REPUBLIC OF BOLIVIA

BOLIVIAN NATIONAL RAILWAYS

RAILWAY CONSTRUCTION PROJECT, EASTERN LINE

(TAPERAS - ROBORE)

Vol. 1. Instructions to Bidders
2. General Conditions of Contract
3. Bid Form
4. General Specifications
5. Technical Specifications
6. Special Specifications
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8. Drawings
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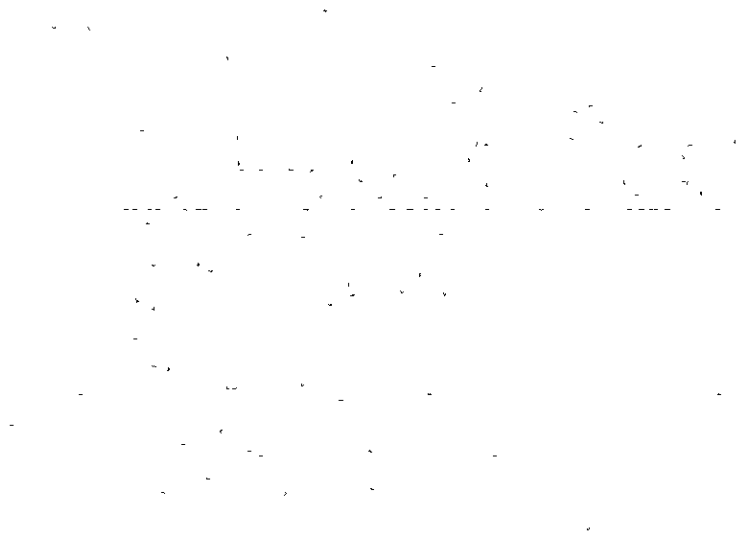
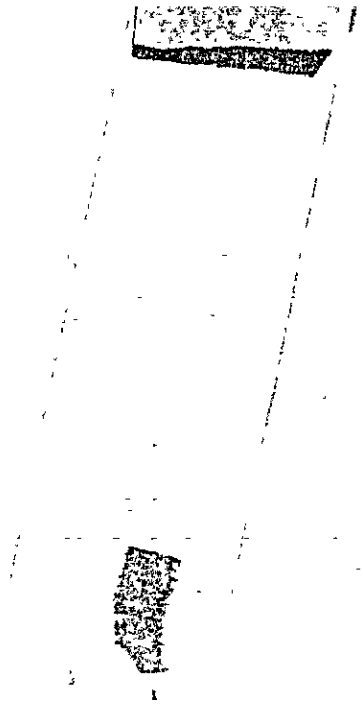
Volume 5

March, 1981

JAPAN INTERNATIONAL COOPERATION AGENCY

(JICA)





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CONTENTS

Technical Specification

SECTION 1 ALIGNMENT SURVEY WORKS

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TS 1.01 **Scope**

The Contractor shall carry out all alignment survey works necessary for the preparation of Detailed Drawings.
The alignment survey works consist of (a) the alignment location survey, (b) the bench mark survey, (c) the profile levelling survey, (d) the cross-section levelling survey, (e) the plane survey and (f) the resurvey due to partial realignment.
The re-establishment of the centerline on the completed subgrade for the purpose of track construction is included in the track construction work, and the cooperation with the Engineer in checking survey and measurement for payment are construed to be included in respective sections of work.

TS 1.02 **Surveyors**

All survey works required under this section as well as other sections of work shall be executed by competent surveyors. The Contractor shall be responsible for the accuracy of all survey works and measurements made by his surveyors.

TS 1.03 **Plans and Data to be furnished**

The Employer will provide the Contractor with a topography map of the Site with contour lines in the scale of 1:5,000 made from airphoto, containing the proposed alignment of the railway to be constructed together with all alignment data thereof. All survey works shall be carried out in reference to the National Triangulation Point and National Bench Marks.

TS 1.04 **Alignment Location Survey**

(1) General
The Contractor shall establish at the Site the entire alignment shown in the Drawings under the supervision by the Engineer.

(2) Stakes to be established
The types of stakes to be established are as follows. On every stake the type of stake and its constants shall be indicated. All stakes are of wood.

(a) Main Stakes

Table 1-1 Size of Main Stakes

Location	Size of Stake	Embedding Dept
Intersecting points	9 cm x 9 cm x 90 cm	more than 80 cm
Beginning points & Ending points of Transition Curve	9 cm x 9 cm x 90 cm	more than 80 cm
Beginning points & Ending Points of Circular Curve	9 cm x 9 cm x 90 cm	more than 80 cm

(b) Centerline Stakes

Table 1-2

Location	Interval of Stakes	Size of Stake	Embedding Depth
Straight portions	100 m	4.5 cm x 4.5 cm x 60 cm	more than 40 cm
Straight portions	1.0 km	9 cm x 9 cm x 90 cm	more than 70 cm
Curved portions	20 m	4.5 cm x 4.5 cm x 60 cm	more than 40 cm

(c) Protecting Stakes

Table 1-3

Stakes to be protected	Size of Stake	Embedding Depth	Number of protecting stakes per location
Main stakes	4.5 cm x 4.5 cm x 60 cm	Appropriately	4
Centerline stakes at every one kilometer	4.5 cm x 4.5 cm x 60 cm	Appropriately	4

(3) **Accuracies**

The accuracies of supplementary traversing survey for the alignment location sruvey shall be as follows:

(a) Difference in horizontal angles measured — within 15 seconds
(b) Difference in double angles measured — within 30 seconds
(c) Difference in vertical angles measured — within 40 seconds
(d) Difference in closing of directional angles measured — within 30 second x $\sqrt{n}$

Note: n means the number of measured lines.

(4) **Fruits to be submitted**

Fruits to be submitted after completing the alignment location survey are as follows:

(a) Measurement data sheets of supplementary traversing survey;
(b) Plan showing measured data of the supplementary traversing survey and the alignment locaiton survey.

TS 1.05 **Bench Mark Survey**

(1) **General**

In this survey the Contractor shall establish a bench mark at every one kilometer along the proposed alignment and altitude of bench marks shall be measured.

(2) **Bench Marks**

Bench marks to be established shall be located so as to enable to use them throughout the construction period. Bench marks shall be of wood piles of 12 cm x 12 cm x 120 cm and shall be embedded into the firm ground more than 110 cm in depth, a metal nail shall be driven on the top of piles. Every bench mark shall be surrounded by 4 protecting stakes.

(3) **Accuracies**

The required accuracies of bench mark survey are as follows.

(a) Difference of return levelling within 10 mm x $\sqrt{S}$

(b) Difference in closing levelling within 10 mm x $\sqrt{S}$

Note: S means levelled distance expressed in Km.

(4) **Fruits to be submitted**

Fruits to be submitted after completing the levelling survey are as follows:

(a) Levelling Field Note-Books;

(b) Data Sheets of Measurements;

(c) Description on bench marks;

(d) Calculation Note-Books;

(e) Calculated Data Sheets of given points;

(f) Plan showing the locations of Bench Marks.

