 0.1\frac{B}{L}$	0.3

B: Length of short side in rectangle (m)
L: Length of long side in rectangle (m)

Table 3-19 Bearing Capacity Coefficient

φ	Nc	Nr	Nq
0	5.3	0	1.0
5	5.3	0	1.4
10	5.3	0	1.9
15	6.5	1.2	2.7
20	7.9	2.0	3.9
25	9.9	3.3	5.6
28	11.4	4.4	7.1
32	20.9	10.6	14.1
36	42.2	30.5	31.6
Greater than 40	95.7	114.0	81.2

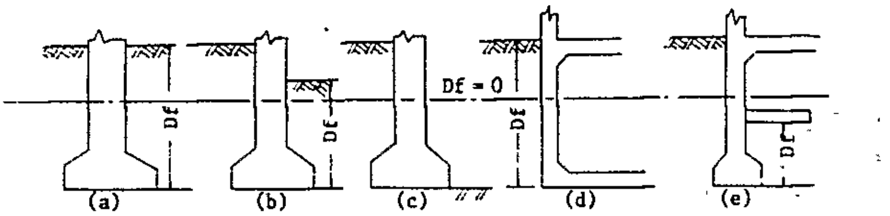


Fig. 3-9 Calculating Embedment Depth

(c) Stability and Support

When the resultant acting on a foundation bottom surface is distributed over the surface, the vertical pressure shall not exceed the allowable bearing force of the ground.

In calculations of stress on foundation bottom surfaces, generally speaking, no tensile stress is assumed to act between the foundation bottom surface and the ground.

When the structure has its foundation in water, its stability shall be calculated after considering the pumping pressure on the foundation bottom surface.

When there is a layer with a small allowable bearing capacity deeper than the foundation bottom surface, the vertical unit pressure distributing the force acting on the foundation surface on the ground surface shall not exceed the allowable bearing capacity of the stratum.

(d) Stability against Overturning of Foundation

In principle, the acting point of the resultant of the load on the foundation bottom surface shall be located on the inner 1/3 of the bottom surface width when the structure has soil as a foundation.

The acting point shall be located on the inner 1/4 when the foundation is a bedrock, or a similar firm foundation.

The following safety factor shall be met with respect to the overturning of a foundation.

The resistance moment against overturning shall usually be a value above that found by multiplying the overturning moment caused by an external force by the following safety factor.

When earth resistance and other factors can definately be expected in front of the embedment section, these factors may be included in the calculations.

	Safety Factor
Normal Time	3.0
Normal time + temporary time	2.0
Normal time + flood time	1.5

The rotation center in overturning is the footing front end in a direct foundation. In Figure 3.10, the resistance moment M_r and overturn moment M_o can be expressed by the formulas shown below when the partial forces of earth pressure are assumed to be P_V and P_H' the structure weight, W, and resistance earth pressure, P_P.

$$M_r = W \cdot a + P_V \cdot b + P_P \cdot C$$

$$M_o = Ph \cdot d$$

Therefore, when the safety factor is Fa, the following formula shall be satisfied:

$$M_r \geqq F_a \cdot M_o$$

(e) Stability against Foundation Sliding

(i) The force resisting sliding on the bearing and foundation bottom surface, etc. shall exceed the value calculated by multiplying the externally generated force causing sliding by the safety factor shown below.

Approach to virtual rear surfaces in stability calculations.

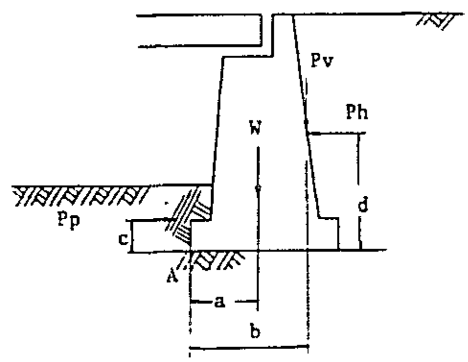


Fig. 3-10

	Safety Factor
Normal time	2.0
Normal time + temporary time	1.5
Normal time + flood time	1.2

(ii) The frictional resistance force shall be calculated by the formula given below:

$$R_f = P_n \times \tan\phi' \quad \ldots\ldots\ldots\ldots\ldots \quad (1)$$

where R_f: frictional resistance force (t)
P_n: force acting vertically on sliding surface (t)
p': frictional angle of sliding surface which as shown in following table

Table 3-20

	Value of tan ϕ'	
Friction Force	Concreting at Site	Non-Concreting at Site
Earth and Concrete	tan ϕ	tan (2/3 ϕ)
Rocks and Concrete	0.6 – 1.0	—

where ϕ: Internal friction angle of soil

(iii) The resistance force for with cohesive soil shall be calculated by the formula given below:

$$R_f = C'A = \frac{qu}{Z} \cdot A \quad \dots\dots\dots \quad (2)$$

where C': shearing resistance force of cohesive soil (t/m^2)
qu: uniaxial compression strength of cohesive soil (t/m^2)
A: foundation effective bottom area (m^2)

When boulders, debris, or other material is palced, the smaller value between Formulas (1) and (2) shall be used.

TS 3.08 Detailed Design of Abutments and Piers

Abutments and piers shall be designed in accordance with the following requirements:

(1) General
When designing a bridge to be built over a river, the positions and shapes of the abutments and piers shall be decided so as to minimize resistance to current and corrosion of the foundations taking into consideration the direction, flow speed, etc. during a flood.

(2) Abutments

(a) Design Policy
The type and construction of abutments shall be selected appropriately to suit the situation at the site as regards safety and the purpose of the abutment.

(b) Study of Ground
In addition to the load affected the foundation of abutments, consideration shall be given to possible breakdown and displacement of the ground due to the load of rear embankment.

(c) Foundation Embedment Depth
In addition to foundation stability, the embedment depth for abutment foundations shall be decided after considering the following items:
(i) Lowering and scouring of riverbed
(ii) Effects of meteorological variations
(iii) Effects on existing structures
(iv) Workability and economy

(d) Draining Work

Each abutment shall have an appropriate system to drain water from earth on the rear surface. Where it would be impractical to provide drainage system, the effects of the water pressure shall be taken into consideration.

(e) Cross Sectional Direction to be Studied

(i) When designing abutments, stability in the cross sectional direction and memebr strength shall be studied as necessary.

o Roadway Direction
Study regarding the vertical load and horizontal load, which acts towards the front of the abutment (Fig. 3-11 (a)).
Study regarding the vertical load and horizontal load which acts towards the rear of the abutment (Figure 3-11 (b)).

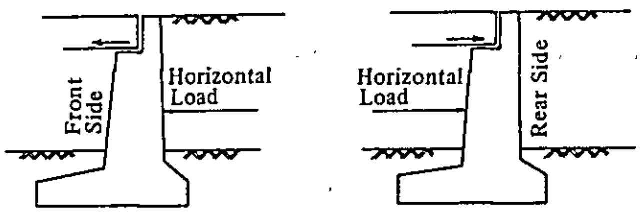


Fig. 3-11

(ii) Direction Perpendicular to Roadway
When the load is asymmetric and as directed by the Engineer, a study of the vertical load and horizontal load, perpendicular to the roadway, shall be made.

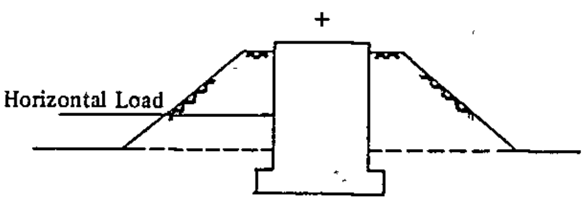


Fig. 3-12

(iii) When necessary, a study for other cross sectional directions shall be made in addition to the one shown above regarding special cases such as diagonal abutments.

(f) **Load**

The following loads shall be used in calculating abutment body unit stress and stability.

(i) Handling of load
TS 3.04 (3) (d) shall apply in ordinary cases.

(ii) The train load shall be strudied for that load layout which is most dangerous to the abutment unit stress or stability after combining with the braking load acting on the abutment, or the horizontal component of the traction load.

(iii) The longitudinal load acting on beams shall be considered to act horizontally on the lower surface of the shoe. The horizontal loads acting in the direction perpendicular to the roadway shall be considered to act on the respective points.

(iv) TS 3.03 (4) (j) shall apply regarding the amount of the horizontal load in a bridge axial direction acting on a fixed, or movable, support.

(g) **Earth Pressure Acting on an Abutment**

(i) The earth pressure acting on an ordinary abutment shall be taken to be Coulomb's earth pressure.

(h) Design of Bearing Surface

Bearing surface shall be designed in accordance with 3.08 (4).
Structural detailes of bearing surface shall conform to 3.08 (b).

(i) Structural Details

The following are abutment structural details:

(i) The dimensions of the top of the abutment body shall be decided in accordance with the type and span of superstructure. In this instance, appropriate dimensions shall be selected after considering beam erection and exchange, repairs of bodies, and other factors.
Abutments installed on soft ground often slide and deform due to consolidation and deformation of the soft ground by the rear embankment, and an expansion of the bearing surface, installation of jack bases for raising the beam, and other means shall be considered.

(ii) The body top surfaces shall be suitably sloped to facilitate draining of water. Care shall be exercised for draining of water near the anchor bolts of shoes also requires attention.

(iii) When the possible collision of a load with the abutment has to be considered, an appropriate protection system shall be taken into account to prevent damage to concrete caused by the collision.

(iv) Skew abutments shall be provided with tie holders to maintain the tie laying pattern (Fig. 3–13).
When widths of abutment bodies are large, additional bars shall be installed horizontally near the exposed surfaces to prevent temperature variations and cracking by drying shinkage.

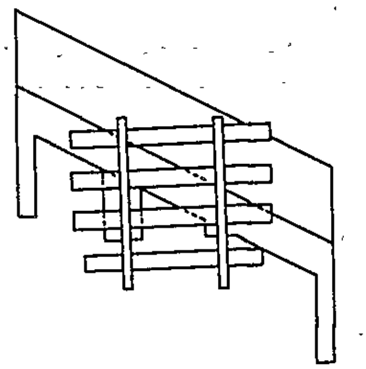


Fig. 3-13 Tie Holder

(3) **Pier**

(a) Handling of Load

(i) TS 3.04 (3) (d) shall apply in ordinary instances.

(ii) Method for Longitudinal Load

- o Longitudinal loads acting on girders and beams such as braking and traction loads can be considered to act horizontally on the lower surfaces of the shoes.
- o The magnitude of the horizontal force acting on a fixed, or movable, bearing shall be in accordance with TS 3.03 (4) (j).

(iii) Others
When there are possibilities of floating logs colliding with Piers, the collision load of floating logs shall also be considered in addition to current pressure. The load shall be determined by the Engineer.

(d) Design Calculations
(i) Piers shall be calculated in accordance with respectives structual type and load condition.
(ii) Buckling shall be studied for Piers whose cross sections are relatively small in to the heights.

(c) Cross Section Calculations

For plain concrete:

$$\sigma c = \frac{N}{A} \pm \frac{N \cdot e}{W}$$

where
- σc: edge unit stress of concrete cross section (kg/cm^2)
- N: axial force (kg)
- A: gross concrete cross sectional area (cm^2)
- e: distance from centroid aixis on concrete cross section (cm) to acting point of N (cm)
- W: cross sectional coefficient of concrete cross section relative to centroid axis (cm^3)

In determination of a cross section, or in calculations of unit stresses, the tensile stress of concrete is usually disregarded, and longitudinal strain shall be considered to vary in proportion to the distance from the neutral axis of the cross section.
Acting points of axial loads shall usually fall inside 1/2 the distance from the centroid of the gross cross section to the compression edge.
The concrete tensile stress may be taken into consideration in the design, instead of compliance with the requirements, as especially approved by the Engineer.

For reinforced concrete:

$$\sigma c = \frac{N}{Ai} \pm \frac{N \cdot e}{Wi}$$

where
- σc: edge unit stress of concrete cross section (kg/cm^2)
- N: axial force (kg)
- Ai: reduced cross section area AC + 15 As (cm^2)
- e: distance from centroid axis of the reduced cross section to acting point of N (cm)
- Wi: cross sectional coefficeint relative to centroid axis of reduced cross section (cm^3)
- As: total cross section area of axial reinforcement bars (cm^2)
- Ac: gross concrete cross section area (axial bar cross sectional areas are not decreased) (cm^2)

When the tensile stress on a cross section meets the following conditions as a result of calculations in accordance with the foregoing equation, the concrete compressive unit stress may be calculated taking the gross cross section as being effective.

o When the body is bent in the main shaft direction of a cross section and when the absolute value of the edge tensile unit stress caused on one side of a cross section is less than 1/4 of the edge compression unit stress that takes place in the cross section at the same time.

o When the absolute value of the tensile unit stress caused at a corner of a cross section bent in two perpendicular directions is less than 0.35 times the compression unit stress that takes place at the same time at the corner on the opposite side of the cross section

When the tensile stress on a cross section does not meet the foregoing conditions as a result of calculations by the equation shown above, calculations shall be made disregarding the concrete tensile stress in accordance with TS 3.04 (1) (b) (v).

(d) Structural Details

(i) The dimensions of the top surface of a pier body shall be determined in accordance with the type and span of the superstructure. The dimensions shall be appropriate dimensions taking girder and beam erection and exchange, repair of the bodies, and other factors into consideration.

(ii) Bearing surface shall be reinforced sufficiently in accordance with TS 3.08.

(iii) The top surfaces of the bodies shall be sloped to facilitate draining of water. Care shall be exercised for draining of water near the anchor bolts of bearing surface.

(iv) When there is a possibility of floating logs, rocks, etc. collinding with the piers, suitable protection shall be considered to protect the piers against damage to the concrete.

(4) Bearing Surface

(a) Handling of load
When designing bearing surface, the following combination loads shall be used:

Combination Load	Coefficient to be multiplied standard allowable unit stress
Dead load + train load + (impact) + centrifugal load	1.0
Dead load + train load + (impact) + braking, or traction load	1.15

The horizontal load to be used in designing bearing surface shall act on the upper surface of the shoes.

(b) Shearing Unit Stress in Bearing Surface

(i) When calculations for reinforcement bars bearing surface are not made, in bearing surface calculated by the equation below the shearing unit stress shall be less than the value of τa_1 given in Table 3-23.

$$\tau = \frac{H}{Ar}$$

$$Ar = \sqrt{2}x\,(2x + 2a + b)$$

where x: shearing unt stress (kg/m^2)
Ax: area of shearing break surface caused by horizontal force (cm^2)
H: horizontal force acting on shoe (kg)
x, a, b: See Fig. 3–17

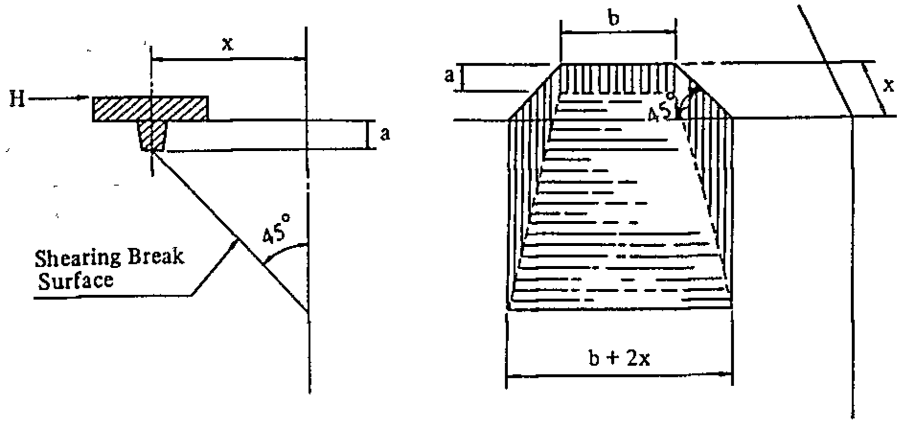


Fig. 3-17

Table 3-23 Allowable shearing Unit Stress

(kg/cm^2)

	design strength σ_{28} 180	design strength σ_{28} 210
When not calculating for bars τa_1	2.0	2.1
When calculating for bars τa_2	7	

The shearing unit stress shall not exceed the value of τa_2 given in Table 3-23 even when calculations for reinforcing bars are made in accordance with the following:

(ii) **Calculation of Reinforcing Bar Quantity**

- o When the shearing unit stress is less than the allowable shearing unit stress shown in Table 3-23, the minimum bar quantity shown in the structual detailes shall be used aside from reinforcing bars for the vertical load calculated in this paragraph.