TS 1.06 **Profile Levelling Survey**

(1) **General**

In Profile Levelling Survey the Contractor shall measure altitude of all centerline stakes and sudden changes of ground height referencing to altitude of nearest bench mark and also the horizontal distances between sudden changes of gound height and the nearest centerline stakes. Levelling shall be started from a bench mark shall be closed to the same bench.

(2) **Accuracy**

The required accuracy in the Profile Levelling Survey is specified within 30 mm in closing difference.

(3) **Preparation of Longitudinal Profile of Alignment**

The Contractor shall prepare longitudinal profiles of the alignment conforming with the followings conditions:

(a) Scales of profile: Vertical 1/500
Horizontal 1/2,500

(b) Profiles: Original profile drawn on section paper with ink;
Second original drawn on polyestel film with ink;

(c) In the profile it is requested to indicate gradients of profile, locations and parameters of curves, interval distances of measured points and their calculated altitudes.

(4) Fruits to be submitted

Fruits to be submitted after completing the profile levelling survey are as follows:

(a) Levelling Field Note-Books;
(b) Original Drawing of Profile drawn on section paper rolls;
(c) Second Original Drawing of Profile drawn on polyestel film;
(d) Blue prints of profile in three copies.

TS 1.07 Cross-Section Levelling Survey

(1) General

In the cross-section levelling survey the Contractor shall measure the elevations of and distances between all centerline stakes, other additional points requested by the Engineer plus all centers of proposed structures and additional points to be requested by the Engineer and also all changes of ground height in the direction of right angle to the centerline at each centerline stakes.

The width of cross-section levelling survey is 40 meters, namely 20 meters each from the centerline to both sides.

(2) Accuracy

The required accuracy of cross-section levelling survey are within 10 cm in distance measurement and 5 cm in elevation measurement.

(3) Preparation of Cross-Sections

In preparation of cross-sections the following conditions shall be observed:

(a) Scale of cross-sections shall be 1/100 in both horizontal as well as vertical directions;
(b) Cross-sections shall be drawn with ink on transparent section-papers in 1.0 mm grid;
(c) In all cross-sections a base line indicated with altitude, ground heights of cross-section and distance from the starting point should be indicated.

(4) Fruits to be submitted

Fruits to be submitted after completing the cross-section levelling survey are as follows:

(a) Cross-Section Levelling Field Note-Books;
(b) Original drawings of cross-sections drawn on tracing papers.

TS 1.08 Plane Survey

(1) General

In the plane survey the Contractor shall survey and prepare plans including all areas of right-of-way, station ground and additional plans of bridge and box-and pipe-culvert (box, pipe) sites. The minimum width of plane survey is 30 meters, namely 15 meters each to both sides from the centerline of proposed alignment.

(2) Accuracy

The allowable tolerance of measurements in plane survey shall be within 0.5 mm on the final plans.

(3) Preparation of Plans

In preparation of plans the following conditions shall be observed:

(a) Standard scale of plans is 1/500, which may be changed by the Engineer's direction into 1/200 to 1/1,000.

(b) In plans it is requested to indicate locations of all bench marks, centerline stakes, creeks, rivers, channels, roads, boundaries, type and kinds of ground use and also all items related with the project work and the acquisition of right-of-way.

(c) Contour-lines shall be basically at one meter interval, and shall be at 0.5 meter interval in flat areas.

(4) **Fruits to be submitted**

Fruits to be submitted after completing the plane survey are plans drawn on polyestel film with ink.

TS 1.09 **Resurvey**

In cases when the Engineer requests to revise a part or parts of the proposed alignment by shifting the location of centerline, changing curves and/or gradients and also changing the locations of proposed structures the Contractor shall obey the Engineer's instructions.
In cases when it became necessary to conduct noticeable resurvey and/or additional survey they shall be performed by the Contractor after the necessary negotiation between the Engineer and the Contractor on their contents and the payment for them

TS 1.10 **Payment**

Costs of cutting trees to secure the surveying visibility are included in the survey work except for the areas to be cleared and grubbed in the earthwork as shown in the drawings.
The cost of cutting trees and clearing of the sight lines for survey works shall be construed to be included in Pay Item "Survey Work" except for such costs inside of the areas to be cleared and grubbed in earthwork.
The Survey Work is construed to be made 100% when the Contractor submitted all fruits of survey work required and obtained the approval of the Engineer.

Pay Item No. and Name	Unit of Measurement
111 Alignment Survey Works	Lump sum

The payment of the survey works in lump sum will be made in the following two installations:

- 80% (Eighty per-cent) on the completion of centerline stakes for the earth work;
- 20% (Twenty per-cent) on the completion of whole works.

SECTION 2 SUBSURFACES EXPLORATIONS

SECTION 2 SUBSURFACE EXPLORATIONS

TS 2.01 **Scope and Purposes**

Subsurface explorations specified in this Section consist of explorations to be conducted with the seismic explorations, the electric registivity method and the exploratory excavations for the purpose to identify the types of soil of cut portions and depths of ground water table.

TS 2 02 **Qualification of Explorers**

Explorers who will engage in the subsurface explorations shall be competent enough to execute such subsurface explorations as required in this specifications. Technical career and background experiences of explorers shall be submitted to the Engineer in advnace for review and approval.

TS 2.03 **Seismic Explorations**

(1) The purpose of these explorations are to confirm the soils type, the depth and the inclination of basic strata at planned cut protions in earthwork, and also to confirm the depth of supporting strata and bearing power thereof for selecting optimum type and depths of foundations of railway bridges. The scope of depth of explorations is down to 30 meters beneath the ground surface or river bed.

(2) The explorations shall be conducted with the refracting method along measuring lines, the locations thereof are shown in the attached map. In giving impacts to the ground a hammer shall be used basically, but explosives may be used as the case may need. In using explosives for explorations the Contractor shall obtain approval of the Engineer in advance and shall take all necessary precautions specified in TS 4.05 (3).

(3) Measuring lines hsall be located divided into sections of 120 meters in length, in which hammering or blasting shall be conducted at 30 meters interval including additional one more point on each extended portion on both ends of the lines.

(4) Measuring sites of seismic wave speeds shall be basically located in 5 meters interval

(5) After conducting each measurement additional measurements shall be immediately carried out if the measurement was not successful.

(6) The results of measurements shall be analized taking into account the results of surface reconnaissance and the results of indoor seismic tests of samples taken from outcropped rocks.

(7) The Contractor shall, after analyzing measured data, submit to the Engineer for review and approval the followings:
   (a) Report on Subsurface Explorations by Seismic Method, in which the Contractor shall point out anticipated problems to be encountered in the execution of the Works from the viewpoint of these explorations:
   (b) Locaiton map of sites of seismic explorations (Scale: 1/250,000);
   (c) Distribution map of seismic wave-speeds measured and concluded geological plan of measured area (Scale: 1/5,000);

(d) Time-Distance Curves of Seismic Wave-Speeds along measuring lines by the method of difference (Scale: 1/1,000);

(e) Geological Formation Profile of Measuring Lines (Scale: 1/1,000) in which distribution of seismic wave-speeds shall be also recorded. (Scale: 1/1,000);

(f) Geological Formaiton Profile of the Railway Alignment (Scale: horizontal in 1/2,500 and vertical in 1/250); and

(g) Measurement records of seismic vibration.

TS 2.04 **Exploratory Excavations**

(1) The purpose of these excavations is to confirm the depth and characteristics of supporting strata of bridge foundations so as to supplement the results of Subsurface Explorations by seismic explorations

(2) Locations, forms and sizes of exploratory excavations will be directed by the Engineer among proposed sites of piers and abutments.

(3) Visual confirmation and geological identification of supporting strata shall be conducted by the Contractor under the presence of the Engineer every time when the geological formation is found different from the results of seismic explorations. The Contractor shall take photograph of them in color films, colored prints (8 cm x 11.5 cm in size) thereof shall be classified and to be included in the report to be submitted to the Engineer.

TS 2.05 **Subsurface Explorations by Electric Registivity Method**

(1) The purpose of these explorations is to confirm the distribution of underground water in order to install a well for supplying water to railway station and residence for railway official and his family at every intermediate railway station.

(2) In conducting the electric exploration the instrument of alternating current type shall be used, and the measuring shall be made by using Wenner's Method and Schlumberger Method, and the analyses of their measured data shall be made by using Sundberg's Standard Curves etc., to measure differences of electric registivity of underlying strata along the measuring lines.

(3) The sites and the direction of measuring lines will be directed by the Engineer.

(4) The maximum distance between electric poles is limited at 20 meters.

(5) The explorating depth shall be 200 meters. After conducting three measurements by the horizontal exploration in the upper strata and their analyses, then a vertical exploration by Schlumberger Method shall be conducted at the locations where are considered the existence of ground water.

(6) The Contractor shall, after conducting the explorations, submit to the Engineer for review and approval the followings:

(a) Report on the subsurface electric explorations by Registivity Method, in which the Contractor shall point our water-retaining strata;

(b) ρ - a Curves drawn on logarithmic section papers; and

(c) Records of measurements.

TS 2.06 **Survey on Filling Materials**

(1) The purpose of this survey is to confirm types and characteristics of soils to be excavated in roadway and borrow pits, their suitability for embankment and appropriate compacting method.

(2) The locations, where soil samples are to be taken, will be directed by the Engineer, 2 sites in low lying area and 2 sites in highland area.

(3) The following soil tests shall be carried out on soil samples collected at those sites hereinbefore mentioned:

(a)	Determining field moisture equivalent of soils	AASHTO T-93-68
(b)	Sieve analysis of fine and coarse aggregates	AASHTO T-27-74
(c)	Amount of material finer than 0,075 mm sieve in aggregate	AASHTO T-11-78
(d)	Determining the liquid limit of soils	AASHTO T-89-76
(e)	Determining the plastic limit of soils and plasticity index of soils	AASHTO T-90-70
(f)	Density of soils in-place by the cylinder method of soil	AASHTO T-204-64
(g)	Moisture-Density relation of soils using a 5.5-lb (2.5 kg) Rammer and 12 in. (305 mm) drop	AASHTO T-99-74

(4) After the survey was conducted the Contractor shall submit the followings:
- (a) Report on Soils Tests of Filling Materials, in which the Contractor shall point out anticipated problems to be encountered in earthwork from the view point of soil tests;
- (b) Location map showing locations of sampling soils; in scale of 1:250,000
- (c) Summary soils tests; and
- (d) Data sheets of soils tests.

TS 2.07 **Payment**

The subsurface explorations is construed to be made 100% when the Contractor submitted all fruits of subsurface explorations required and obtained the approval of the Engineer on the contents thereof.

Pay Item No. and Name	Unit of Measurement
211 Subsurface Explorations	Lump sum

The payment of subsurface exploraions in lump sum will be made in the following one installation:

- 100% (Hundred per cent) on the completion of the subsurface explorations.

SECTION 3 PREPARATION OF DETAILED DRAWINGS

SECTION 3 PREPARATION OF DETAILED DRAWINGS

TS 3 01 General

In preparation of Detailed Drawings of the Works the Contractor shall prepare them respecting the intentions of the Basic Drawings and paying attention simultaneously to the actual conditions of the Site. If there exists any portion or portions in the Basic Drawings which are considered not suitable to the actual conditions of the Site, the Contractor shall notify the actual conditions of the Site, the Contractor shall notify the Engineer case by case the reason of unsuitableness of the said portion or portions of the Basic Drawings and shall propose appropriate alternative design together with sufficient back-data to justify their revisions. The Contractor shall, upon the approval of the Engineer, proceed to finish up details of the partial revesions of the Basic Drawings according to the Design Criteria of respective Clauses of this Section.

TS 3.02 Design Criteria for Railway Alignment

The design criteria for railway alignment are as follows:

(1) **Maximum grade in longitudinal profile** in stfaight portions of the main track between stations is limited to 10/1,000 in general; however, the grade up to 12/1,000 is allowed by the Engineer's judgement if there exists no hindrance to train operation. The grade in curved portions shall be reduced as follow due to curve resistance:

Maximum grade in curved portions = 10/1,000 – 0.54G/1,000
(or 12/1,000 – 0.54G/1,000)

Where, G indicates the angle at the center of curve in degree sustained by a chord of 20 m.

The relation between reduis R and of angle G is as follow:

$$R = \frac{10}{\sin\frac{G}{2}}$$

Where, R = Radius (m)
G = Angle (degree)

The grade of the main track as well as side tracks within station yards shall be levelled off normally.

(2) **Vertical Curve**
Vertical curve of the radius of 2,000 m shall be inserted at the grade-changing points. points.

(3) **Minimum Radius of Horizontal Curves**
The minimum radius of horizontal curves shall be limited to 301.61 m on main track, while it may be reduced down to 150 m on side tracks in station yards. At least 100 m of a straight portion should be inserted between two consecutive curves.

(4) **Superelevation**
Superelevation of railway track at curved portions should be calculated by the following formula:

$$C = \frac{G}{g.R}\left(\frac{Vo}{3.6}\right)^2 = \frac{G\,Vo^2}{0.127\,R}$$

C : Amount of superelevation (mm)
G : Track gage (1,000 mm)
Vo: Average train speed (km/h) $= \sqrt{\frac{\Sigma V_1^2}{N}}$
R : Radius of curvature (m)
g : Acceleration due to gravity = 9.8 m/sec^2
V_1 : Speed of various trains passing over the curved portion (km/h)
N : Total number of trains per day

The following conditions must be satisfied by superelevation:

Maximum Superelevation on Main Track (Refer to Table 3-1)
In consideration of the operating conditions on the Eastern Line between Santa Cruz and Corumba, the maximum allowable operating speed shall be assumed 90 km/h for ferrobuses and 70 km/h for other trains.