- o When the shearing unit stress exceeds the values shown in Table 3-23, the equation shown below shall be used to calculate the reinforcing bar quantity:

$$As = \frac{H}{\sigma sa}$$

where
As: reinforcing bar quantity (cm^2)
H: horizontal force acting on shoes (kg)
σsa: standard allowable tensile unit stress of reinforcing bars (kg/cm^2)

- o Reinforcing bars for bearing pressure caused by a vertical load shall be calculated in accordance with the equation given below and shall be placed within the range shown in Figure 3-18, placing densely in the upper section and less densely in the lower section.

$$As = \frac{1}{4}\left(1 - \frac{b_1}{b_c}\right)\frac{P}{\sigma sa}$$

where
As: reinforcing bar quantity (cm^2)
σsa: allowable tensile unit stress of reinforcing bar (kg/cm^2)
P: bearing pressure (kg)
b_1: acting width of bearing pressure (cm)
b_c: distribution width of bearing pressure (cm)

$$b_c = 2b_2 \leqq 5b_1$$

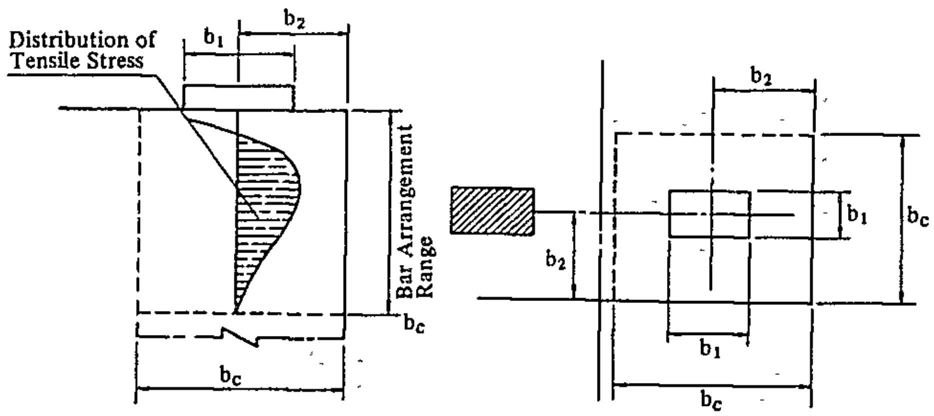


Fig. 3-18 Reinforcing Bars for Bearing Pressure

(c) Structrual Details

(i) Arrangement of Reinforcing Bars in Bearing Surface

Reinforcing bars for the horizontal shearing force acting on a bearing surface shall be placed in the area shown in Fig. 3-19 and shall be sufficiently extended outside the area. The bars shall then be fixed.

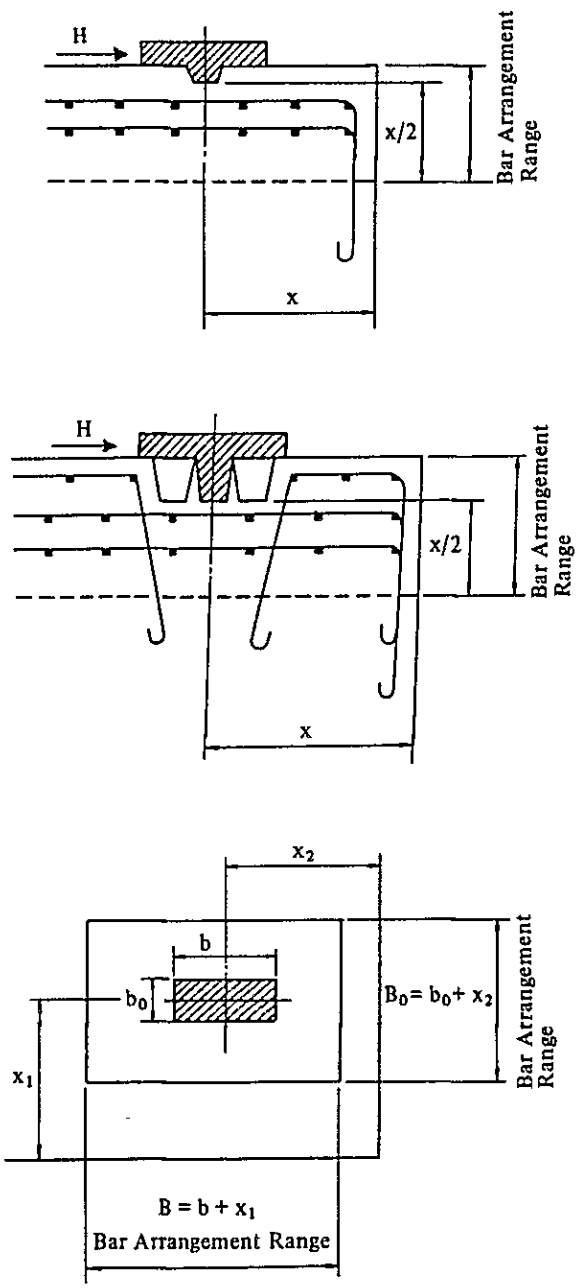


Fig. 3-19 Reinforcing Bar Araangement for Bearing Surface

(ii) Reinforcing bars greater than #4 shall be arranged on bearing surface to stand a hrizontal shearing force in a bridge axis direction and horizontal shearing force in a bridge axis driection and horizontally at spacings below 20 cm.

(iii) Reinforcing bars for a horizontal shearing force and those for a bearing force on a bearing surface shall be chosen taking the main reinforcements in the substructure of a bearing surface into consideration.

(iv) Bearing Sruface Dimensions

Calculations of reinformements are not requred for a horizontal shearing force when the dimensions of the bearing surface are normally below the values shown here. (See Fig. 3-20 and 3-21)

For plate girder

When ℓ < 25 m	a = 20 cm
When 25 m < ℓ	a = 25 cm
For a truss	a = 30 cm

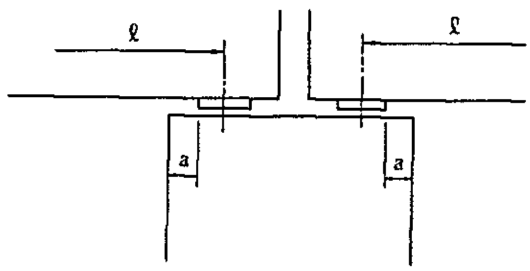


Fig. 3-20 Dimensions of a

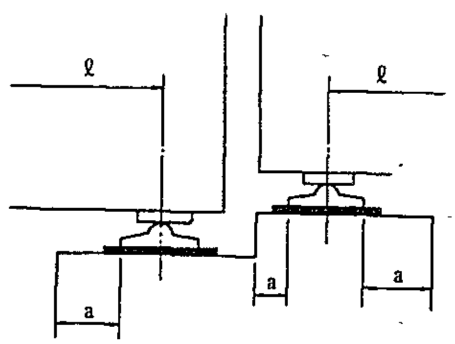


Fig. 3-21 Dimensions of a

(v) In a skew bridge, the value of x' shall be used as x shown in (b) (i) when the shoe is arranged as shown in Fig. 3-22 relative to the bearing surface.

The minimum distance in the bridge axis direction from the shoe edge to bearing surface edge shall usually be greater than 15 cm.

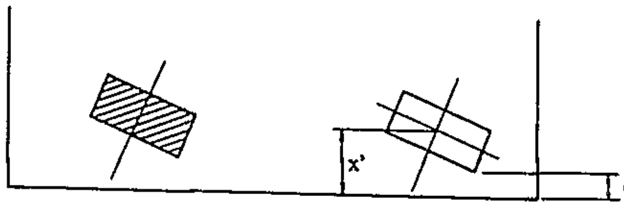


Fig. 3-22 Shoe Layout in Skew Bridge

The distance b in a direction perpendicular to the bridge axis from the shoe edge to bearing surface edge shall be greater than the value selected for skew bridge types. (See Fig. 3-23)

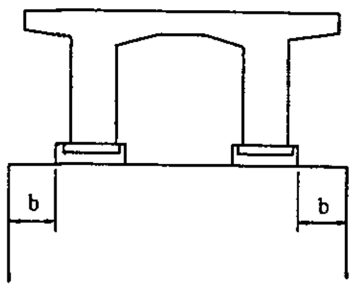


Fig. 3-23 Dimension of b

TS 3.09 Detailed Design of Steel Girders and Beams

In detailed design of steel girders and beams, the following items shall be met.

(1) Loads

(a) Types of Loads
The loads shown in Table 3-24 shall be considered in designing steel beams.

Table 3-24

		Types of Loads	Symbols	
1 2 3 4	Principal Loads	Dead Load Train Load Impact Centrifugal Load	P	D L I C
5 6	Secondary Loads	Braking Load and Traction Load Wind Load	B W	
7 8	Other Loads	Effect of Temperature Change Load in Erection and Other Loads	T ER	

(b) Dead Load
Refer to TS 3.03.

(c) Train Load
Refer to TS 3.03.

(d) Loading Method of Train Load
Refer to TS 3.03.

(e) Impact Load
Refer to TS 3.03.

(f) Centrifugal Load
Refer to TS 3.03.

(g) Braking Load and Traction Load
Refer to TS 3.03.

(h) Wind Load
Refer to TS 3.03.

(i) Temperature Change

(i) In regard to statically indeterminate structures, a temprature rise of 40°C and fall of 40°C of the whole structure shall be taken into account in the design as a standard. However, it is left to the Engineer's discretion.

(ii) With respect to structures exposed directly to the sun, a temperature difference of 15°C shall be considered between the upper and lower chord members of a truss of between the upper and lower flanges of a plate girder. But this provision may not be applied to structures where the stresses due to the effect mentioned in (i).

(iii) The coefficient of linear expansion of steel shall be 0.000012 per centigrade degree.

(j) Load in Erection and Other Loads

(i) Stress in all component parts of a bridge shall be checked by taking into consideration the method of erection, weight during the erection, etc. Care must be exercised with regard not only to the stresses during the erection but also to the residual stresses which may remian after erection, if necessary.

(ii) When cable, poles, refuge, equipment parts, water tank, etc. are to be mounted on a bridge, their weight and various loads working to them shall be taken into consideration in the design of structural members of the bridge.

(iii) In case displacement of supports is anticipated, which may exert influence on the stress of the structure, it shall be taken into consideration in the design.

(2) Allowable Unit Stresses

(a) Allowable Unit Stress

(i) The design stresses in the bridge members resulting from principal loads or one of secondary loads shall not exceed the allowable unit stress specified below.

(ii) Combinations of principal loads, secondary loads and other loads shall in principle be as listed in Table 3-25. The allowable unit stresses in these cases shall be obtained by multiplying the allowable unit stresses prescribed below by the coefficients shown in this Table 3-25.

Table 3-25

	Load Combinations	Multiplying Coefficients
1	P + T	1.15
2	P + B	1.25
3	P + W	1.25
4	P + B + W	1.40
5	W + B	1.25
6	ER	1.30

(b) Allowable Unit Stress for Structural Base Metal and Weld Metal

(i) Basic Allowable Unit Stresss

The basic allowable unit stresses for structural steel and welded parts shall be as shown in Table 3-26.

Table 3-26

(unit: kg/cm²)

<table>
<tr><th colspan="3">Kinds of Stresses</th><th>Types of Steel</th><th colspan="2">S41
SM41 &
SMA41</th><th></th></tr>
<tr><td rowspan="6">Structual steel</td><td colspan="2" rowspan="2">Tensile Stress
(Net Section)</td><td>Axial Tension</td><td colspan="2" rowspan="4">1400</td><td rowspan="4">(1)</td></tr>
<tr><td>Tension due to Bending</td></tr>
<tr><td colspan="2" rowspan="2">Compresive Stress
(Gross Section)</td><td>Axial Compression</td></tr>
<tr><td>Compression due to Bending</td></tr>
<tr><td colspan="2">Shearing Stress</td><td>About Gross Section</td><td colspan="2">800</td><td>(2)</td></tr>
<tr><td colspan="2">Bearing Stress</td><td>Between Steel Plates</td><td colspan="2">2100</td><td>(3)</td></tr>
<tr><td rowspan="10">Welded Parts</td><td rowspan="5">Groove Weld</td><td rowspan="2">Radiographic Inspection is Conducted</td><td>Tensile Stress</td><td colspan="2" rowspan="2">1400</td><td rowspan="2">(4)</td></tr>
<tr><td>Compressive Stress</td></tr>
<tr><td rowspan="2">No Raiographic Inspection is Conducted</td><td>Tensile stress</td><td colspan="2">1120</td><td>(5)</td></tr>
<tr><td>Compressive Stress</td><td colspan="2">1260</td><td>(6)</td></tr>
<tr><td>For Either of the above Cases</td><td>Shearing Stress</td><td colspan="2">800</td><td>(7)</td></tr>
<tr><td colspan="2" rowspan="2">Fillet Weld</td><td>Tensile and Compressive Stress in Welded Direction</td><td colspan="2">1400</td><td>(8)</td></tr>
<tr><td>Tensile, Compressive and Shearing Stress about Throat of Fillet Weld</td><td colspan="2">800</td><td>(9)</td></tr>
<tr><td colspan="2" rowspan="3">Field Weld</td><td>Tensile Stress</td><td rowspan="3">Multiply the above by the factors on the right column in their Respective cases</td><td>0.8</td><td>(10)</td></tr>
<tr><td>Compressive Stress</td><td>0.9</td><td>(11)</td></tr>
<tr><td>Searing Stress</td><td>0.9</td><td>(12)</td></tr>
</table>

Note:
1) The criteria for acceptance in radiographic inspetction shall be in principle higher than Class 2 of JIS Z 3104–1968 for tensile joints and it shall be higher than Class 3 for compressive joints.
2) The net section of a steel piece of (1) shall be the gross section minus the area to be lost due to bolt holes.
3) In the cases of (10) and (11), for the tension and compression in the direction of weld, the factor for multiplication shall be 1.0.

(ii) **Allowable Unit Buckings Stresses**

The allowable unit buckling stress of bridge members shall be as specified by Table 3-27.

Table 3-27

(Unit: kg/cm^2)

Kind of Stress \ Types of Steel		SS41, SM41, and SMA41	
Compressive Stresses	Axial Stresses	1250 at $0 < l/r \leqq 28$	①
		$1250\text{-}8.0\ (l/r\text{-}28)$ at $28 < l/r \leqq 130$	
		$7400000\ (r/l)^2$ at $130 < l/r$	
	Bending Stress	(1) As to bending about the strong axis, an equivalent ratio $(l/r)_e$ which is expressed by the following formulas, shall be used instead of l/r ① . $(l/r)_e = F \dfrac{l}{b}$ where $F = \sqrt{12} + 2\beta/\alpha$ in the case of I-shaped cross section. $F = 1.3\sqrt{3\alpha+\beta}\ \sqrt{b/l}$ for $\alpha \geqq 2$ $F = 1.3\sqrt{6+\beta}\ \sqrt{b/l}$ for $\alpha < 2$ in the case of box cross section.	②
		(2) As to bending about the weak axis. 1250	③

Note:

1) l in ① is the buckling length of the member (cm) and r is the radius (cm) of gyration of the gross section about the axis concerned. See Table 3-28 for determination of l.

2) l in ② is the distance (cm) between the fixed points of the flange, b is the width (cm) of the flange of I-section girder or the distance between the centers of the web plates of box-section girder, α is the ratio of the thickness (tf) of the flange to the thickness (tw) of the web plate, (tf/tw) and β is the ratio of the height (h) of the web plate to b, (h/b).

Table 3-28

Kind of Members	l
Chord Memebrs of Truss	Length in the skeleton
Web Memebrs of Truss (for the buckling out of the plane of the truss)	Length in the skeleton
Web Members of Truss (For the buckling in the plane of the truss)	0.9 times the length in the skeleton
Lateral Bracing Memebrs and Sway Bracing Memebers	Length in the skeleton

(c) **Basic Allowable Unit Stresses**

The basic allowable unit stresses for bolts and pins shall be as shown in Tables 3-29 and 3.30 respectively.

Table 3-29

(Unit: kg/cm^2)

Kinds of Stress \ Bolts	High-Strengh Bolts		Ordinary Bolts
	F10T	F11T	4T
Shearing Stress	1250	1300	900
Bearing Stress	–		1900

Note: No checking is required for the bearing stress of high-strength bolts.

Tabe 3-30

(Unit: kg/cm^2)

Kinds of Stress \ Type of Steel	SS41 and SM41
Bending Stress	1900
Shearing Stress	1000
Bearing Stress	1600
Pin Hole Bearing Stress	1600

(d) Bearing

(i) **Allowable Unit Stresses for Steel Bearing**
The allowable unit stresses for steel bearing shall be as given by the following expressions.
In this case, the values of K_1 and K_2 are as given in Table 3-21 and the way of selecting r_1 and r_2, is as shown in Fig. 3-24.

- Line Bearing $K_1 \left(\frac{r_1 \cdot r_2}{r_1 - r_2} \right)$ kg/cm
- Roller Bearing $0.8\ K_1 r_2$ kg/cm
- Spherical Bearing $K_2 \left(\frac{r_1 \cdot r_2}{r_1 - r_2} \right)^2$ kg

Table 3-31

Coefficients \ Combination of Materials	SS41 and SC46
K_1	100
K_2	0.8

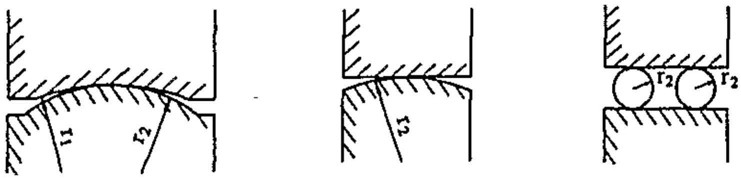


Fig. 3-24

where r_1: concave radius (cm)
r_2: convex radius (cm)

(ii) In case cast steel is used for the bearing part, the allowable unit stresses shall be as specified in Table 3-32.