Required Superelevation (Refer to Table 3-1)

Table 3-1 Track Superelevation by Speed and By Radius and Radius of Curvature

(Unit: mm)

Average Speed (km/h)	Radius of Curvature (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

(5) **Slack of Track Gage**
The maximum slack of gage shall be limited at 30 mm. Tapering-off of specified slack shall be made over the total length of transition curve. Slacks by radius are shown in Table 3-2.

Table 3-2 Slack of Track Gage

Radius of Curvature (m)	Slack of Gage (mm)
$R < 170$ m	30
$170\ m \leqq R < 200$ m	25
$200\ m \leqq R < 240$ m	20
$240\ m \leqq R < 320$ m	15
$320\ m \leqq R < 400$ m	10
$400\ m \leqq R < 600$ m	5
$600\ m < R$	0

(6) **Transition Curves**

The straight track shall be normally connected with circular curve through the standard transition curve of cubic parabola. Length of a transition curve shall be selected among those calculated under the following formula taking into account the speeding-up of train operation in future

$$L = 300\ C$$

Where,

L: Required length of a transition curve (mm)

C: Amount of Superelevation (mm)

Note: Calculated length of transition curve according to the above formula shall be rounded up in 5 m step.

Transition curve is not applied to those circular curves having radius longer than 600 m.

Formula of Cubic Parabola (Refer to Fig. 3-1)

Length of transition curve = L

Projected length of transition curve on tangent = X

Magnitude of shifting $F = \frac{X^2}{24R}$

Ordinate of Biginning of circular curve $Yx = \frac{X^2}{6R}$

Sprial angle $\delta_0 = \frac{X}{6R}$

Angle between tangents at biginning of transition curve and at beginning of circular curve $\theta = \frac{X}{2R}$

Ordinate at a distance x from the beginning of transition curve $Yx = \frac{X^3}{6Rx}$

Projected length of tangent at beginning of circular curve $j = \frac{X}{3}$

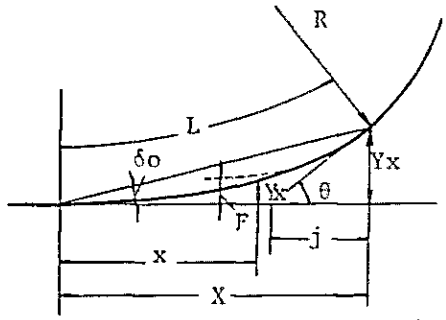


Fig. 3-1 Transition Curve of Cubic Parabola

TS 3.03 **Design Criteria for Earthwork**

The design criteria for railway earthwork are as follows:

(1) ***Over-clearance of Track for Rolling Stock and Buildings***

The main line of railway is of single track and the clearance gages over railway track on stright track for rolling stock and buildings are shown in attached Fig. 3-2. In curved portions the clearance shall be widen on the both sides of curve so that set-off of the fixed structures may maintain clearance as provided on the straight track for passing rolling stock.

(2) Track Gage

The gage of railway track is 1,000 mm.

(3) Subgrade Width (Refer to Fig. 3-3)

Subgrade width is 6.00 m. The subgrade shall be provided with a slope of 3.0% down grade from the centerline of the subgrade toward both shoulders for the purpose of surface drainage.

(4) Side Slopes of Embankment (Refer to Fig. 3-3)

In case of embankment of less than 5.0 m in height the side slopes shall be in 1.0 (vertical) . 1.5 (horizontal), and in case of embankment taller than 5.0 m the side of slopes shall be 1.0 (vertical) : 1.5 (horizontal) for the height of 3.0 m under the shoulder edge and 1.0 (vertical) : 1 8 (horizontal) for the rest part of the embankment.

A bench of 1.0 m wide shall be provided between two types of slopes hereinbefore mentioned.

(5) Backslopes in Cut Portions (Refer to Fig. 3-3)

In case of cut portions of less than 2.0 m in depth the side ditches of trapezoidal section, 1.0 m wide at top, 40 cm wide in bottom and 30 cm deep and berms of 2.0 m wide shall be provided outsides of both ditches; and backslopes shall be excavated 1.0 (vertical) : 1.2 (horizontal).

In cut portions of soft or weathered rock and hard rock the side ditches shall be 40 cm wide and 30 cm deep, and berms shall be of 1.0 meter wide in case of soft and weathered rock and 20 cm wide in case of hard rock. Backslopes shall be vertical. Intercepting ditches of 1.0 meter wide and 60 cm deep shall be excavated parallel to and more tan 2.0 meters distant form the upper cut line. No treatment shall be made on rock out backslopes.

Excavated soils from intercepting ditches shall be left along intercepting ditches as a water training dike preventing inflow of surface water from the background onto cut backslopes.

(6) Railway Track Structure

The track structure shall be as follows:

(Refer to Drawings.)

- Rails shall be 37.2 kg/m type and 18 m long of designation JIS-E-1101-1980 or its equivalent.
- Rails of 18 m long shall be welded into 36 m rails and shall be joined together at Site suing joint bars of 37.2 kg/m rail type aforementioned or it equivalent.
- Ties shall be made of QUEBRACHO timber with the dimensions of 0.12 m x 0.24 m x 2.00 m.
- Ties shall be spaced at a rate of 1,600 pieces per kilometer on main track and at a rate of 1,500 pieces per kilometer on side tracks.
- Ballast shall be crushed stone of hard rock and shall be filled to the thickness of 20 cm beneath the bottom of ties on the gage line in straight track sections, and 20 cm beneath the bottom of ties on the gage line of inner rail in curved portions where superelevation is provided to the track.
- Rails shall be fastened to ties by steel drive spikes of 1/2" x 5-3/4" of A.R.E.A. Timber Drive Spikes or its equivalent.
- The turnout to be used on main track as well as on side tracks shall be # 10

turnout of 37.2 kg/m rail of JIS-E-1101-1980.

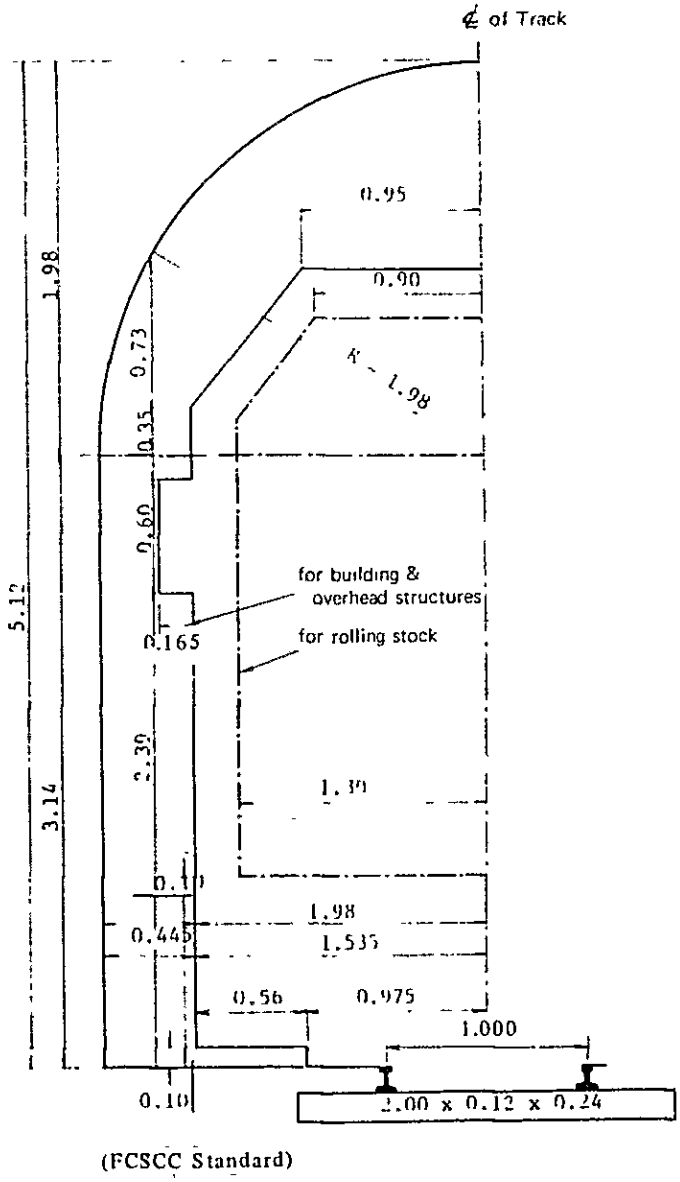
– The longitudinal profile of track alignment shall be expressed by the elevation of top of rail.

TS 3.04 **Design Criteria for Railway Structures**

(1) **Scope**

Preparation of Detailed Drawings for railway structures consists of Pipe Culverts, Box Culverts, Foundations, Substructures and Super-Structures of steel bridges.

Concerning those items relating to preparation of Detailed Drawings of structures are specified in this section, the Contractor shall follow those specifications and the directions to be given by the Engineer.



(FCSCC Standard)

Fig. 3-2 **Over-Clearances of Track for Rolling Stock and Buildings**

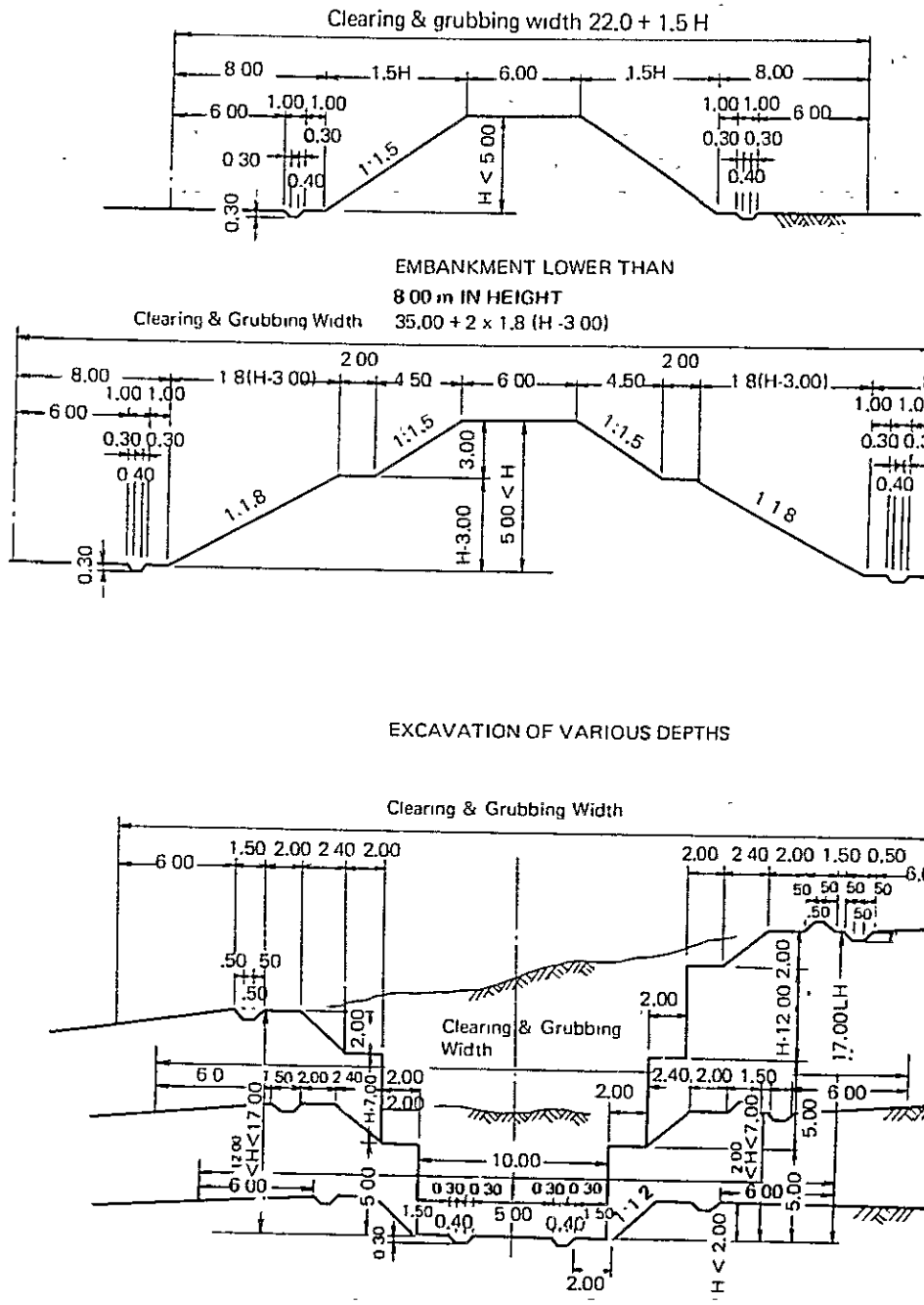


Fig. 3-3 Standard Cross-Sections of Earth Work

Fig 3-3 Standard Cross-Sections of Earth Work

(2) Basic Rules

(a) The Contractor shall upon designing structures consider objectives of structures, suitability of type to be adopted, convenience and easiness in construction, inspection and maintenance, construction economy and fitness to surrounding conditions.

(b) In design calculation the Contractor shall study strength, deformation and stability of structures under loading conditions specified in these specifications.