Table 3-23

Kinds Stress \ Cast Steel	SC46 and SCW42
Tensile Fiber Stress	1100
Compressive Fiber Stress	1250
Shearing Stress	800

(iii) Allowable Unit Stresses for Cast Iron Bearing
The allowable unit bearing stresses for cast iron bearings shall be as given by the expression below.
In this case the value of K is as given by Table 3-33 and the manner of selecting r_1 and r_2, is as shown in Fig. 3-24 of (1).

For linear bearing $K\left(\frac{r_1 \cdot r_2}{r_1 - r_2}\right)$ kg/cm

Table 3-33

Coefficeint \ Combination of Materials	SS41 and FC15	SS41 and FC25
K	70	150

(iv) The allowable unit stresses when cast iron is used for the bearing part, shall be as specified in Table 3-34.

Table 3-24

(Unit: kg/cm²)

Kinds of Stress \ Cast Iron	FC15	FC25
Tensile Fiber Stress	400	600
Compressive Fiber Stress	800	1200
Shearing Stress	300	450

(v) Allowable Unit Stress for Copper Alloy Bearing Plate
The allowable unit bearing stress for copper alloy bearing plate shall be 300 kg/cm².

(vi) Allowable Unit Bearing Stress for Concrete
The allowable unit bearing stress for concrete at a bearing part such as shoe shall be in principle 40 kg/cm². It may be increased at the discretion of the Engineer.

(3) General Provisions for Design

(a) Elastic Constants of Steel
Elastic constants of steel shall be as given in Table 3-35.

Table 3-35

Young's Modulus E	2,100,000 kg/cm²
Shear Modulus G	810,000 kg/cm²
Poisson's Ratio ν	0.3

(b) Width of Bridge
The width of bridge shall be usually larger than 1/20 of its span.

(c) **Deflection of Bridge**

Deflection of main girder, floor beam and the difference in deflection at the position of right and left rails shall be as specified by the following paragraphs. In this case, the train load shall be that specified in TS 3.03 (c), and no impact shall be taken into account.

(i) As much efforts as possible shall be made to keep the deflection of the main girder within the value given in Table 3-36 except in special cases. When some appropriate measures and as cambering the track are taken to offset the deflection, the values in (3) (b) may be exceeded to some extent.

Table 3-36

Types of Bridge	Deflection Due to Train Load
Plate Girder Truss	L/800 L/1,000

Note: L is the span length.

(ii) The deflection of the floor beam at the points of connection with the stringers shall be in principle less than 4 mm for the end floor beams and less than 5 mm for the intermediate floor beams.

(iii) The difference between the deflections of the right and left rails at the end of a skew bridge shall not in principle exceed 3 mm. (See Fig. 3-25)

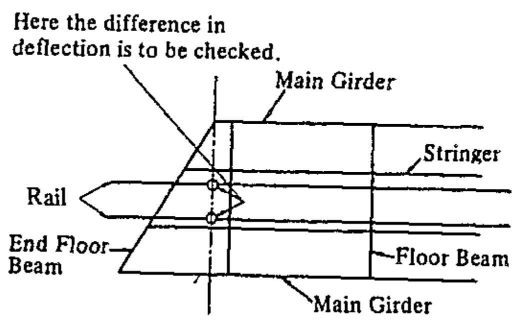


Fig. 3-25

(d) Checking of Overturn of Bridge

(i) A bridge shall be stable enough to resist overturn when it is subjected either to a force 1.3 times as large as the centrifugal load specified in TS 3.03 and a force 1.3 times as large as the wind load.

(ii) With regard to the effects of wind, vertification of calculation shall be conducted for both cases in which the train load specified in TS 3.03 (4) (c) is taken into account and in which the bridge is not loaded with train.

(e) Slenderness Ratio of Structural Members

The Slenderness ratio l/r of structural members shall not exceed the values given in Table 3-37.

Table 3-37

Kind of Memebrs	Slenderness Ratio
Main Compressive Members	100
Secondary Compressive Members	120
Tensile Members	200

(f) Secondary Stresses

Various parts of the structure shall be designed with care concerning the secondary stresses due to the folloiwng causes.

(1) Eccentricity of members.
(2) Rigidity of panel point.
(3) Deflection of floor beam.
(4) Deformation of floor system due to change in length of chord members.
(5) Deflection of member due to its own weight.
(6) Friction of movable end bearing s of bridge.
(7) Others.

(g) Composition of Member Cross Section

(i) Cross sectional composition of girders and welded built-up members shall be arranged in such a way that welded parts are positioned as symmetrically as practicable vertically and horizontally.

(ii) Members and their joints shall be designed in such a way as to facilitate the assembly work, welding, and inspection and to minimize concentration of welding and stresses. Furthermore, prevention of shrinkage stress and deformation due to welding shall be taken into consideration.

(iii) A member shall be designed in such a way that the centroid of corss section meets the center of section and lies on the skeleton line as much as possible.

(h) **Thickness of Steel**

The minimum thickness of steel material shall be as specified below.

(i) With regard to primary memebers, the minimum thickness shall be as a rule 9 mm, but that of orthotropic deck plate shall be 12 mm, while that of buckle plate, 8 mm.

(ii) The minimum thickness fo secondary members shall be as a rule 8 mm, but it shall not apply to fillers, protection plates, etc.

(i) **Minimum Size of Angle Steel Bars**

The minimum length of outstanding legs of angle steel bars to be used for lateral bracing, brake truss and sway bracing shall be 75 mm.

(j) **Camber**

A bridge with a span of more than 30 m shall be provided with a camber. The camber shall be of such an amount as to offset the deflection of the main girder or truss due to a uniform load equal to 1/3 the uniform load of cooper E45 and the dead load placed on the entire length of the main span.

(4) **Effective Sectional Area**

(a) **Bolt Hole**

(i) The diameter of a bolt hole in the calculation of net sectional area of a structural member shall be 3 mm larger than its norminal diameter.

(ii) With respect to a hight strength boult (friction type), the area to be deducted shall be determined by consultation with the Engineer.

(b) **Calculation of Net Sectional Area**

(i) The net sectional area of a tensil memebr shall be the product of the net width of plate and its thickness. The net width of a component piece shall be obtained by deducting the widths of bolt holes from the gross width.

(ii) The net width of the component piece at any cross section passing bolt holes in chain one by one shall be obtained by deducting from the gross width the width of "w" given by th following formula progressively for each of the bolt holes on the section.

$$w = d - \frac{p^2}{4g} \quad (mm)$$

where d : the diameter of bolt hole (bolt diameter plus 3 mm).
p : the bolt pitch (mm).
g : the gauge between bolt lines (mm).

(iii) With regard to members of T-shaped, crusiform and square built-up sections, calculation by the methods in (i) and (ii) shall be performed for each of the pieces composing the sectional shape.

(iv) With respect to an angle steel bar, as illustrated in Fig. 3-26, the entire developed width shall be taken as the sum of widths of the two legs minus the thickness. The gauge "g" between the bolt lines on the two legs shall be taken as the sum of lengths from the backs to the bolt lines minus the thickness.

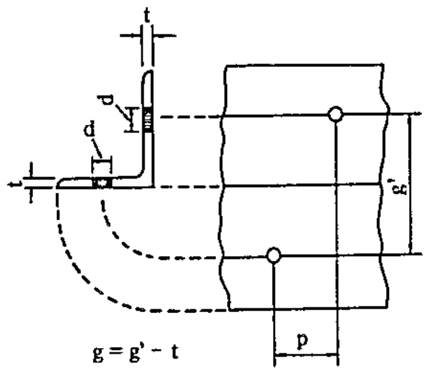


Fig. 3-26

(c) Effective Sectional Area of Tension Angle Members Eccentrically Connected
In case a tension member consisting of one or two angle steel bars is connected in such a way that a bending moment is caused to the member due to eccentricity, as shown in Fig. 3-27, the net sectional area of the leg connected with the gusset plate plus half the gross sectional area of the other leg shall be considered as effective.

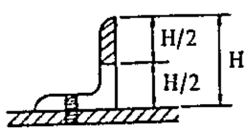


Fig. 3-27

(d) Effective Sectional Area of Compression Members
The effective sectional area of a compression member shall be equal to its gross sectional area, provided that ordinary bolt holes and pin holes shall be deducted from the gross sectional area.

(e) **Effective Sectional Area When Deflection and Statically Indeterminate Force are to be Calculated**

The effective sectional area when deflection and statically indeterminate force are to be calculated shall be equal to the gross sectional area.

(5) **Calcualtion for Design of Memebers and Connection**

(a) **Bending Stress in Members**

The stress due to bending moment of plate girders and similar structures shall be calculated in accordance with the following provisions.

(i) Stress due to bending moment

$$\sigma = \frac{M}{I} \cdot y$$

where σ: the unit bending stress (kg/cm^2).

M: the bending moment (kg.cm) (Same in (ii)).

I: the momne of inertia (cm^4) of the gross section about the neutral axis of the gross section of the plate girder (Same in (ii)).

y: the distance (cm) from the neutral axis of the gross section of the plate girder to the position where the stress is to be calculated.

(ii) Extreme fibrer stress due to bending moment

$$\sigma c = \frac{M}{I} \cdot yc, \quad \sigma t = \frac{M}{I} \cdot yt \cdot \frac{Afg}{Afn}$$

where σc: the unit bending compressive extrème fiber stress (kg/cm^2).

σt: the unit bending tensile extreme fiber stress (kg/cm^2).

yc: the distance from the neutral axis of the gross section of the girder to the extreme fiber of the compresive flange.

yt: the distance from the neutral axis of the gross section of the girder to the extreme fiber of the tensile fange.

Afg: the gross sectional area (cm^2) of the tensile flange.

Afn: the net sectional area (m^2) of the tensile flange.

(b) **Checking of Calculation of Members Subjected to Both Axial Force and Bending Moment**

A member subjected simultaneously to a force in the axial direction and a bending moment shall separately conform to respective requirements of 2 (a) and 2 (b) regarding each of them and shall be checked by the following formulas in addition.

(i) When the axial force is tensile:

Regarding stress intensity

$$\frac{P}{An} + \frac{Mx}{Ix} \cdot yt \cdot \frac{Afg}{Afn} \leqq \sigma ta \quad \cdots\cdots\cdots\cdots (1)$$

(ii) When the axial force is compressive:

o Regarding stress intensity

$$\frac{P}{Ag} + \frac{Mx}{Ix} \cdot yt \leqq \sigma ca \quad \ldots\ldots\ldots\ldots\ldots \quad (2)$$

o Regarding the stability of the entire member in the plane of bending

$$\frac{P}{Pcax} + \frac{Mx}{Mxao} \leqq 1.0 \quad \ldots\ldots\ldots\ldots\ldots \quad (3)$$

o Regarding stabiltity of the entire member out of the plane of bending

$$\frac{P}{Pcay} + \frac{Mx}{Mxa} \leqq 1.0 \quad \ldots\ldots\ldots\ldots\ldots \quad (4)$$

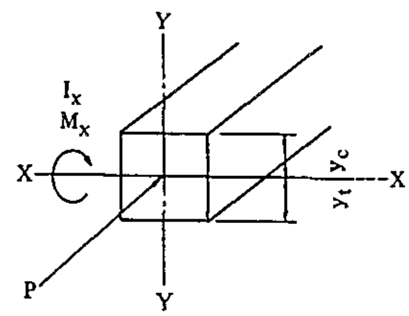


Fig. 3-28 Co-ordinates and Force

where

P: the axial force acting on the member.

Pcax and Pcay: the allowable buckling loads (kg) and X-axis and Y-axis respectively.

Mx: the bending moment (kg-cm) acting about X-axis of the member. In Equations (1) and (2), it is the bending moment at the section to be checked, while in Equations (3) and (4) it is an equivalent moment Mxeq obtained by the following formula when the bending moment varies linerly from Mx_1 at one end to Mx_2 at the other end, and Mx_1 is greater than Mx_2.

$$Mxeq = 0.6\, Mx_1 + 0.4\, Mx_2$$
$$\text{provided } Mxeq \geqq 0.4\, Mx_1$$

Mxao: the allowable bending moment (kg- cm) about X-axis when no lateral buckling out of the plane in which the bending works is taken into consideration.

Mxa: the allowbale bending moment (kg-cm) about X-axis when lateral buckling out of the palne in which the bending works is taken into consideration.

An and Ag: respectively the net sectional area and the gross sectional area (cm^2) of the section to be checked.

Afn and Afg: respectively the net sectional area and the gross sectional area (cm^2) of the flange to be checked.

Ix: the moment of inertia of the gross section about X-axis.

yt and yc: respectively the distance (cm) from the X-axis to the position for stress calculation on the tensile and compressive sides.

σta: the basic allowable unit tensile stress specified by TS 3.09 (2) (b) (when increase according to (2) (a) is included)

σca: the allowable unit compressive stress at $l/r = 0$ as specified in (2) (b) (ii) (when increase according to (2) (a) included).

(c) ***Shearing Stress in Members***

(i) The average unit shearing stress in web plate of a plate girder or a similar structure shall be calculated by the following formula.

$$\tau m = \frac{S}{Aw}$$

where τm : is the aveage unit sheairng stress (kg/cm^2) in the web plate.

S : is the shearing force (kg) acting in the section about which the calculation is to be made.

Aw : is the gross sectional area (cm^2) of the web plate.

(ii) The unit shiearing stress due to a torsional moment of a box girder shall be calculated by the following formula.

$$\tau t = \frac{Mt}{2A \cdot t}$$

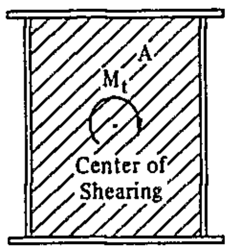


Fig. 3-29

where τt : is the unit shearing stress (kg/cm^2) due to torsional moment.

Mt : is the torsional moment (kg.cm) about the center of shearing.

A : is the area (cm^2) enclosed with center lines of web plates and flange plates. (See Fig. 3-29)

t : is the thickness (cm) of the web plate or the flange plate.

(d) Combined Stress due to Bending Moment and Shearing Force

When a bending moment and a shearing force simultaneously act on a plate girder or a smiliar structure, checking of calculation shall be performed by the formula below.

$$\sqrt{\left(\frac{\sigma}{\sigma a}\right)^2 + \left(\frac{\tau}{\tau a}\right)^2} \leqq 1.1$$

provided that σ and τ shall not exceed σa and τa respectively,

where
- σ is the unit bending stress calculated by (5) (a) (i). (kg/cm^2)
- τ is the unit bearing stress calculated by (5) (c) or (11) (c) (ii). (kg/cm^2)
- σa is (1), (4), (5), (6), (8), (10) and (11) in Table 3-26 (including increase according to (2) (a)).
- τa is (2), (7), (9) and (12) in Table 3-26 (including increase according to (2) (a)).

(e) Stress Calculation for Bolts and Pins

(i) Whene tensile, compressive or shearing force acts on butt joing or lap joint with bolts, the stress caused in each bolt shall be calculated by the formula below.

$$\rho = \frac{P}{N}$$

where
- ρ is the stress (kg) in each bolt.
- P is the force acting on the joint (kg).
- n is the number of bolts used for the joing (See Fig. 3-30).

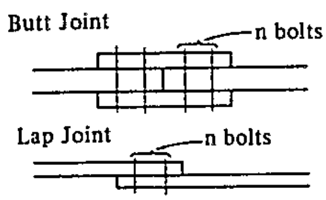


Fig. 3-30 Bolt Joints

(ii) In the case of frictional joint wiht high-strength bolts, the allowable shearing strength per frictional face per bolt is to be obtained by multiplying the sectional area based on the nominal diameter of the bolts by the allowable stress prescribed in (2) (c). No checking is required regarding the bearing stress in this case.

(iii) The effective bearing area in the calculation of bearing strength of a pin shall be the product of its diameter and thickness of the steel material in contact with the pin.

(f) **Welded Joints Subjected to Tensile Force, Compressive Force of Shearing Force**

When tensile force, compressive force or sheaing force acts on welded joint, the stress in groove weld or fillet weld shall be calculated by the following formulas.

$$\sigma = \frac{P}{\Sigma al} \quad \text{and} \quad \tau = \frac{P}{\Sigma al}$$

where
- σ is the unit tensile stress or unit compressive stress taking place in the weld (kg/cm^2).
- τ is the unit shearing stress (kg/cm^2) in the weld.
- P is the force (kg) acting on the joint.
- a is the throat thickness (cm) of weld (Refer to (8) (b)).
- l is the effective length (cm) of weld (Refer ot (8) (c)).

(g) **Checking of Stresses in Filet Weld of T-Joint Subjected to Both Bending Moment and Shearing Force**

When fillet weld of T-joint is subjected to both bending moment and shearing force, the stresses in the fillet weld joint shall be calculated in accordance with the following paragraphs.

(i) The stress due to bending moment tshall be obtained by the fomula.

$$\sigma = \frac{M}{I} \cdot y$$

where
- σ is the unit bending stress in the fillet weld (kg/cm^2).
- M is the bending moment (kg.cm) acting on the joint.
- I is the moment of inertia (cm^4) of the figure obtained by developing the throat section of fillet weld on the plane to which the member is attached as shown in Fig. 3-31.
- y is the distance (cm) from the neutral axis of the developed figure to the point to be checked.