(3) Design Calculations

(a) Design calculations should be performed on structures in their static conditions basically designated;

(b) Structural analyses should be basically based on the principle of elasticity;

(c) Designing of structure members should be based on the allowable stress method;

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

(4) Design Criteria

(a) Types of Design Load

In designing railway structures the following types of design load shall be taken into calculation:

(i) Dead load
(ii) Live load;
(iii) Impact or dynamic effect of the live load;
(iv) Centrifugal force;
(v) Longitudinal forces;
(vi) Wind loads;
(vii) Current pressure;
(viii) Earth pressure;
(ix) Thermal force due to temperature variation;
(x) Others such as buoyancy, shrinkage stresses, rib shortening, erection stress, etc.

(b) Dead load (Refer to Table 3-3)

In calculation of dead load following unit weight of materials should be applied.

(c) Live Load

(i) Train Load

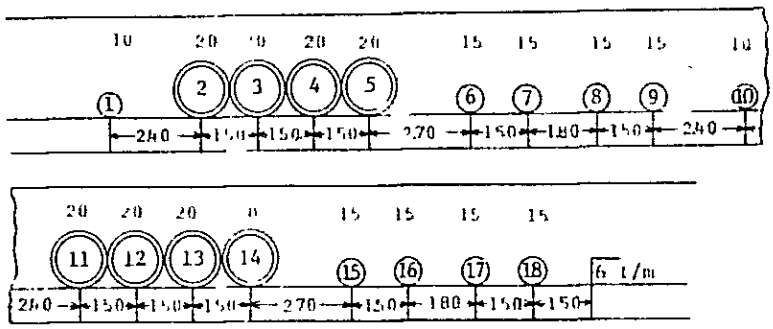
Train load of Cooer E-45 as shown in the Fig. 3-4 should be applied in stress analyses so as to give the maximum stress in structure members.

(ii) Unifrom load due to pedestrians

Uniform load on walkway due to pedestrians shall be assumed to be 300 kg/m^2.

Table 3-3 Unit Weight of Materials

Type of Material	Unit Weight (kg/cm^3)
Steel, Cast steel	7,850
Cast iron	7,250
Reinforced concrete	2,500
Plain concrete	2,350
Cement mortar	2,150
Asphalt for water proofing	1,100
Stone masonry	2,600
Timber	800
Sand, Soils, Gravel	1,600 – 2,000
Ballast	1,900
Railway track panel in case of wood ties	450 kg/m



Notes to Train Load:

(1) Dimensions are in meter.

(2) Figures above axles are axle weight expressed in ton; and

(3) Figures in wheels are wheel numbers counted from leading wheel axle.

Fig. 3-4 Cooper E-45 Loading

(iii) **Impact due to Train load**

Impact due to train load shall be calculated by train load multiplied by the following coefficient of impact:

– Coefficient of impact to steel railway bridges due to train load shall be calculated by the following formula:

$$L \leq 30\,m \qquad i = 0.7 - \frac{L^2}{4{,}000}$$

$$L \geq 30\,m \qquad i = \frac{10}{L} + 0.14$$

Where,

L = Length of base of influence line possessing same sign which induces the maximum liveload stress to structure member (m)

i = Coefficient of impact

– Coefficeint of impact to concrete railway structures due to train load shall be as shwon in the following table under the condition that in case of continuous girder or continuous rigid frame structure in which span length is not uniform and the minimum span length is longer than 70% of the maximum span length L shall be assumed to be the average span length. (Refer to Table 3-4)

Table 3-4

L (m)	5	10	20	30
i	0.48	0.43	0.37	0.34

Note: i means coefficient of impact.

(iv) In case of structures which are covered with ballast or earth of more than 1 0 m in thickness the coefficients of impact hereinbefore mentioned are allowed to decrease irrespective of afore-mentioned Clause only in case of substructures of large cross section.

(d) **Centrifugal Force**

Centrifugal force to be induced when a train passes on a curved track shall be train load multiplied by the following coefficient, which shall be assumed to act to the direction in right angle against the track center line and in horizontal direction at the height specified in the following table.

Table 3-5

Radius of track curvature	Coefficient	Height of application point of centrifugal force above rail level (m)
$R \leqq 1{,}000$ m	0.12	1.8
$1{,}000\text{ m} < R < 2{,}000$ m	0.08	1.8
$2{,}000\text{ m} \leqq R$	0	–

(e) **Longitudinal Force**

Longitudinal force due to train braking and train starting shall be assumed to be the larger one between the following two forces and shall be assumed to act at the height specified in the following table.

Table 3-6

Braking Force	:	15% of train load
Starting Froce	:	25% of total driving wheel loads
Height of Point of Application	:	1.8 m above rail level

(f) Earth Pressure

(i) Positive and negative earth pressures shall be calculated by Coulomb's formula. Characteristics of soils to be used in calculation in general cases are as follows:

Table 3-7

Unit weight of soils	:	α = 1,600 kg/m^3
Inner frictional angel of soils	:	ϕ = 33° 40'

But in case when results of soils tests are considered reasonable to apply to calculation the Contractor may after approval of the Engineer apply them to calculation.
Inner frictional angle of soils is assumed to be the same value mentioned above even in case of soils under the ground water level.

(ii) Internal frictional angle between soils and the face of concrete shall be be generally assumed to be half of soils' internal frictional angel.

(iii) In case of culverts and substructures under the uniform earth pressure the soils static pressure shall be assumed as follow only when the displacement and deformation due to such pressure is very small.

$$P = K_0 \cdot \alpha \cdot H$$

Where,

P : Earth pressure (ton/m^2) at depth H;
K_0 : Earth pressure coefficient = 0.5
α : Unit weight of earth (ton/m^3)
H : Depth of earth (m)

(g) Equivalent uniform Train Load as Surcharge

Train load in the following equivalent uniform distributing load may be applied as surcharge.

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

Where,

q : Equivalent uniform distributing Train Load (ton/m^2)
P : Train Load = 20 tons/axle
a : Wheel base = 1.50 m
b : Lateral distributing width of train load (m)

(h) **Thermal Force due to Temperature Variation and Shrinking Force due to Drying**

(i) **Temperature Change**

The range of temperature change is to be directed by the Engineer. The coefficient of linear expansion of structural materials are specified as follows:

Types of Material Coefficent of Linear Expansion

Steel	12×10^{-6}/degree in centigrade
Reinforced Concrete	10×10^{-6}/degree in centigrade

(ii) **Coefficient of Shrinkage of Concrete due to Drying**

Coefficient of shrinkage of concrete in calculation of indeterminate structures of reinforced concrete should be assumed as 15×10^{-5}/ degree in centigrade.

(j) **Other Loads**

(i) **Frictional 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
Synthetic Rubber Bearings	Concrete and Rubber	0.55

(ii) **Wind Pressure**

Wind pressure acting on structures shall be assumed to act only from one direction horizontally as follows:

- Against horizontal projected area of structures and Train : 150 kg/m^2
- Tower building of circular cross-sections : 60% x 150 kg/m^2 of horizontally projected area.

(iii) **Water Current Pressure**

Water Current pressure against bridge piers shall be calculated by the following formula and acting at the height of 60% of water depth from riverbed:

$$P = KAV^2$$

Where,

P : Water Current Pressure (ton)
K : Coefficient due to cross-sectional shape of pier (refer to Fig. 3-5)
A : Horizontally projected area of bridge pier (m^2)
V : Water Current speed (m/sec.)

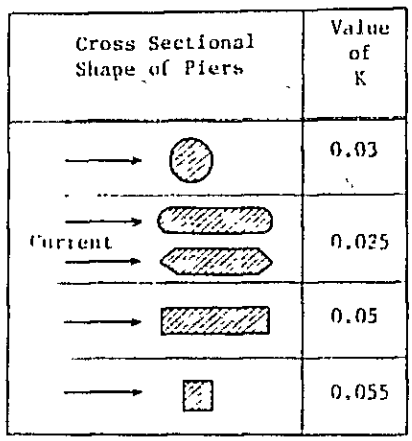


Fig. 3-5

TS 3 05 Design Criteria of Railway Steel Bridges

(1) Materials

Materials to be used in manufacturing railway steel bridges shall be such materials as specified in the followings or their equivalents.

(a) Sturctural Steel

Steel materials to be connected by welding or by high-tension bolts shall be such materials as specified in the following table:

Table 3-9 Stuctural Steels

Material	Items	Standards			
		Designaiton	Name of Material	Symbol	Thickness (mm) t
Steel plates, Shape steels, Flat steels and Steel bars	Main Structual Members to be welded	JIS G 3106-70 (Rolled Steel for welded structures)	1st Type	SM 41 A SM 41 B SM 41 C	$t \leqq 16$ $16 < t \leqq 25$ $25 < t \leqq 50$
	Secondary structual members to be welded or connected with high-tention bolts	JIS G 3101-70 (Rolled Steel for General Structures)	2nd Type	SS 41	$t \leqq 50$

Table 3-10 Chemical Components of Steel

Symbol of Material	Thickness (mm)	Chemical Components (%)				
		Carbon	Silicon	Manganese	Phosphorus	Sulfur
SM 41 A	t < 50	< 0.23	–	2.5 x C <	< 0.04	< 0.04
SM 41 B	t < 50	< 0.20	< 0.35	0.6 – 1.2	< 0.04	< 0 04
SM 41 C	t < 50	< 0.18	< 0.35	1.4	< 0.04	< 0.04
SS 41					< 0.05	< 0 05

Note: C in case of SM41A in the item of manganese means percentage of carbon.

Table 3-11 Mechanical Strength of Steel

Symbol of Material	Tensile Strength (kg/mm^2)	Yielding Point (kg/mm^2)	Thickness (mm)
SM 41 A	41 – 52	25 <	t < 16
SM 41 B		24 <	16 < t < 40
SM 41 C		22 <	40 < t
SS 41			

(b) **Welding Electrodes**

Welding electrodes shall be of the following materials:

Table 3-12 Materials of Welding Electrodes

Materials to be joined	Designation of welding Electrodes	Class of Electrodes
In case of plates of SS 41, SM 41, are welded together	JIS Z 3211 (Coated Electrodes in Shielded Metal Arc Welding for Mild Steel)	43 kg class

(i) Designaitons of welding wire for submerged arc welding shall be of JIS Z 3311-64 (Wires for Submerged Arc Welding) and appropriate electrode and flux shall be selected according to the quality of steel.

(ii) Designations of materials of high tension bolts and common bolts shall be as follows:

Table 3-13 Materials of Bolts

Materials to be joined	Name of High-tension Bolts	Name of Common Bolts
	JIS B 1186-1970 (Sets of High-tention hexagonal bolts with hexagonal nuts and flat washers)	JIS B 1180 (Hexagon bolts) and JIS B 1181 (Hexagonal nuts)
SS 41, SM 41	F 10T, F 11T	4T

(c) Materials the Bearings

Materials of bearings of steel bridges shall be such as specified in the next table:

Table 3-14 Materials for Bearings

Types of Metal	Designations	Symbols
Cast Iron	JIS G5501-56 (Grey Cast Iron)	FC15 and FC25

(2) Allowable Stresses

(a) Principle

In calculation of necessary cross-section of structural members it is required to determine the total cross-section as effective for compression based on the principle of elasticity, while to determine the cross-section for tension excluding those decrease in corss-section due to holes of bolts. But it shall be calculated using total cross-section only in case of calculation of indeterminate structures.

(b) Combination of Loadings

The combinaiton of main load and subsidary loads shall be as follows, in which the calculation of allowable strength shall be such values as specified in the following table multiplied with the following coefficeints:

Table 3-15

	Combination of Loadings	Coefficient α
(i)	(Dead load) + (Train load) + (Impact) + (Centrifugal force)	1.0
(ii)	(Dead load) + (Train load) + (Impact) + (Centrifugal force) + (Thermal effect)	1.15
(iii)	(Dead load) + (Train load) + (Impact) + (Centrifugal force) + (Braking or Starting force)	1.25
(iv)	(Dead load) + (Train load) + (Impact) + (Centrifugal force) + (Wind pressure)	1.25

(c) **Reduction of Allowable Stresses**

In case when compression acts on structure members reduction of allowable stress shall be made taking into consideration effects of buckling.

(d) **Welding Portions**

Allowable stress of the welding portions of structure members shall be assumed as follows:

Table 3-16 Allowable Stress in Welding Portions

(Unit: kg/cm^2)

	Type of stresses in Material		Type of Material SS 41 SM 41A SM 41B SM 41C
Structural Steel	Tensile stress (per net cross-section)	Axial stress Bending stress	1,400
	Compressive stress (per total cross-section)	Axial stress Bending stress	
	Shearing stress	per total corss-section	800
	Bearing stress	Steel plate against steel plate	2,100
Welding Portion	Group welding	Tensile stress	1,400
		Compressive stress	
		Shearing stress	800
	Fillet Welding	Tensile stress & compressive stress in beading direction	1,400
		Tensile stress, compressive stress and shearing stress concerning thickness	800

Note: (1) Basic stress of welded portions shall be appropriately reduced according to the results of X-ray examination and the workmanship of field welding.

(e) **Allowable Stresses for Buckling**

Allowable stresses for buckling of bridge members shall be as shown in the following table:

Table 3-17 Allowable Buckling Stresses of Bridge Girder Members

(Unit: kg/cm²)

		SS 41, SM 41A, SM 41B, SM 41C
Compressive Stress per Total Cross-Section	Axial Stress ①	When $0 < L/r \leqq 28$: $1{,}250$ When $28 < L/r \leqq 130$: $1{,}250 - 8.0\ (L/r - 28)$ When $130 < L/r$: $7{,}400{,}000\ (r/L)^2$
	Bending Stress	(1) Bending against strong axis: L/r in axial stress shall be replaced with following equivalent slender ratio. $(L/r)_e = F\frac{L}{b}$ Where, $F = \sqrt{12 + 2\beta/\alpha}$ in case of I-beam girder In box-type girder $\alpha \geqq 2$ $F = 1.3\sqrt{3\alpha + \beta}\sqrt{b/L}$ $\alpha < 2$ $F = 1.3\sqrt{6 + \beta}\sqrt{b/L}$ ②
		(2) Bending against weak axis: $1{,}250$ ③

Note 1: In Case of ① , L is the buckling length expressed in cm and γ is the radius of gyration of total cross section expressed in cm. As for the value of L, refer to the following table.