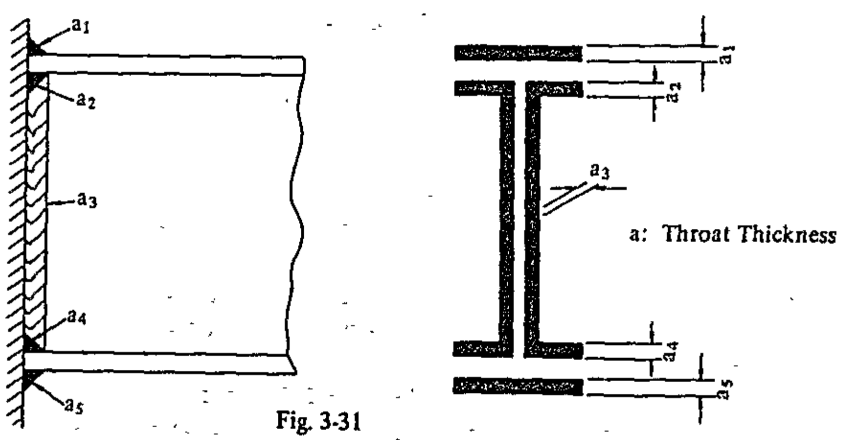


Fig. 3-31

(ii) The unit stress τ due to shearing force shall be obtained by (5) (f), but with respect to I-shaped steel, H-shaped steel, channel steel and other steel members of similar section, the shearing force shall be assumed to the resisted by the weld on the web plate alone.

(iii) When the above member is simultaneously subjected to both bending moment and shearing force, it shall be checked by the following formula.

$$\sqrt{\left(\frac{\sigma}{\sigma a}\right)^2 + \left(\frac{\tau}{\tau a}\right)^2} \leqq 1.1$$

provided that σ and τ shall not exceed σa and τa respectively,

where σ is the unit stress calculated by (i) (kg/cm²).

τ is the unit stress calculated by (ii) (kg/cm²).

σa and τa are the basic allowable unit stress prescribed by (9) and (12) in Table 3-26.

(h) Connection of Members

(i) The connection members with high-strength bolts or by welding shall in principle be designed on the basis of calculated working stress, but with regard to a butt joint with groove weld, the enitre cross section shall be welded.

(ii) In addition to the preceding paragraph, connection for main memebrs shall be designed with due cares to give at least 75% of the member strength based on the basic allowable unit stress for tension members or on the allowable buckling unit stress for compression members. (When the members are subject to both tension and ocmpression, take the allowable unit stress of the same sign as the larger member stress of the two.)

(iii) Connection of members shall be so designed as to minimize the eccentricity in each component comprising the member.

(i) Splice Connection of Web Plates of Plate Girder

(i) In splice connection for web plates of plate girder, splice plates shall be applied to both side of web plate and fastened with two or more rows of high-strength bolts on each side of the joint center.

(ii) Vertical splice connection of web plate shall be checked against the bending moment as well as the combined force due to shearing and bending moment. As a rule in this regard, the stress acting on the high-strength bolt shall be calcualted by the following formulas.

$$R_1 = \frac{Mw}{\Sigma y^2} \cdot yn \leqq \rho a$$

and
$$R_2 = \sqrt{\left(\frac{S}{n}\right)^2 + R_1{}^2} \leqq \rho a$$

where R_1 is the force acting on a high-strength bolt due to bending moment at yn (kg).

R_2 denotes the combined force (kg) acting on a high-strength bolt due to both shearing force and bending moment.

$Mw = M\frac{Iw}{I}$ represents the resiting bending moment of web plate (kg-cm).

M is the resiting bending moment (kg-cm) of the plate girder at the connection.

Iw is the moment of inertia (cm^4) of the gross section of the web plate about the neutral axis of the gross section of the plate girder (cm^4).

I is the moment of inertia (cm^4) of gross section about the netural axis of the gross section of the plate girder (Same in (iii))

Σy^2 is the sum of square of distances from the neutral axis to high-strength bolts on one side of joint center (cm^2).

yn is the distance (cm) from the neutral axis of the gross section of the plate girder to the farthest high-strength bolt on the web plate.

ρa is the allowable strength (kg) obtained by TS 3.09 (5) (e) (ii) based on the basic allowable unit stress of high-strength bolt specified in TS 3.09 (2) (c).

S is the maximum shearing force (kg) at the connection.

n is the total number of high-strength bolts on one side of the joint center of the web.

(iii) The force acting on high-strength bolts used for connecting flange plates or web plates in the direction of bridge axis shall be calculated by the formula below.

$$H = \frac{SQ}{I} \cdot p$$

where H is the force (kg) acting on a high-strength bolt.

S is the shearing force (kg) acting on the section to be calculated.

Q is the statical moment of area (cm^3) of the part of the cross section that lies outside the surface or the line along which the connection is considered, about the neutural axis of the gross section of the plate girder.

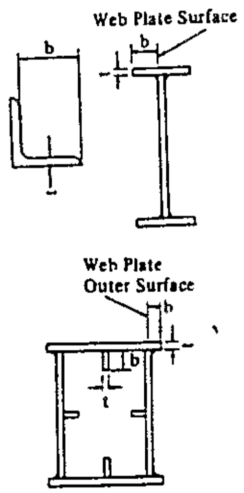
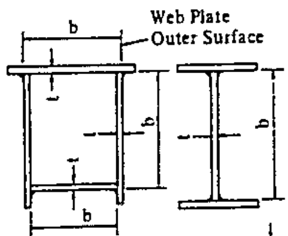
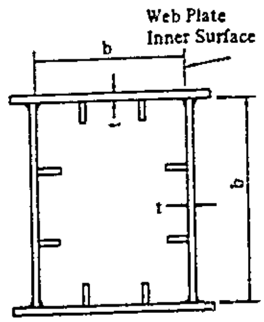
p is the pitch between the high-strength bolts (cm).

(6) **Width-to-Thickness Ratio of Plate Element and Stiffeners**

(a) **Plate Element Subject to Compression in Axial Direction of Members**

(i) The minimum thickness of plate subject to compression in the axial direction of the member shall conform to the values given in Table 3-28.

Table 3-38

Condition of Plate Edge	Simply supported along one edge	Simply supported along two pooriste edges	The same as 2 , but provided with n longitudinal stif- in equal disances
Maximum width-to-thickness Ratio of plate (b/t)	$\frac{450}{\sqrt{\sigma}}$ but less than 16	$\frac{1\,400}{\sqrt{\sigma}}$ but less than 50	$\frac{1\,400}{\sqrt{\sigma}} \cdot n$ but less than 59 n
Example			
	①	②	③

σ: is the maximum compressive working unit stress (kg/cm^2). In combined loading where increase of allowable unit stress is permitted as specified in (2) (a), it shall be divided by the "multiplying coefficient" shown in Table 3-26.

t: plate thickness (cm) (Same as in (ii)).

n: number of panels divided by stiffeners (Same as in (ii)).

b: plate width (cm (See examples in Table 3-38).

(ii) In the case of plate supported along both edges and provided with (n−1) stiffeners at n equal spacings (See ③ in Table 3-28), the geometrical moment of inertia (I) of each stiffener shall be larger than the value calculated by the formula below.

$$I = \frac{5}{11} bt^3 \gamma$$

where b: is the width (cm) of the plate as shown in ③ in Table 3-28.

γ: is the rigidity ratio calculated by the following formulas.

In the above case, the maximum width-thickness ratio shall be in conformity with the value in ① in Table 3-28. In case stiffeners of special shape are used, the above rule shall not apply.

In case

$$\frac{(b/t)s}{(b/t)_0} > \sqrt{\frac{1+\alpha^2}{2(1+n\delta)}}$$

$$\gamma = \frac{4}{n}\left[\left\{\frac{(b/t)s}{(b/t)_0}\right\}^2 (1+n\cdot\delta)\cdot\alpha^2 - \frac{(1+\alpha^2)^2}{4}\right]$$

In case

$$\frac{(b/t)s}{(b/t)_0} \leqq \sqrt{\frac{1+\alpha^2}{2(1+n\delta)}}$$

$$\gamma = \frac{4}{n}\left[\left\{\frac{(b/t)s}{(b/t)_0}\right\}^2 (1+n\cdot\delta) - 0.5\right]^2$$

where

(b/t)s: width-to-chickness ratio used in the design.

$(b/t)_0$: maximum width-to-thickness ratio as specified in ② in Table 3-28.

α is aspect ratio, the ratio (a/b) of the length (a) to the width (b) of the plate element as shown in Fig. 3-32.

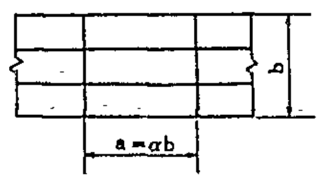


Fig. 3-32

I: geometrical moment of inertia (cm^4) of the gross section of the stiffener concerning the axis X-X, which is taken as shown in Fig. 3-33.

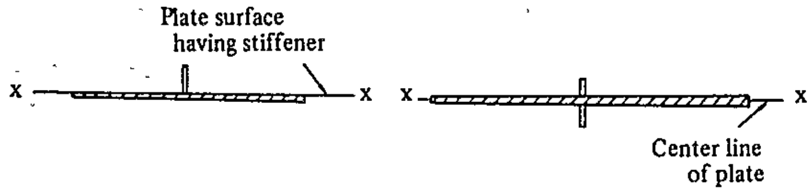


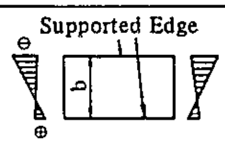
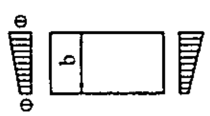
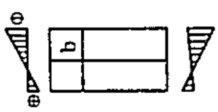
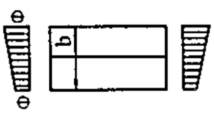
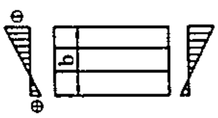
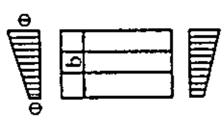
Fig. 3-33

δ is the ratio (F/bt) of the sectional area (F) of one stiffener to the sectional area of the plate concerned (b.t).

(b) **Palte Elements Subject to Combined Compression and Bending Moment**

(i) The minimum thickness of plate subject to compression and bending moment in combination and supported along its two opposite edges shall conform to the values given in Table 3-29.

Table 3-39

Arrangement and number of stiffeners	Range of ψ	Max. width-to-thickness ratio of plate (b/t)	Application
No stiffeners	$-1.0 \leqslant \psi \leqslant 0.25$	$\frac{2,200 - 3,200\psi}{\sqrt{\sigma 1}}$ but less than $80 - 120\psi$	
	$0.25 < \psi \leqslant 1.0$	$\frac{1,400}{\sqrt{\sigma 1}}$ but less than 50	
One stiffener near the middle of plate width	$-1.0 \leqslant \psi \leqslant 0.5$	$\frac{3,800 - 2,000\psi}{\sqrt{\sigma 1}}$ but less than $135 - 70\psi$	
	$0.5 < \psi \leqslant 1.0$	$\frac{2,800}{\sqrt{\sigma 1}}$ but less than 100	
Each stiffener near lines dividing plate width into 3 equal portions	$-1.0 \leqslant \psi \leqslant 1.0$	$\frac{5,400 - 2,400\psi}{\sqrt{\sigma 1}}$ but less than $180 - 60\psi$	
	$0.5 < \psi \leqslant 1.0$	$\frac{4,200}{\sqrt{\sigma 1}}$ but less than 150	

where t: thickness (cm) of the plate.

b: width (cm) of the plate.

ψ = σ_2/σ_1 is the ratio of stresses at both edges of the plate element, provided that $-1.0 \geqq \psi \geqq 1.0$.

σ_1 and σ_2: combined unit stresses (kg/cm^2) due to axial compression and bending moment on the respective edges subject to compression and tension under the beding moment only. However, in the case of combinaed loading where an icnrease of allowable unit stress is permitted as prescribed in (2) (a), they shall be divided by the multiplying coefficent given in Table 3-36.

(ii) The values of the required geometrical moment of inertia (I) and of maximum width-thickness ratio of each stiffener for a plate supported at both ends and having a stiffener at center of the plate width and on lines equally dividing the palte width into three (② and ③ in Table 3-39) shall be obtained in accordance with (6) (a) (ii). (b/t) in this instance shall be the maximum width-thickness ratio in accordance with ① in Table 3-39.

(c) Web Plates of Members Subject to Bending Moment

(i) The minimum thickness of the web plate of a member subject to bending moment and provided with vertical stiffeners shall satisfy the values in Table 3-40, which vary accoridng to the materials to be used.

Table 3-40

Material	Maximum Ratio of Width-to-Thickness (D/t)	
	Without Horizontal Stiffeners	With 1 Horizontal Stiffener
SS41, Sm41 and SMA41	155*	250

* can be $\frac{5,400}{\sqrt{\sigma}}$ when the stress intensity of the web plate is small, but shall not exceed 200.

where t: thickness (cm) of web plate. (Same in (ii))

D: depth (cm) of web plate. (Same in (ii))

σ: extreme fiber compressive unit stress (kg/cm^2) of web plate. For combined loading, where an increase of allowable unit stress is permitted as specified in (2) (a), the value shall be divided by the "multiplying coefficients" given in Table 3-26.

(ii) In case one horizontal stiffener is used, it shall be located at about 0.2D from the compression flange and the geometircal moment of inertia (I) of the horizontal stiffener referred to in the preceding paragraph shall be larger than the value calculated by the following formula.

$$I = 2dt^3 \quad \text{provided } d/D \leqq 2$$

The maximum width-to-thickness ratio of the horizontal stiffener shall conform to ① in Table 3-39, but this shall not apply to horizontal stiffeners with a special shape.
In the above formula,

d: spacing (cm) between vertical stiffeners, measured between centers of stiffeners in case they are welded, or between bolt lines in case the angle bar stiffeners are connected by bolts.

I: geometrical moment of inertia (cm^4) of the gross section of stiffener, and the way of assuming the neutral axis for the calculation of I shall be selected shown in Fig. 3-33 in (6) (a) (iii).

(iii) In case two or more horizontal stiffeners are to be used, the values of Table 3-40 are not applicable.

(d) Web Plates of Members Subject to Combined Shearing Force and Bending Moment

(i) In a member subject to shearing force and bending moment in combination, the minimum thickness of web plate requiring no intermediate stiffeners shall be conform to the values given in Table 3-41, which vary according to the track structure and the material to be used.

Table 3-41

Materials	Maximum Ratio of Width-to-Thickness (D/t)	
	Web plate of a member where the flange directly bears sleepers or the like.	Web plate of a member where the flange is not directly loaded.
SS41, SM41 and SMA41	70	$\frac{2{,}000}{\sqrt{\tau}}$ but smaller than 110.

where t thickness (cm) of web plate. (Same in (ii) and (iii))

D: depth (cm) of web plate. (Same in (ii) and (iii))

τ: shearing unit stress specified, provided that in the case of combined loading, where an increase of allowable unit stress is permitted as prescribed in (2) (a), it shall be divided by the "multiplying coefficients" shown in Table 3-26.

(iii) In the case of a member subject to shearing force and bending moment, the spacing between intermediate stiffeners shall conform to the values calculated by the following formulas, depending on whether horizontal stiffeners are used or not.

1) In case no horizontal stiffeners are used,

$$d \leqq 3{,}000 \cdot \frac{t}{\sqrt{\tau}}$$

In case the bending compressive unit stress (σ) at the joint of the web plate with the flange exceeds the values given in Table 3-42, the spacing between the intermediate stiffeners shall be checked according to the following formulas.

When $\frac{d}{D} \leqq 1$,

$$\left(\frac{D}{100t}\right)^4 \left\{ \left(\frac{\sigma}{3{,}250}\right)^2 + \left[\frac{\tau}{540 + 720\left(\frac{D}{d}\right)^2}\right]^2 \right\} \leqq 1$$

When $1 < \frac{d}{D} \leqq 2$,

$$\left(\frac{D}{100t}\right)^4 \left\{ \left(\frac{\sigma}{3{,}250}\right)^2 + \left[\frac{\tau}{720 + 540\left(\frac{D}{d}\right)^2}\right]^2 \right\} \leqq 1$$

Table 3-42

σ / Materials	Bending compressive unit stress of web plate at stationary line σ (kg/cm^2)
SS41, SM41 and SMA41	500

2) In case one horizontal stiffener is arranged near 0.2D from the composition side.

$$d \leqq 2{,}700 \frac{t}{\sqrt{\tau}}$$

In case the bending compressive unit stress (σ) at the joint of the web plate with the flange exceeds the values given in Table 3-43, the spacing between intermediate stiffeners shall be checked according to the following formulas.

When $\frac{d}{D} \leqq 0.8$,

$$\left(\frac{D}{100t}\right)^4 \cdot \left\{ \left(\frac{\sigma}{15,000}\right)^2 + \left(\frac{\tau}{850 + 720\left(\frac{D}{d}\right)^2}\right)^2 \right\} \leqq 1$$

When $0.8 < \frac{d}{D} \leqq 2$,

$$\left(\frac{D}{100t}\right)^4 \cdot \left\{ \left(\frac{\sigma}{15,000}\right)^2 + \left(\frac{\tau}{1,130 + 540\left(\frac{D}{d}\right)^2}\right)^2 \right\} \leqq 1$$

Table 3-43

Materials \ σ	Bending compressive unit stress of web plate at stationary line σ (kg/cm^2)
SS41, Sm41, SMA41	1,200

where d: spacing (cm) between intermediate stiffeners, which is determined in accordance with (6) (b) (i). (Same in (iii))

τ: average of the shearing unit stresses (kg/cm^2) of web plate between stiffeners, as specified in (5) (c).

σ: average of the extreme fiber compressive unit stresses (kg/cm^2) of web plate between stiffeners.

In the case of combined loading, where an increase of allowable unit stress is permitted as prescribed in (2) (a), τ and σ shall be divided by the "multiplying coefficients" shown in Table 3-26.

(iii) The geometric moment of intertia (I) of intermediate stiffeners referred to in the preceding paragraph shall be larger than the value calculated by the following formula.

$$I = \frac{5}{22} \cdot ds \cdot t^3 \cdot \gamma$$

But the maximum width-to-thickness ratio of an intermediate stifefener shall be 16. These provisions are not applied to stiffeners with a special shape.

In the above formula,

ds: spacing between stiffeners (cm) adopted in the design.

I: geometric moment of inertia (cm^4) of the gross section of intermediate stiffener, where the neutral axis shall be selected as shown in Fig. 3-33 of (6) (a) (i).

γ: stiffiness ratio calculated by the following formula.

$$\gamma = 25 \left(\frac{D}{d}\right)^2 - 20 \quad \text{but } \gamma \geqq 5$$

(7) Floor System

(a) Stringer

(i) The span length of a stringer assumed for design calculation shall be as a rule the distance between the centers of floor beams.

(ii) A stringer shall preferably be designed as a continuous srructure.

(b) Bending Moment of Continuous Stringer

The moment at the span center and the moment at the intersection with an intermediate floor beam when the stringer is calculated as a continuous stringer shall usually conform to the values given in Table 3-44. The allowable unit stresses to be used shall conform to the basic allowable unit stresses specified in (2) (a) with respect to tension and to the buckling allowable unit stresses specified in (2) (b) with respect to compression.

Table 3-44

Position \ Types of Steel	SM41 and SMA41
Bending moment at the span center of the end stringer and other similar ones.	1.0Mo
Bending moment at the span center of an intermediate stringer.	0.8Mo
Bending moment at the intersection with an intermediate floor beam.	0.75Mo

Note: Mo is the bending moment at the span center when the stringer is calculated as a simple beam.

(c) Floor Beam

(i) The floor beams shall be arranged at a right angle to the main truss or girder as much as practicable.

(ii) The dpan length of the floor beam used in design calculation shall be in principle equal to the distance between the centers of main trusses or girders.

(iii) As a rule, a through plate girder shall be provided with end floor beams.

(iv) The end floor beams shall be strong enough for jacking-up of the bridge as much as possible. In regard to the increase of allowable unit stresses in the design, the value for erection load as prescribed in (2) (a) shall be used.

(d) Connection between Stringers and Floor Beams

(i) In the connection between stringers and floor beams at their webs, only shearing force shall be taken into consideration as a rule; and it shall be 1.2 times as large as the reaction force as a simple beam, whether the stringer is a continuous beam or simple beam. The allowable unit stress for the high-strength bolts in this case shall conform to the basic allowable unit stress specified in (2) (c).

(ii) The stringer shall be as a rule connected to the web of the floor beam by means of the latter's stiffener and a connection angle in combination. It is preferable that the stiffener of the floor beam at the connection consists of an angle steel, fastened with high-strength bolts, too, and that the connection angle is made as long as practicable and thicker than 11 mm.

(e) Connection of Floor Beam with Main Girder

(i) In the through plate girder, the web of the floor beam shall in principle be connected with the web plate the main girder by the medium of its stiffener and a connection angle in combination and fastened with high-strength bolts. The lower flange of the floor beam and the lower flange of the main girder are preferably connected by the medium of a gusses plate.
The connection angle is preferably at least as long as the depth of the floor beam and thicker than 10 mm.

(ii) In the design of connection of the floor beam and the main girder, the end negative bending moment due to the rigidity of the main girder and the rigidity of the connection shall be taken into consideration.

(8) Welded Joint

(a) Types of Weld

(i) For welded joints that are intended to transmit stresses, groove weld or continuous filler weld shall be employed.

(ii) Intermittent weld, plug weld or slot weld shall not be used for the fabrication of main memebers.

(b) Throat Thickness of Welded Joints

The throat thickness of welded joints that are intended to transmit stresses shall be taken in conformity with the following provisions.

(i) The throat thickness in groove weld shall be equal to the thickness of plates to be connected. When the plates are different in thickness, the thickness of the thinner plate shall be taken as the throat thickness as shown in Fig. 3-34.

(ii) The throat thickness of fillet weld are designated as the height as measured from the root of the joint of the inscribed isosceles triangle which is so placed that its apex may fall on the joint root as shown in Fig. 3-35.

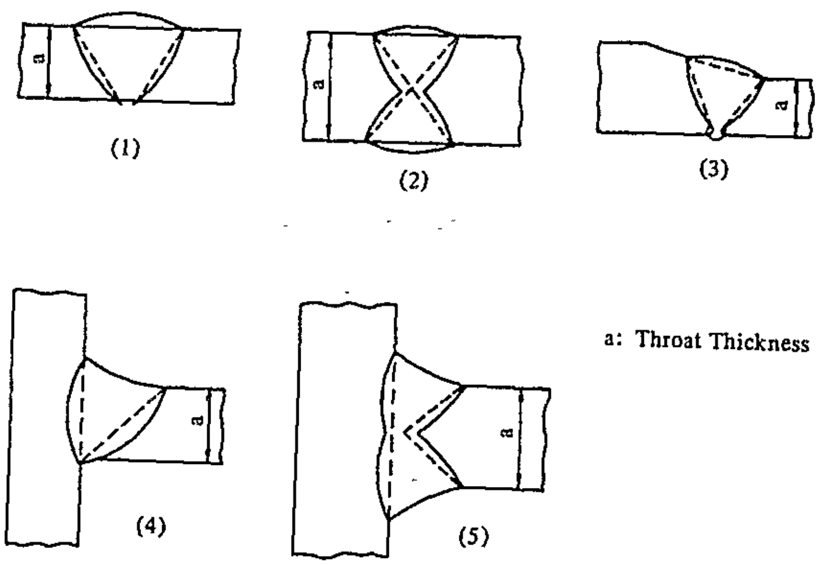


Fig. 3-34 Throat Thickness of Groove Weld

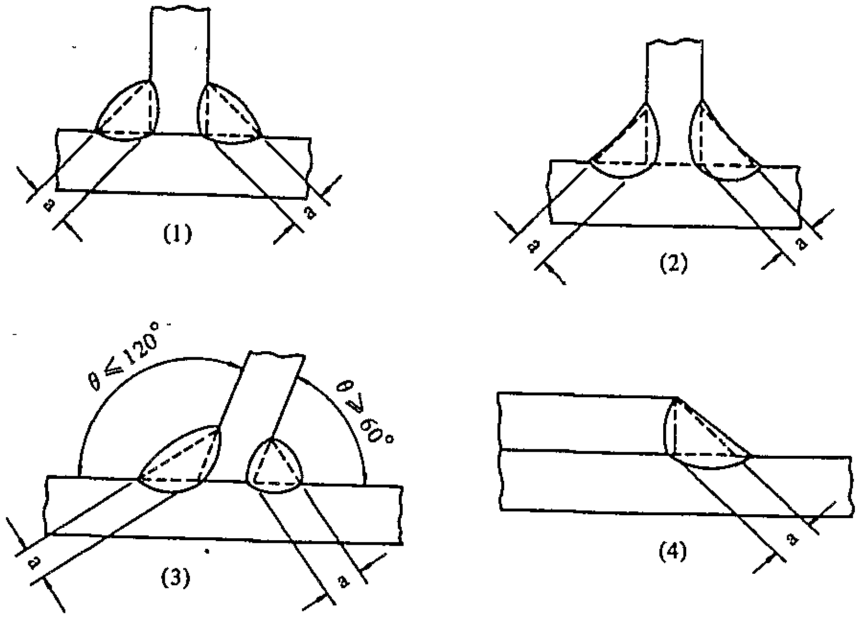


Fig. 3-35 Throat Thickness of Fillet Weld

(c) Effective Length of Weld

(i) The effective length of weld used in stress calculation of welded joint shall be the length of welded part whose throat thickness satisfies the requirement of the design.

(ii) In case the weld line in groove weld is not perpendicular to the direction of stress, the effective length is regarded as the length of the actual effective weld line projected on a line perpendicular to the stress direction.

(iii) In the case of fillet weld, when the welding is extended around the corner, such extended welded portion shall not be counted as the effective length.

(d) Groove Welded Butt Joint

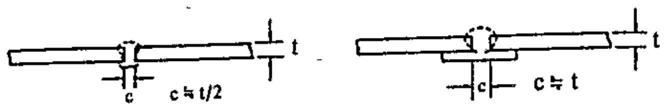
(i) In the butt joint of groove weld the entire cross-section shall be welded and the member shall be of such a construction as the back welding can be conducted. In case the back welding is unpracticable because of unavoidable tructural reasons, backing strips shall be used instead.

(ii) In a groove weld butt joint between main members of different sectional dimensions, the thickness and width shall be changed gradually in a lengthwise slope not exceeding 1/5.

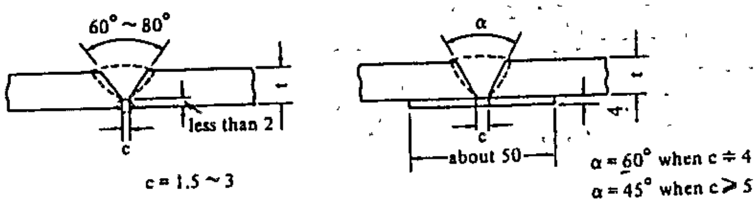
(e) **Details of Groove Welded Joints**

In the case of manual are welding, details of the shapes shwon in Fig. 3-36 shall be usually applied to groove welded joints.

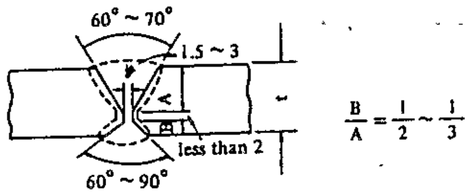
(Unit: in mm)



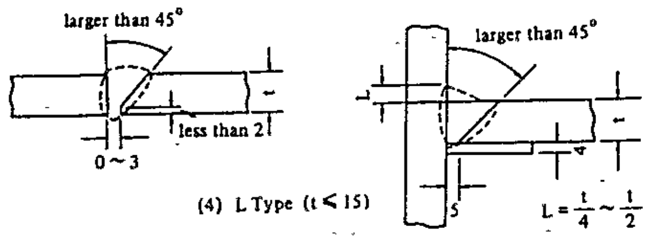
(1) I Type (t = 4 ~ 6)



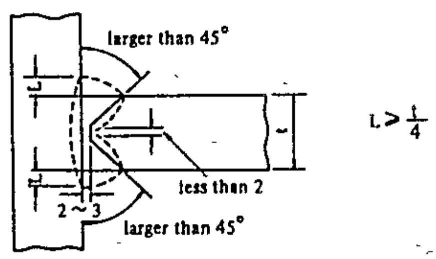
(2) V Type (t = 5 ~ 15)



(3) X Type (t = 10 ~ 30)



(4) L Type (t ≤ 15)



(5) K Type (t = 10 ~ 30)

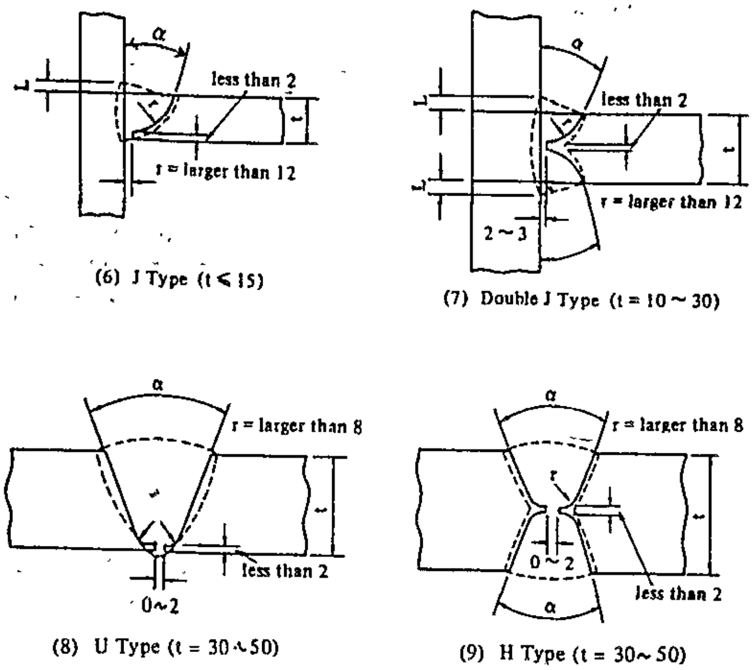


Fig. 3-36 (Unit: mm)

Note: For all of (6), (7), (8) and (9), α shall be larger than 25°C for both welding from upper-side and welding from under-side; and larger than 40°C for horizontal and vertical welding.

(f) Size of Fillet Welds

(i) Fillet welds shall be, as a rule, of equal size (lengths of the two legs are equal). However, front fillet weld in a main member shall be of unequal size with longer leg in the stress direction and finished if necessary.

(ii) In fabrication of main members, the size "s" of fillet weld transmitting stresses shall be larger than 6 mm and preferably within the range indicated by the following formulas.

$$s \leqq t_1 \text{ and } s \geqq \sqrt{2t_2}$$

where t_1: thickness (mm) of the thinner plate.
t_2: thickness (mm) of the thicker plate.

(g) Minimum Length of Fillet Weld
The minimum length of fillet weld shall be determined in such a way that its minimum effective length be either 10 times the size or 80 mm, whichever is the greater.

(h) Lap Joints

(i) In lap joints transmitting stress, mroe than two lines of fillet weld shall be used and the minimum amount of overlap of plates shall be five times the thickness of the thinner plate to be connected.

(ii) In case an end of a member subject to an axial force is connected with another member by means of lap joint consisting of side fillet welds only, the length of each fillet weld shall be larger than the spacing between them. In this case, the spacing of weld lines shall be smaller than 16 times the thickness of the thinner plate to be connected. If the spacing is larger than the above, an appropriate method shall be taken to prevent separation of the plates.

(i) Fillet Welded T-joint

(i) In case fillet weld is used for T-joint, it shall be applied to both sides a plate. However, when the structural memeber is of such a construction as to provide a sufficient rigidity against lateral deformation, a singel side fillet weld may be applied.

(ii) When fillet welding in jointing members whose angle of intersection is below 60°, or above 120°, the fillet welding shall not be considered in strength calculations.

(j) Combined Use of Welds and Ordinary Bolts
In regard to a joint with combined application of welds and ordinary bolts, the bolts shall be neglected in the stress calculation for design.

(9) Bolt Joint and Pin Connection

(a) Shape and Size of Bolts

(i) High-strength bolts of M20, M22 and M24 shall usually used. Their shapes and sizes shall conform to JIS B 1186–1970 unless otherwise specified.

(ii) When high-strength nolts need not be used as in the case of shoe fittings, side walk, protection plates and drainage facilities, ordinary bolts may be used. Ordinary bolts for these purposes shall conform to JIS B 1180 (Hexagonal Bolts) and JIS 1181 (Hexagonal Nuts).

(b) Minimum Spacing between Bolt Centers
The minimum spacing between centers of bolts shall usually conform to the values shown in Table 3-46. In spacial cases, however, the spacing may be reduced down to three times the diameter of the bolt.

Table 3-45 Minimum Spacing between Bolts

Size of High-Strength Bolts	Size of Ordinary Bolts	Minimum Spacing of Center (mm)
M24	M24	85
M22	M22	75
M20	M20	65

(c) **Maximum Spacing between Bolt Centers**

(i) The maximum spacing between centers of bolts shall conorm to the following:

- The maximum spacing between centers of bolts in joints and built-up compression members shall conform to the smaller values shown in Table 3-46.

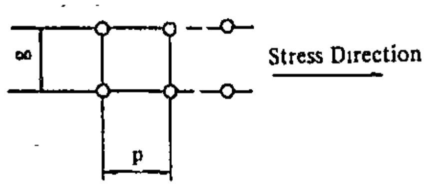
Table 3-46

Size of High-Strength Bolts		Maximum Spacing between Centers (mm) p	g
M24	170	12t in the case of square arrangement.	24 but
M22	150	15t–(3/8)g but smaller than 12t in the	smaller than
M20	130	case of staggered arrangement	300

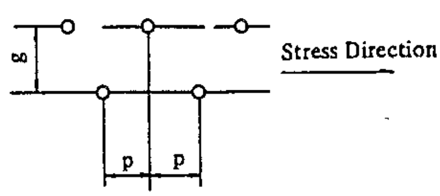
In the table,

t: thickness (mm) of the outer plate or shape steel.
p: component of bolt pitch (mm) in stress direction.
g: component of bolt gauge (mm) perpendicular to the direction of stress.

In the case of square arrangement



In the case of staggered arrangement



- The maximum spacing as measured int hestress direction for bolts to stitch tension members shall be 24t but shall not exceed 300 mm.

(ii) The provisions in the preceding paragraphs need not be applied protection plate, drainage faciliteis, etc.

(d) Minimum Edge Distance
The minimum distance from the center of bolts of the edge shall conform to the values given in Table 3-47.

Table 3-47

Size of High-Strength Bolts	Size of Ordinary bolts	Sheared Edge and Manual Flame-Cut Edge (mm)	Rolled Edge, Machined Edge and Automatic Flame-Cut Edge (mm)
M24	M24	42	37
M22	M22	37	32
M20	M20	32	28

(e) Maximum Edge Distance
The maximum distance from the center of bolts to the plate edge of a part shall be eight times the thickness of the outer plate or shape steel, but not exceed 150 mm.

(f) High-Strengh Bolts for Angle Steels
The diameter of high-stength bolts for angle steels shall not exceed the values in Table 3-48.

Table 3-48

	Main Memebrs	Secondary Members
Length of Angle Legs (mm)	Size of High-Strength Bolts	Size of High-Strength Bolts
Grater than 100	M24	M24
90	M22	M24
75	M20	M22

(g) Minimum Number of Bolts
The minimum number of high-strength bolts composing a group for connection of memebrs shall be two.

(h) **Connection with Pins**

When connecting members with a pin, care shall be exercised to prevent the pin from moving laterally and to prevent the nut from getting loose.

(i) **Pins**

Pins shall be designed to meet the following requirements.

(i) The diameter of pins shall be 75 mm or larger.

(ii) The length of the pin finished part shall be more than 6 mm in addition ot the distance between the outer faces of the members, and. Lomas nuts or ordinary nuts with washers shall be used at both ends of the pin.

(iii) Metric fine threads shall be used for the screw of the pin, and the thread pitch shall be usually set at 4 mm.

(j) Memebrs with Pin Holes

(i) The difference of pins and pin holes in diameter shall usually be 0.5 mm for pins smaller than 130 mm in diameter and 1 mm for pins of 130 mm or more in diameter.

(ii) In regard to a tension member with a pin hole, the net sectional area measured through the pin hole center, at right angles to its axis shall be more than 40% larger than the net sectional area of the member which is required based on stress calculation; and the net sectional area masured between the pin hole edge and the end of the member in the axial direction shall be larger than the above required net sectional area of the member.

(iii) Eye-bars are allowed not to conform to the requirements of (ii) above.

(10) **Bracings and Diaphragms**

(a) Brancing Members

(i) Built-up members or shape steels shall be used for lateral bracing, brake trusses and sway bracing, and in case these members cross each other, they shall be connected at their intersecting point.

(ii) For long bracing members, a solid-web construction shall be preferably adopted as much as possible practicable.

(b) Lateral Bracings

(i) As a rule, and lower lateral bracings shall be provided. However, with respect to a through plate girder bridge, only lower lateral bracings shall be used.

(ii) In regard to a deck plate girder bridge shorter than 16 m for a straight track or shorter than 12 m for a curved track, provided with sufficient sway bracings, lower lateral bracings may be omitted.

(iii) The lateral bracings between compression chord members of a truss shall be designed to resist the force specified in TS 3.09 (1) and furthermore to resist the shearing force equal to 1% of the total compressive force acting on the right and left chord members in the panel under consideration. This shearing force shall be considered as a principal load.

(c) Brake Trusses
Bridges shall be provided with brake trusses in order to resist longitudinal forces such as braking force, traction force. For sets of continuous stringers between expansion joints, the brake trusses shall be installed in the neighborhood of the middle of each set as close as practicable.

(d) Intermediate Sway Bracing Members

(i) The truss shall be provided with a sway bracing at each pabel point whenever possible.

(ii) In the case of a deck plate girder bridge of I-shaped section, the spacing of intermediate sway bracings shall be less than 20 times the width of the compression flange. In no case, it shall exceed eight meters.

(e) End Sway Bracing Members
A deck plate girder bridge and a deck truss bridge shall in principle be provided at their supporting parts with end sway bracing capable of transmitting total lateral load acting on the upper lateral bracing to the support.

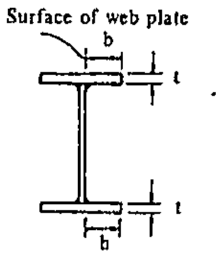
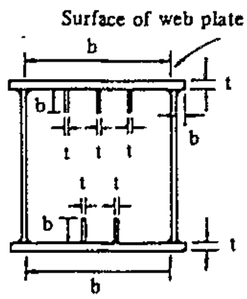
(f) Portal
A through truss bridge or similar structures shall be provided as a rule at the ends with portals strong enough to transmit to the supports all the lateral load acting on the upper chord members.

(11) Plate Girder

(a) Cross Section of Flange

(i) The minimum thickness of compression flange and tension flange shall conform to the values given in Table 3-49.

Table 3-49

		Max. Width-to-Thickness Ratio (b/t)		Examples of Application
		Compresion Flante	Tension Flange	
①	Outstanding legs of flange of I-shape girder	$\frac{450}{\sqrt{\sigma}}$ but less than 16	16	
②	Flange of box-girder with n logitudinal stiffeners arranged at equal spacings on flange plate	$\frac{1,400}{\sqrt{\sigma}}n$ but less than 50 n	60 n	

where t: thickness of the plate (cm).

n: number of panels divided by stiffeners at an equal spacing. In case no stiffener is used, n = 1.

b: width of plate (cm). (See examples in Table 3-49)

σ: maximum working compressive unit stress (kg/cm^2). In the case of combined loading, where increase of allowable stress is permitted according to (2) (a), it shall be the value divided by the "multifying coefficients" given in Table 3-26.

The size of each stiffener in ② in Table 3-49 shall be determined by (6) (a) (ii) for a compression spring, and the maximum width-to-thickness ratio shall be 16 for a tension flange.

(ii) In the case of compression flange, where the section is composed of two or more plates in ply, the distance between side fillet welds connecting these plates with each other shall be shorter than 24 times the thickness of the thinner plate. In the case of tension flange, it shall be shorter than 30 times.

(iii) The outstanding width of flange plate which bears directly sleepers shall be smaller than 10 times the thickness of the plate,provided that the minimum width of flange shall be 200 mm and the minimum plate thickness shall confrom to the values given in Table 3-50. When rigid sleeper fastening blocks are used or in the case of a grider of box-cross section, the provisions in this paragraph do not apply.

Table 3-50

Type of Steel	Min. Plate Thickness (mm)
SS41, SM41 & SMA 41	16

(iv) It si desired that the number of plates in ply composing the flange section does not exceed two.

(b) Frong Fillet Weld at End of Cover Flange Plate

The front fillet weld at the end of a cover plate shall as a rule be of unequal size and finished.

(c) Welds to Connect Flange Plante and Web Plate

(i) The welds to connect flange plate and web plate shall be fillet welds and the total of their throat thicknesses shall in principle be larger than the web plate thickness.

(ii) In case a thick web plate is used for structural reasons and the shearing stress in the web plate is sufficiently small, the total of throat thicknesses of the fillet welds referred to above may to be smaller than the thickness of the web plate. In this case, the shearing stress in the fillet welds shall be checked by the following formula. Checking on the combined stress with the shearing stress and the bending stress shall be made in accordance with (5) (b).

$$\tau h = \frac{SQ}{I\,(\Sigma a)}$$

where τh: shearing unit stress (kg/cm^2) working in the throat of the fillet weld.

S: shearing force (kg) acting on the cross section of the girder to be calculated.

Q: statical moment of area (cm^3) of the flange about the neutral axis of the gross section of the plate girder.

I: geometric moment of inertia (cm^4) of the gross section around the neutral axis of the gross section of the plate girder.

Σa: sum of throat thicknesses (cm).

(iii) When the upper flange of deck plate girder bears sleepers, the welds described in (i) above shall in principle be of K-groove weld.

(d) End Stiffener

(i) The outstanding width of the end stiffener shall conform to ① in Table 3-38 in (6) (a).

(ii) In the checking of the end stiffener of weld construction, with respect to its compressive strength as a column, the portion of web plate corresponding to 24 times its thickness as shown in Fig. 3-37 may be included in the effective cross sectional area. The length l of member to be used in the calculation of compressive unit stress shall be half the length of the stiffener.

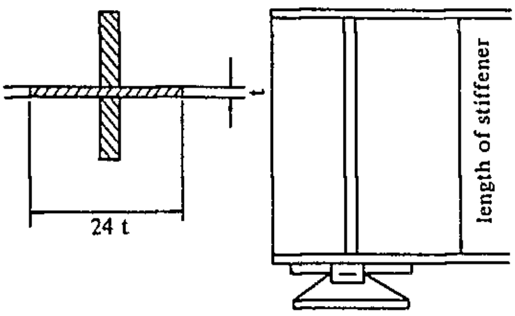


Fig. 3-37

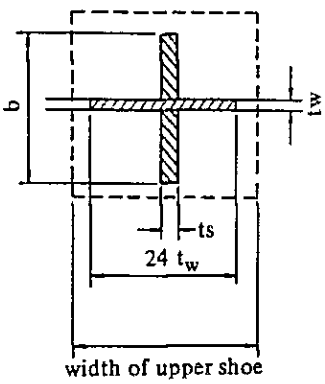


Fig. 3-38

(e) Stability of Upper Falnges of Through Plate Girder

(i) As a rule the floor beams of a through plate girder shall be provided with knee braces on their both ends.

(ii) The knee braces shall statisfy the following provisions concerning rigidity and strength.

o The rigidty k of the U-shape construction consisting of floor beam and vertical stiffeners shall satisfy the formula shown below.

$$k \geq \frac{8A\sigma ca}{l}$$

where k: rigidity K/δ (kg/cm) of U-shape construction, that is, the horizontal force to cause δ = 1 in Fig. 3-39.

A: cross sectional area (cm^2) of the upper flange.

σca: allowable bending compressive unit stress (kg/cm^2) of the main girder.

l: assumed buckling length of the main girder flange (cm).

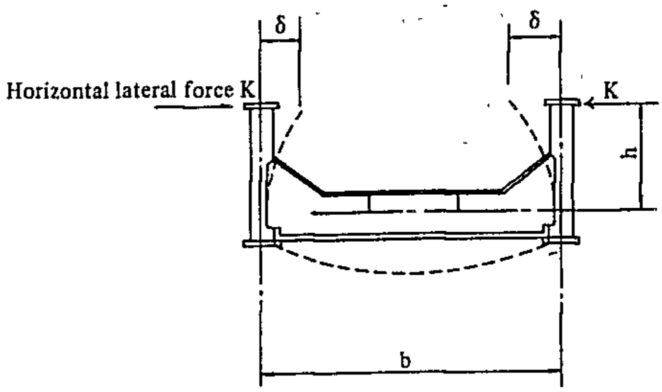


Fig. 3-39

o The construction referred to above must have a sufficient strength when applied to its top to stand the horizontal lateral force of the magnitude given by the following formula,

$$H = \frac{A\sigma c}{100}$$

where H: horizontal force (kg) applied to check the strength.

σc: bending extreme-fiber compressive unit stress acting on the top (kg/cm^2).

(12) Truss

(a) Composition of Chord Memebrs and Others

(i) Chord members of a truss, end posts and diagonal members to be installed at intermediate supports of a continuous truss shall be preferably designed as box-section members. In this respect, the sectional area of the plates parallel to thr plane of the truss shall preferably constitute more than 40% of the gross sectional area of the members.

(ii) In the preceding paragraph, the slenderness ratio of the member regarding the radius of its gyration of its cross section about the vertical axis shall be preferably made smaller than that about the horizontal axis.

(iii) In case the end post or the like is subject to bending moment, checking of its strength shall be made according to the requirement of (5) (b).

(b) Members with Perforated Plates

(i) Construction of perforated plates shall conform to the following requirements.

o The minimum thickness of perforated plates shall conform to the values given in Table 3-51.

Table 3-51

Types of Axial Working Stress	Maximum Width-to-Thickness Ratio	
Compression	b/t	50
	s/t	$\frac{450}{\sqrt{\sigma}}$ but less than 16
Tension	b/t	60
	s/t	16

o Dimensions of perforated plates are as follows.

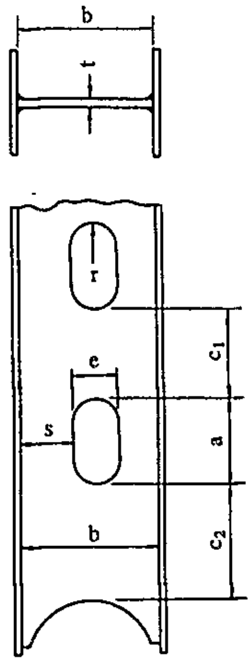


Fig. 3-40

$a \leqq 2e$

$c_1 \geqq b$

$c_2 \geqq 1.25b$

$r \geqq 40$ mm

σ: maximum compressive working stress (kg/cm^2). When combining loading permitting increae of allowable stress as prescribed in (2) (a), the value shall be divided by the "multiplying coefficients" of Table 3-26.

b: width of perforated plate (cm).

t: thickness of perforated plate (cm).

s: spacing between the edge of the hole and the edge of the plate, measured at the middle of the hole (cm).

a: length of the hole, measured in the direction of stress (cm).

e: width of the hole (cm).

c_1: clear distance (cm) between two adjacent holes.

c_2: minimum distance between the edge of the end hole and the end of the perforated plate, measured in the stress direction (cm).

r: radius of curvature of the hole (cm).

(ii) The radius of gyration and effective area of section of the member with perforated plate shall be calculated regarding the section which crosses the hole at its maximum width. When a member is composed of two or more perforated plates and hole positions of the different plates are staggered each other, the calculation shall be performed on the assumption that the holes of the differenct plates are located on the same cross section.

(c) Thickness of Mian Truss Gussets

In the construction of a main truss or other similar structures, when two gussets are used in pairs to connect a web member with a chord member, the thickness of each gusset plate shall preferably be larger than the value calculated by the formula below, or 11 mm, whichever is larger.

$$t = \frac{22P}{b}$$

where
- t: thickness (mm) of the gusset plate.
- P: maximum force (t) acting on one of the members connected to the gusset.
- b: width (mm) of the plate of the said member which is in contact with the gusset.

(13) Baring

(a) Bearings in General

(i) Bearings shall be designed in such a manner as to evely distribute the load on the top of abutment or pier and to be strong enough to resist both the longitudinal and transverse loads as well as up-lifting force.

(ii) The construction shall be such that it can resist up-lifting force, even if it is not likely to occur on calculation basis.

(iii) Due care shall be exercised in the design of a movable bearing provided with copper alloy bearing plate, rollers or rockers, so that they might not come offer the bearing surfaces.

(b) Types of Movable Bearings

The types of movable bearings and their applications shall be as prescribed in Table 3-52 in principle. It is advisable not to use different types of movable bearings at the same end of a bridge.

Table 3-52

Types of Bearing	Bearing Consisting of Sole Plate and Bed Plate in Combination	Slide Bearing Made of Cast Iron of Cast Steel		Bearing Provided with Copper Alloy Bearing Plate, Rockiers, Rollers or Others	
Types of Bridge / l(m)	$l < 8$	$8 \leqq l < 35$	$l \geqq 35$	$8 \leqq l < 35$	$l \geqq 35$
Single Span	Used in Anu Magnitude of Reaction	$R \leqq 200t$	–	$R > 200t$	Used in Any Magnitude of Reaction
In case Two or More Spans Affect the Movement of Bearing	–	$R \leqq 200t$	$R \leqq 100t$	$R > 200t$	$R > 100t$

Notes: 1) l denotes the total length of a bridge or bridges which affects the movement of the bearing.
2) R is the maximum reaction to be allowed at one support.

(c) Allowance of Movement at Movable Bearing
The movable bearing shall be designed so as to allow for the change in the length of the bridge between the movable bearing under consideration and the fixed bearing at a rate of 1.5 mm in one meter.

(d) Coefficient of Friction of Movable Bearing
The coefficient of friction of amovable bearing to be used for design shall be of the values shown in Table 3-53.

Table 3-53

Types of Bearings		Coefficient of Friction
Slide Bearings	Steel and Steel	0.25
	Steel and Cast Iron	0.20
	Steel and Copper Alloy Bearing	0.10
Roller or Rocker Bearings		0.10

(e) Dimensions of Bearing Parts

(i) The thicknesses of the main parts of cast steel and cast iron shoes shall conform to the requirements of the following provisions.
- o Greater than 25 mm for cast steel shoes.
- o Greater than 35 mm for cast iron shoes. It shall not be provided with buttress as a rule.

(ii) The thickness of the copper alloy bearing palte shall be greater than 25 mm.

(iii) The thickness of sole plate and bed plate shall be greater than 22 mm.

(iv) The diameters of rollers shall be greater than 100 mm except special cases.

(v) When a spherical bearing is used for a steel post, its radius shall be larger than 75 mm. The difference in radius between upper and lower spheres shall be as a rule 1 mm or so.

(f) Anchor Bolts

The anchor bolts shall in principle be string enough to fix the position of the shoe and resist the longitudinal load and transverse load, axial force caused by fixing moment as well as up-lifting force. Its construction shall conform to the requirements of the following provisions.

(i) Its length to be buried into the sub-structure shall be more than 10 time the diameter in the case of a plate girder bridge and more than 15 times the diameter in the case of a truss bridge.

(ii) The minimum diameter of the anchor bolt shall be 30 mm.

(iii) Anchor bolts to resist an up-lifting force in design shall be connected with an appropriate anchoring device and the latter shall be fixed to a weight 1.5 times as large as the up-lifting force assumed in design.

(g) Dust-Proof Cover for Bearing

The bearing shall be provided with a dust-proof cover if necessary.

TS 3.10 Payment

Detail designs shall be considered completed when the all the work required such as stability and stress calculations, drawing drafting, and bills of quantities by Description of Work itme for all the detail designs the contractor is required to submit has been completed and when the fruits thereof have been approved by the Engineer. Upon the completion of the detail designs, the Engineer shall issue a completion certificate to the Contractor.
The payment for the detail design shall be made in the month in which a completion certificate is issue to the contractor.

Payment Item Description of Work Item	Unit of Measurement
3. Detailed Designs	Lump Sum

TS 4 EARTHWORK

TS 4 EARTHWORK

TS 4.01 Scope of Application

This section covers the scope of earthwork to be applicable to execution of cutting, filling, clearing and grubbing of riverbed, general excavation, structure excavation and other related work necessary for earthwork specified under technical specifications herein.

The Contractor shall be responsible for the execution of the work strictly in accordance with this specification and contract documents.

The Contractor shall submit to the Engineer a construction work plan, including distribution of soil material volumes based upon mass curve diagram, transportation plan for soil material and work progress schedule for review and approval.

TS 4.02 General

(1) Classification of Earthwork

Earthwork shall be classified as follows:

(a) Main Line Cuttings (Soil-mixed Sand)
(b) Main Line Cuttings (Loose Rocks)
(c) Temporary Line Cuttings (Soil-mixed Sand)
(d) Temporary Line Cuttings (Loose Rocks)
(e) Main Line Embankments
(f) Temporary Line Embankments
(g) Clearing and Grubbing of Riverbed
(h) Excavation (Soil-mixed Sand)
(i) Excavation (Loose Rocks)
(j) Demolition of Structures
(k) Boulder

(2) Roadbed Preparation Standard

Roadbed surface shall be prepared and finished to the lines and grades sufficient to the accuracy within the limits of plus 2 centimeters and minus 5 centimeters from formation level as shown on the drawing.

(3) Classification of Soil Materials

Soil materials derived from cutting, clearing and grubbing of riverbed, excavation shall be determined by the Engineer on the basis in the following standards and be classified into soil-mixed sand and loose rocks:

(a) Soil-mixed Sand:

Materials containing the degree of which can be excavated effectively with the use of the bulldozer, and the maximum size of rock shall be less than 50 centimeters in diameter.

(b) Loose Rocks:

Materials containing the degree of which can be excavated effectively with the use of the bulldozer equipped with a hydraulic ripper or breaker, and the size of which exceeding 50 centimeters that might require dynamite during excavation work.

(4) Quantities

Quantities of cutting, filling, clearing and grubbing of riverbed, excavation and related work to be measured for payment shall be limited to the lines, grades, and the extent as shown in the document and drawings prepared under this contract and shall comply with longitudinal sections and cross sections as shown on the drawings approved by the Engineer.

Any execution of the work for other than those as shown on the drawings shall not be measured for payment.

The Contractor shall be responsible for measurement and keeping the record of sections for cutting, filling, clearing and grubbing of riverbed and excavation for eventual submittal to the Engineer for his review and approval.

The Engineer will review and approve the records as the basis for payment provided that the records are verified and substantiated by the Contractor.

Where excessive materials excavated by the Contractor, the Contractor shall be responsible for backfilling of the materials as directed and approved by the Engineer. Backfilling work under this condition shall not be subjected to measurement for payment.

(5) Removal of Existing Obstacles

All the unit cost for cutting, clearing and grubbing of riverbed and excavation shall include the cost for removal of all materials derived from the areas within the limits of earthwork as specified and approved.

Where dynamite blasting required for a rock, concrete block or brick, size of which exceeds 1 m^3 per each material, measurement for payment shall be made on the basis of the unit price of loose rock in the applicable classification as shown in the Priced Bill of Quantities.

(6) Diversion of Drainage System or Waterway

Prior to commencement of earthwork, the Contractor shall be responsible for removing the water blocked or dammed in trenches, pits or any other depressions in the locations where cutting, borrow excavation and filling work will be carried out, and the Contractor shall provide equipment necessary for removing or draining of water and diversionary drainage channel which is deemed necessary for execution of earthwork and protection of structures as directed by the Engineer.

Unless otherwise the payment is specified in the technical specifications or drawings, all the costs necessary for provisional work such as treatment of surface run-off or ground water and sheathing work using sheet piles or any other related materials all of which are required during the earthwork shall be included in the unit price of each pay item as indicated in the Priced Bill of Quantities.

Draining facilities and temporary sheathing facilities shall be always kept in neat and proper order and be maintained in the satisfactory condition as required.

Any damage due to absence or negligence of implementation of applicable draining facilities by the Contractor during the period of both construction and maintenance shall be restored and repaired to the conditions as required by the Contractor at his own cost.

(7) Utilization and Disposal of Soil Materials derived from Cutting, Clearing and Grubbing of Riverbed and Excavation

Unless otherwise specified in the technical specifications or general specifications, all the soil materials derived from the job site shall be effectively utilized for filling and or backfilling.

The Contractor shall dispose of the soil materials which are not utilized for the work and other materials determined as unsuitable materials by the Engineer, and the disposal work shall comply with the requirements directed by the Engineer.

(8) Removal of Loose Soil or Rocks

Any loose soil materials or rocks on the slope surface shall be removed in accordance with the directions of the Engineer. Payment for removal of the materials shall be made on the basis of respective unit price of soil mixed sand or loose rock under all the related work including cutting, clearing and grubbing of riverbed and excavation. Where any additional work required due to default or negligence of implementation for forming proper slope surface by the Contractor, payment for such work shall not be made.

(9) Removal of Slides and Slipouts, Preparation of Berm, Shaping of Slope Surface

The Engineer shall reserve the right to instruct the Contractor to remove the slides and slipouts and provide berm where necessary, and to instruct the Contractor to correct any defects which might cause landslide or uneven surface on the slope. Payment for such remedial works shalll be made on the basis of the unit price of soil-mixed sand or loose rocks for all the work including cutting, clearing and grubbing of riverbed and excavation.

Where such remedical work is required due to default by the Contractor, payment for the work shall not be made.

(10) Borrow Pit

Borrowing the materials required for the work from borrow pit shall be carried out on the basis of the construction work plan or work programme previously submitted and as approved by the Engineer specified in TS 4.01 "Scop of Applicaiton".

In general, borrowing shall be executed only where the soil materials derived from cutting, clearing and grubbing of riverbed and excavation are considered to be unsuitable for the work as specified.

In principle, suitable soil-mixed sand materials derived from cutting, clearing and grubbing of riverbed and excavation shall be entirely utilized for filling or backfilling.

Surplus soil materials obtained from the borrow pit which was opened for convenience of the Contractor and not utilized for the work as required, shall be disposed of by the Contractor at his own cost in such manner that all conditions are sufficient and satisfactory to the Engineer.

Any alteration in the distance of transportation for the materials from the borrow pit shall not be justified for additional payment or amendment to the contract amount.

The borrow pit shall always be kept in order and be maintained in satisfactory condition to be free from blockage and damming of water. Upon completion of borrowing the materials, the area shall be restored to the condition satisfactory to the Engineer and land owner.

(11) Powder (or Explosives)

(a) In the event of using powder for excavation, the Contractor shall obtain the Engineer's approval prior to commencemet of the work.

(b) The Contractor shall provide a warehouse or any other appropriate building in proper location(s) for storage of powder in the method as approved by the Engineer.

The record of inventory shall be kept and shall be readily available for the Engineer's review where necessary.

In no event shall unauthorized personnel have an access to the area as specified.

All doors in entrance and passage shall be locked and appropriate precautious detecting devices shall be provided for the safety.

(c) The Contractor shall be responsible for taking preventive measures for misuse and abuse of the powder.

The Contractor shall select and appoint qualified and experienced personnel as responsible person to handle the power complying with existing laws and regulations or whatever it may be required for the work.

(d) All excavations with the use of breaker and blasting method shall be carried out in such a manner that excavations can be accomplished to the lines, grades and extent as rquired, and greatest care shall be exerised to minimize adverse effect to the original ground after excavation worik has completed.

The Contractor shall be fully responsible for the blasting work. The Contractor shall not be entitled for payment for additional work which might be required due to collapse or occurrence of any other defects caused by the blasting at the areas other than those as specified and approved.

(e) The Contractor shall take utmost precautious measures to protect workers and structures at job site during the blasting operations against any possibel damage cuased by balsting. The preparatory work such as charging of powder, attaching of exploder, determining of amount of power required for the locations shall be performed in an orderly manner. The Contractor shall keep the records for the locations where the powder have been used, and amount of the powder, and submit the records to the Engineer for his review.

(f) The Engineer, whenever in his judgement the blasting may have a detrimental effect on the workers or adjacent structures, or the blasting is being carried out in unsafe manner, shall reserve the right to direct the Contractor to discontinue the blasting and perform the excavation work by any other methods suitable to the conditions encountered.

Where necessary, the Contractor shall submit request for blockage of railroad or road traffic to the government authorities concerned for obtaining the approval and report to the Engineer of the result.

(g) The Contractor shall abide by the applicable laws and regulations of the Republic of Bolivia with respect to storage, transporting and handling of poweder and the blasting operations, and at the same time, the Contractor shall be responsible for ensuring the safety of adjacent existing structures, public facilities and utilities, and workers at job site.

Where any damages occurred to existing structures, facilities or the third party caused by the blasting, the Contractor shall take necessary step at his own cost to restore or repaire the facilities or whatever, compensate the cost incurred by the third party irrespective of locations whether it is inside or outside the limits of right-of way provided by the Employer.

(h) Expenses required for blasting operations, protective equipment and safety provisions or any other work required shall be included in the unit price of relative works as shown in the Priced Bill of Quantities.

(12) Clearing and Grubbing

Clearing and grubbing to be executed prior to commencement of filling or excavation shall include such work as clearing of all vegetable growth, such as trees, logs, upturned stumps, roots of downed trees, brush, grass, weeds, and all other objectionable material, including concrete or masonry, within the limits of the work, removal and disposal of cleared and grubbed materials.

All the stumps and roots at the locations of the filling work shall be removed from within the limits of at least 50 cm below the surface of the ground. Holes, pits and any other depressions resulted from removal of the roots shall be backfilled with suitable soil-mixed sand materials as approved by the Engineer.

All the expenses required for the execution of clearing and grubbing shall be included in the unit price of the relative work as shown in the Priced Bill of Quantities.

TS 4.03 Main Line Cuttings

(1) Definition

Main line cuttings shall refer to the work of cutting the existing ground in accordance with the earthwork drawings and profiles to prepare and finish the roadbed within the limits of the existing line and proposed area where the existing line will be diverted and new line will be constructed.

Main line cuttings are classified into crushed earth and loose rock sections, and the classification shall be made based on provision of "Classification of Soil Materials" in TS 4.02 (3) above.

Main line cutting shall include all the preparatory work as specified in TS 4.02 "General", finishing of the formation level and slope surface, and construction of side ditches or related work as required.

(2) Execution

(a) All debris, loose rocks, roots of downed trees and unstable soil lumps or other objectionable materials shall be removed from the slope surface and area adjacent to slope shoulder.

(b) When powder is used for excavation, the work shall be carried out with care in such a manner that rocks outside the limits of the work are not loosened caused by blasting.

(c) During the cutting work of soil-mixed sand and loose rock, excavation method and draining during the work shall be closely checked so as not to remain the areas adjacent to subgrade in loose and muddy conditions.

(d) During the course of excavation work, observation shall be closely made for indications in soil conditions and spring water condition which might adversely affect the grade of slope, and provide diversionary drainage ditch for protection.

(3) Determination of Soil-mixed Sand and Loose Rock

Soil-mixed sand and loose rock materials are classified as specified in TS 4.02 (3).

When the Contractor encountered the condition indicating the existence of loose rock during the work, the Contractor shall prepare the documents which will be substantial data for request for payment in future, specifying the location, level, length and extent, and submit them to the Engineer for review and approval.

(4) Method of Measurement

Volume of cutting work as the objective of payment shall be expressed in terms of cubic meters as a result of calculation of measured sections by the average section

method.
The Contractor shall prepare detailed drawings of profiles and cross sections in the designated scale on the tracing paper of the designated size and submit them to the Engineer for approval.
These drawings shall be used as the basis for calculation or determination of quantities for payment. The Contractor shall submit to the Engineer for review three copies of the drawings and detaile quantity calculation sheets.

(5) Basis of Payment
Cutting work shall include all expenses normally required for execution of the main line cuttings as specified under these specifications regardless of the distance required for transporting of materials.

Pay Item No.	Description of Work Item	Unit of Measurement
4	Main Line Cutting (Soil-mixed Sand)	m^3
5	Main Line Cuttings (Loose Rock)	m^3

TS 4.04 Temporary Line Cuttings

(1) Definition
Temporary line cuttings shall refer to the work of cutting of the ground for formation of roadbed for the temporary line to be provided as a detour in the area as provided on the temporary basis as a provisional step in constructing the structures on the existing line.
Temporary line cutting work shall be carried out in accordance with the earthwork drawings and the profile drawings as similar provisions under TS 4.02 "General" and shall include finishing of the formation level and construction of side ditches.
Temporary line cuttings shall be classified into soil-mixed sand and loose rock, and the classification shall be as specified under provisions of TS 4.02 (3).

(2) Execution
The work shall be executed in accordance with the provisions under TS 4.03 Main Line Cuttings – (2) "Execution".

(3) Determiantion of Soil-mixed Sand and Loose Rock
The provisions of TS 4.03 Main Line Cuttings – (3) Determination of Soil-mxied Sand and Loose Rock shall apply to this work.

(4) Method of Measurement
The provisions under TS 4.03 Main Line Cutting – (4) "Method of Measruement" shall apply to this section.

(5) Basis of Payment
The work shall include all the expenses normally required for the temporary line cuttings work as specified under these technical specifications, regardless of the distance required for transporting of materilas.

Pay Item No.	Description of Work Item	Unit of Measurement
6	Temporary Line Cuttings (Soil-mixed Sand)	m^3
7	Temporary Line Cutting (Loose Rock)	m^3

TS 4.05 Main Line Embankments

(1) Definition

Main Line embankments construction shall refer to the filling of the materials to form roadbed and roadway in section where the existing line route will be diverted and a new line will be constructed, and also in sections where the shape of embankments of the existing line do not coincide with the roadway diagraph and profile.
This work shall include, in addition to all the preparatory work provided in TS 4.02, clearing and grubbing, transporting of soil materials, uniform laying of materials, preparation of benching, adjusting of moiture content ratio, soil compaction, slope tamping, finishing of the formation level, provision of drainage system druing the work, testing and filling, and any other related work.

(2) Embankment Materials

Embankment materials shall be suitable materials for the work approved by the Engineer, including soil materials derived from the cutting, clearing and grubbing of riverbed and excavation work, and soil materials transported and delivered from the borrow pit.
Soil materials which are unsuitable for embankment construction are considered to be such materials as top soil containing a large volume of organic substances, whity acidic soil, bentonite and soil whose natural moisture content ratio exceeds the moisture content limit.

(3) Execution of Test Embankment

Prior to commencement of the embankment work, a test embankment shall be constructed in accordance with the instruction of the Engineer. The test embankment shall be constructed for testing and determining of the optimum moisture content, the number of traffic of compacting equipment, thickness of layer for spreading all necessary for compaction requirements for embankment construction.
The compacting equipment to be used for embankment construction shall apply to this work.

(4) General Requirements for Execution

(a) Embankment materials shall be placed in the width, uniform thickness and level as specified by the Engineer. Normally, the thickness of each layer shall be determined as a result of test embankment construction, however, thickness of each layer shall be less than 50 cm in principle.

(b) When embankment is to be made and compacted on hillsides, the grade of which is greater than 4:1, or where new embankment is to be compacted against existing embankment, the slopes of original hillsides and old or new embankments shall be cut into a sufficient width horizontally as the work is built up in layers. Material thus cut out shall be recompacted along with the new embankment material to prevent slides and slipouts.

Volume of benching work on original hillsides or existing embankment shall not be measured as embankment quantities, however, it shall be included in the unit price of Main Line Embankment.

(c) Embankment construction adjacent to abutment, box culverts, and wing walls shall be carried out after structural strength has reached the requirements as specified by the Engineer.

(d) At locations where it would be impractical to use mobile power compacting equipment, embankment layers shall be compacted to the specified requirements by mechanical tamper that will obtain the specified compaction.

(e) Where embankment shrinkage is anticipated, surcharge embankment shall be constructed to the height and to the limits as specified by the Engineer. Surcharge banking material directed by the Engineer shall be paid on the basis of the unit price of the embankment construction.

(5) **Rock Embankment Construction**

(a) Where rock materials are to be used for rock embankment construction, the materials shall be crushed to diameter of less than 50 cm, and be well distributed throughout the embankment and sufficient earth or other fine material shall be placed around the larger material as it is deposited so as to fill the interstices and produce a dense, compact embankment.

(b) Rock materials shall not be placed within the limits of one metre in depth below the surface of the slope of embankment.

(6) **Execution of Slope Surface of Embankments**

(a) Materials to be used for embankment slope shall be identical to the materials for embankment with the execution of special cases.

(b) As a rule, compaction shall be carried out with the use of mobile power compacting equipment to the extent adjacent to slope shoulder where applicable where it would be impractical to use mobile power compacting equipment, the work shall be carried out by any other method that will obtain the required compaction.

(c) As the embankment construction is built up in layers, thesurface of slopes shall be compacted and finished to the extent as required.

(d) The Contractor shall take necessary steps to preclude any damage or defects cause by rainfall or whatever until the surface of the slopes are in a firm and stable condition.

(7) **Compaction Requirements and Inspection**

(a) Comapction requirements shall be controlled in accordance with AASHTO T222–78, "Non-repetitive Static Plate Load Test of Soil" and the value shall be not less than 11 kg/cm^3 to a depth of 2 meters below the finished grade of embankment, and the value within the limits beyond 2 meters in depth shall be not less than 7 kg/cm³.

(b) Embankment compaction test shall be conducted in accordance with the instructions by the Engineer at three different locations; e.g. the center and both ends of embankment of each 150 cm depth for every 100 meters in extension embankment length.

(8) **Optimum Moisture Content**

Where the moisture content found not meeting the required value, the Contractor shall take any suitable measures to obtain moisture content as required in a manner as approved by the Engineer.

(9) **Stability**

The Contractor shall be responsible for maintaining the embankment in a firm and stable condition. When damage, defects or deformation were found to the embankment due to negligence or default by the Contractor, repair, restoration and compensation to the damage shall be absorbed by the Contractor.

(10) Method of Measurement

Volume of main line embankments as the objective of payment shall be the volume of embankment compacted in the manner as approved by the Engineer, and shall be expressed in cubic metres.

The quantity shall be calculated by the average section method. The Contractor shall prepare the necessary detailed profile and cross section drawings in the designated scale on the tracing papers of the designated size in pencil and submit them to the Engineer for review and approval.

These drawings shall become the basis for calculation of quantities for the payment.

The Contractor shall submit to the Engineer three copies of the aproved drawings and the detailed quantity calculation sheets.

(11) Basis of Payment

The unti price of main line embankments shall include all the expenses required for execution of the work as specified under these technical specifications, conditions of contract and general specifications.

Payment shall be made on the basis of cubic metres for the quantities of embankment construction.

Pay Item No.	Description of Work Item	Unit of Measurement
8	Main Line Embankments	m^3

TS 4.06 **Temporary Line Embankment**

(1) **Definition**

Temporary Line embankment construction shall refer to the work of filling of the materials to form the roadbed and roadway for construction of a temporary line provided as a detour on provisional basis until the structures for the new line is constructed. The work shall include, in addition to preparatory work as specified under TS 4.02, clearing, grubbing, borrowing, transporting of soil materials, palcing, benching, adjusting of moisture content, compacting, tamping, finishing of the formation level, provident diversional drainage ditches during the work, implementation of testing and construction of the embankment.

(2) Embankment Materials
TS 4.05 (2) "Embankment Materials shall apply.

(3) Test Embankment Construction
TS 4.05 (3) "Test Embankment" shall apply.

(4) Temporary Drainage System and Temporary Waterway
Where temporary line embankments are to be constructed across the river or at the area where damming and blockage of run-off water which might adversely affect the embanment slopes is anticipated, the Contractor shall provide suitable temporary drainage system or temporary waterway in consideration of the contributory area of river, topographical conditions of the surrounding area, geological, meteorological and working conditions or any other conditions which are deemed necessary.
The Contractor shall be fully responsible for maintenance of the draining facilities throughout the period of use.
All the expenses required for designing, construction, operations, maintenance and removal of the temporary drainage system and temporary waterway shall be included in the unit price of the temporary line embamkments.

(5) General Requirements for Execution
TS 4.05 (4) "General Requirements for Execution" shall apply.

(6) Execution of Rock Embankments
TS 4.05 (5) "Execution of Rock Embankments" shall apply.

(7) Execution of Slope Face of Embankments
TS 4.05 (6) "Execution of Slope Face of Embankments shall apply.

(8) Compaction Requirements and Inspection
TS 4.05 (7) "Compaction Requirements and Inspection shall apply.

(9) Optimum Moisture Content
TS 4.05 (8) "Optimum Moisture Content" shall apply.

(10) Stability
TS 4.05 (9) "Stability" shall apply.

(11) Provisional Acceptance
The Contractor shall notify the Engineer of completion of roadbed work of temporary lines by each section.
After receipt of the notice from the Contractor, the Engineer will conduct inspection of the temporary line and will issue a certificate of completion to the Contractor for provisional acceptance provided that the work is in compliance with the requirements.
After issuing the certificate for completion, the Employer will divert the existing main line track to the temporary line for trains operations.
While the Employer carries out operations and maintenance for the track on the temporary line, the Conractor shall be responsible for repair or maintenance for temporary line embankment, temporary drainage system and temporary waterways thoroughout the period of use of the temporary line.

(12) Method of Measurement

Volume of temporary line embankments as the objective of payment shall be the volume of embankment materials compacted in the manner as specified and as approved by the Engineer, and shall be expressed in cubic metres.

Quantities shall be calculated by the average section method. The Contractor shall prepare necessary profile and cross section detailed drawings in the designated scale on tracing paper of the designated size in pencil and submit them to the Engineer for review and approval.

The drawings shall become the basis for calculation of quantity for payment.

The Contractor shall submit to the Engineer three copies of approved drawings and detailed quantity calculation sheets.

(13) Basis of Payment

The unit price of temporary line embankments shall include all the expenses required for execution of the work as specified under these technical specifications, conditions of contract and general specification and other related work as required for construction of temporary line embankment.

Payment shall be made on the basis of cubic metres for the quantities of embankment construction work as specified elsewhere in this specification.

Pay Item No.	Description of Work Item	Unit of Measurement
9	Temporary Line Embankment	m^3

TS 4.07 Clearing and Grubbing of Riverbed

(1) Definition

Clearing and Grubbing of riverbed shall refer to the work of removing all objectionable material from within the limits of the work, including construction areas of existing line, temporary line and crossing with new line; and removal of part of embankment which would adversely affect the alignment and profile of the river as planned by roadway diagraph, and excavation work of natural ground, disposal of surplus material, forming and shaping work of river cross sections and associated work.

(2) Execution

(a) The slopes and areas adjacent to shoulder of the river shall be cleared of all vegetable growth, such as trees, logs, upturned stumps, roots of downed trees, brush, grass, weeds, and all other objectionalbe material, including loose rocks and unsuitable soil lumps.

(b) Where powder is used for the excavation of rock bed, care shall be exercised so as not to loosen any rock bed outside the section of the river on the plan.

(c) The work shall be executed with care so as not to cause adverse effect to structures or embankments or natural ground outside the river section in the plan due to rainfall or flood during the period of execution of the work.

(3) Method of Measurement

Volume of the clearing and grubbing of riverbed as the objective of payment shall be the volume of the work calculated by the averaga section method and shall be expressed in cubic metres.

The Contractor shall prepare profile, cross section and plan drawings of clearing and grubbing of riverbed in the designated scale on tracing paper of the designated size in

pencil and submit them to the Engineer for review and approval.
These drawings shall become the basis for calculation of quantity for payment.
The Contractor shall submit to the Engineer three copies of the approved drawings and the detailed quantity calculation sheets.

(4) Basis of Payment
The unit price of the clearing and grubbing of riverbed shall include all the expenses required for the work as specified in this technical specification, conditions of contract and general specifications and also for the execution of the clearing and grubbing of riverbed.
Payment shall be made on a cubic metre basis for the volume of the work calculated in the previous section.

Pay Item No.	Description of Work Item	Unit of Measurement
10	Claring and Grubbing of Riverbed	m^3

TS 4.08 Structure Excavation

(1) Definition
Structure excavation shall refer to the work of excavating the natural ground and backfill for structures to be provided as specified and at the locations indicated on the drawings.
The excavation defined in TS 4.07 "Ckearing and grubbing of riverbed" shall not apply to structure excavation.
Structure excavation shall be clssified into soil-mixed sand and loose rock, and the classification shall comply ith TS 4.02 (3).
Structure excavation shall be limited to excavation work for structures such as bridge substructures, box culverts and U-shape retaineing walls.
Structure excavation work shall include all the work of excavating soil-mixed sand or loose rock, transporting surplus soil material to the strorage area, disposal of unsuitable material, temporary placement, backfilling, compaction of backfilled material, drainage system necessary for the work, the construction of cofferdams or other temporary water control facilities and its subsequent removal, diversionary access, diversionary drainage ditch, removal of any objectionable materials to the structure excavation.

(2) Execution

(a) The Contractor shall notify the Engineer sufficeintly before commencement of the structure excavation work such that the Engineer will have ample time to conduct survey on the existing ground. The existing ground adjacent to the structure shall not be disturbed without obtaining the permission by the Engineer.

(b) The structure excavation shall be sufficient to the extent (as shown on the drawings) such that construction of the structure or substructure can be carried out without any disturbance.

(c) Loosened portions shall be removed from the surface of supporting rock or other supporting soil of solid foundations to remain the suitable open and exposed for cleaning.

(d) Where construction of foundation is to be carried out above the finished subgrade other than solid bedlock, the structure excavation to the level of the supporting soil surface shall not be performed until immediately before commencement of foundation work.
Where the foundation ground is too soft or found and judged to be unsuitable for the work by the Engineer, unsuitable material shall be removed and replaced with uniform grain size sand, gravel and crushed stones. The replacement work for the foundation ground shall be executed to the level of the foundation surface as specified by the Engineer, and compaction shall be done with the sue of suitable tamping equipemnt to obtain adequate bearing capacity.

(e) The contractor shall provide appropriate equipment to prevent rainwater and natural water (spring water) from flowing into the excavated places during the work and also drain the rainwater and spring water from the excavated places using appropriate equipment.

(3) Confirmation of Load Bearing Capacity of Supporting Soil
The Contractor, when the structure excavation work approaches the bottom surface of the structure excavation as shown on the design drawings, shall conduct a survey to determine whether or not the load bearing capacity is adequate as a fountion for the structure. The Contractor shall also carry out a survey when he encounters a ground with sufficient load bearing capacity before reaching the bottom of the structure excavation and the bearing layer is confirmed to extend deeper.
In either case, the Contractor shall carry out the survey under the supervision of the Engineer, and the Contractor shall not construct the foundation or box culvert without approval of the Engneer.
The Engineer, when he judges that the soil or load bearing capacity of the supporting soil are unsuitable as a foundation for the structure, shall be in a position to instruct the Contractor to change the dimensions of the substructure and height of the foundation bottom surface in order to secure a statisfactory foundation base.

(4) Utilization of Soil Materials derived from Structure Excavation
Suitable soil material derived from the structure excavation shall be used for backfilling or embankments. The soil material which is not utilized for the work shall not be disposed of in such a manner that damping into a river or into a waterway. In no event, shall the soil material from the structure excavation be set or placed in such a manner so as to cause an adverse effect to the structure, and disposed of the same shall also be executed with similar care.

(5) Backfilling for structures and Embankment adjacent to Structure

(a) Backfill material shall be placed in uniform layers, and the thickness of each layer of backfill shall not exceed 30 cm before compaction.
Each layer shall be thoroughly compacted with the use of a mechanical tamper.

(b) For backfilling work where the backfilled soil constitute a part of the roadbed, the soil shall be thoroughly compacted in accordance with the requirements as specified in TS 4.05 Main Line Embankments.

(c) For backfilling work for abutment, the work shall be executed with the use of suitable material approved by the Engineer, and the backfilled soil shall be thoroughly compacted with the use of a comapctor or a mechanical tamper.

(d) Backfilling or embankment work shall be executed in such a manner that each layer will be placed and brought up uniformly on all sides of the structure of facility to the approximate height and level.

(e) Backfilling or embankment work shall be done in principle, at a time when the strength of the test piece of concrete used for the structure reaches 75% of the design strength and has been approved by the Engineer.

(f) Portions of weep holes shall be backfilled with gravel or other suitable material so as to enable them to function satisfactorily.

(6) Method of Measurement

The amount of structure excavation as the objective of payment shall be the volume calculated by the average section method and it shall be expressed in cubic metres. However, in case where the section has some payment to be made under clearing and grubbing of riverbed such a section shall be excluded from the calculation.

The volume of soil-mixd sand or loose rock measured for structure excavation shall be measured from the design excavation. This design excavation shall be the value obtainable by multiplying the horizontal projection area of the structure's foundation bottom surface by the average height from the bottom surface to the average existing ground level (the finished surface in the case of clearing and grubbing of riverbed). The average existing ground level shall be calculated from the track centerline for a bridge and also from the centerline of the structure for a box culvert.

The expenses for structure excavation for crushed rock for foundation, retaining wall and miscellaneous concrete works shall not be paid separately, and these expenses shall be included in the measurement unit.

The Contractor shall submit to the Engineer three copies of the approved drawings, which show the level of existing ground before commencement of the structure excavation and also the level of the bottom surface of the structure excavation, and the detailed quantity calculation sheets.

(7) Basis of Payment

The unit price of the structure excavation shall include all expenses for the work as specified in this technical specification, conditions of Contract and general specification and also for execution of the structure excavation.

Payment shall be made on a cubic metre basis for the volume of work calculated in the previous section.

Pay Item No.	Description or Work Item	Unit of Measruement
11	Excavation (Soil-mixed Sand)	m^3
12	Excavation (Loose Rock)	m^3

TS 4.09 Demolotion of Structures

(1) Definition

Structure demolition work shall refer to the work of demolishing, removing and disposing of, in a suitable manner, existing structures which have an adverse effect to construction of new structure. However, an existing structure which is to be removed and disposed of in other sections of this Contract shall be excluded from this section. Further, structures which are deemed to be the objectives of work in this section shall be retaining walls and box culverts.

(2) Execution

(a) In the case of the presence of an existing structure which has an adverse effect to execution of the work, the Contractor shall prepare the general view and the quantity calcultion sheets and submit them to the Engineer together with the demolition work plan. Work shall not commence until approval is given by the Engineer.

(b) During demolition work, hard lumps or debris shall be broken and reduced in size by appropriate means into pieces measruing 0.2 cubic metres or less, and carried away to the downstream side of a river and disposed of the limits of clearing and grubbing of riverbed.

(c) The entire structure shall be demolished and removed even when only a part of the existing structure prevents execution of the work, and the pits, holes or any other depressions resulting from the demolishing work shall be back-filled with suitable material as approved to the extent of the level of the adjacent existing ground level.

(3) Basis of Payment

The Contractor, upon completion of the work, shall ask the Engineer to supervise inspection of the work and also to give approval on completion of the work.

The unit price of structure-demolishing work shall include all the expenses for the work as specified in the technical specification, condition of Contract and general specification and also for execution of the structure demolishing work.

Payment shall be made on a cubic metre basis for the volume of the existing structure as approved in the previous section (a).

Pay Item No.	Description of Work Item	Unit of Measurement
19	Demolition of Structures	m^3

TS 4.10 Boulder for Foundation

(1) Definistion

Boulder for foundation work shall refer to the work of placing and ramming boulder in the locations as shown on the design drawings where the bearing base of the foundation of the structure is not bedrock.

(2) Materials

The material to be used for this work shall be suitable natural stone or crushed stone, hard and durable as approved by the Engineer.

Where the materials derived from TS 4.09 are utilized, hard material shall be selected, processed, and be approved by the Engineer prior to the use.

(3) **Execution**

Boulders shall be placed on the bottom surface of the structure excavation and thoroughly rammed with a rammer or other suitable tools so as not to leave any uneven surface to the level as specified and as required.

(4) **Method of Measruement**

Upon completion of the work, the Contractor shall ask the Engineer to supervise inspection of the work. Subsequent to the completion of the measurement of height to the top of the boulder and also of verifying the ramming depth of the boulders, the Contractor shall ask the Engineer for approval on completion of the work.

The Contractor shall prepare detailed quantity calculation sheets expressed in terms of cubic meters on the basis of the value confirmed by the Engineer, and submit three copies of the detailed quantity calculation sheets to the Engineer.

(5) **Basis of Payment**

The unit price of the boulders for foundation work shall include all the expenses required for the work as specified in this technical specifiction, conditions of contract and general specification and also for execution of the foundation boulder work.

Payment shall be made on a cubic metre basis for the quantity of work calculated in the previous section.

Pay Item No.	Description of Work Item	Unit of Measurement
13	Boulder	m^3