Note 2: In case of ② , L is the distance between fixed points of flange expressed in cm, and b is the distance between centers of web plates of box section expressed in cm. As for the value of h. refer to the following table. α is the ratio t_f/t_w, in which t_f is the thickness of flange, and t_w is the thickness of web. β is the ratio h/b, in which h is the height of web plate and b is the width of web plate.

Table 3-18 Buckling Length

Structual member or girder	Buckling length (L)
Chord member of truss	Length of member
Web-plate of truss (exterior of truss)	Length of member
Web-plate of truss (interior of truss)	Length of member x 0.9
Lateral truss & diagonal truss	Length of member

(f) **Basic Allowable Stresses of Bolts and Pins**

Basic allowable stresses of bolts and pins are specified as follows under the condition that basic allowable stress of high tensile strength bolts shall be the stress when fastened by the specified axial force as frictional spricing joints.

Table 3-19 Basic Allowable Stresses of Bolts

(unit: kg/cm^2)

Types of Stress	High Tension Bolts		Ordinary Bolts
	F10T	F11T	SS41
Shearing Stress	1,250	1,300	900
Compressive Stress	—	—	1,900

Notes: (1) Stress of high tension bolts is not necessary to check in calculation.
(2) F10T means the second type of the designation JIS B1186-1946 (high tension bolt for frictional joint which consists of hexagonal bolt, hexagonal nut and falt washer), and F11T means the third type of the same designation.

Table 3-20 Basic Allowable Stress of Pins

(Unit: kg/cm^2)

Type of Stress	SS41, SM41A, SM41B, SM41C
Fibre stress in bending Shearing stress Compressive stress	1,900 1,000 1,600
Compressive stress in pin hole	1,600

(g) **Bearings**

(i) **Bearings of Cast Iron in Linear Bearing**

Allowable stress of bearings of cast iron in linear bearing are specified as follows (Refer to Fig. 3-6):

Table 3-21 Coefficients K for Allowable Stress of Cast Iron Bearings

(Unit: kg/cm^2)

	Combination of Materials	
	SS41 & FC15	SS41 & FC25
Coefficients K	70	150

Note: Allowable stress of linear bearing (Kg/lin. cm):

$$K = \left(\frac{r1 \times r2}{r1 - r2}\right)$$

Where,

r1, r2. Radius of curvature of bearings (cm)
(Refer to the following Fig. 3-6)

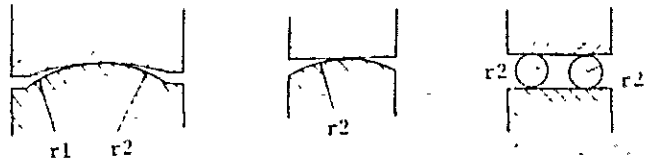


Fig. 3-6 Radius of Curvature of Bearing

(ii) Bearing of Cast Iron in Area Bearing

Allowable stresses of cast iron in area bearing are specified as follows:

Table 3-22 Allowable Stresses of Cast Iron Bearing in Area Bearing Type

(Unit: kg/cm²)

Types of Stress	FC15	FC25
Tensile stress	400	600
Compressive fibre stress	800	1,200
Shearing stress	300	450

(h) Concrete at Bearings

The allowable compressive stress of concrete at bearings is specified basically at 40 kg/cm² under the condition that it may be increased in special case when approved by the Engineer.

(3) Design Criteria of Railway Steel Bridges

(a) Constants of Steel Elasticity

Constants of steel elasticity are specified as follows:

Table 3-23

Young's modulus	E = 2,100,000 kg/cm²
Shearing elastic modulus	G = 810,000 kg/cm²
Poison's Ratio	γ = 0.3

(b) Width of Bridge Girder

Width of bridge girder shall be more than 1/20 of its span length.

(c) Deflection of Bridge Girder

The term 'deflection' as used herein of main girders, lateral girders and that

at locations of right and left rails shall be the deflection computed in accordance with the assumption made for single train loading in which effect of impact ignored. Steel beams or girders having simple spans shall be designed so that the deflection of girders due to live load excluding impact shall not exceed 1/800 of the span, the span length being considered the distance center to center of bearings.

But in case when any consideration is given to balance the deflection of girder, for instance, by giving inverse camber to rails the limit of deflection of girders aforementioned can be reduced by the approval of the Engineer.

The deflection of lateral girders at the joints with main girders shall not exceed 4 mm in end lateral girders and 5 mm in intermediate lateral girders.

(d) Slenderness Ratio of Structural Memebers

The slenderness ratio of structure members L/r shall not exceed the following values:

Table 3-24 Allowable Maximum Slenderness Ratios of Structural Memebers

Types of Structural Member	Slenderness Ratio L/r
Main compressive members	100
Subsidary compressive members	120
Tensile members	200

Notes: (1) L is effective buckling length of member
(2) r is radius of gyration of cross-section $= \sqrt{Ix/A}$
(3) Ix is moment of inertia of cross-section to X-axis.
(4) A is the cross-sectional area of member (cm^2)

(e) Secondary Stresses

In designing structural members the following secondary stresses shall be taken into account in every part of members.

- Eccentricity of members;
- Rigidity of at panel points;
- Deflection of lateral girders;
- Deflection of floor bearing due to variation of length of chord members;
- Deflection due to own weight of members;
- Friction at movable bearings; and
- Others.

(f) Components of Cross-Section of Members

- Attention shall be paid so as to arrange welding protions symmetrically against vertical axis as well as horizontal axis of cross-section of members which are components of girders, and components of welding protions;
- Attention shall be paid in designing so as to facilitate fabricaiton, welding and inspection of members by not concentrating but dispersing welding portions and stressing; and also the shrinkage and deformation to be caused by welding shall be taken into account;

– Main members shall be proporationed so that their gravity axis will situate coinciding with the center of the section and also with its bracing line.

(g) Thickness of Steel Materials

The minimum thickness of steel materials to be used are specified as follows:

– Prime members shall be basically 9 mm thick, but floor plate shall be 12 mm and the buckle plate shall be 8 mm;
– Secondary members shall be basically 8 mm thick, but steel plates to be used as fillers, planking and handrails are not restricted by this paragraph.

(h) Minimum Size of Angle Shaped Steel

The minimum size of legs of angle-shaped steels to be used for lateral trusses, diagonal members and trusses against for force shall not be smaller than 75 mm.

(i) Camber

Appropriate camber shall be provided to all railway steel bridge girders longer than 30 m in span length, the magnitude of which shall be calculated under loadings of 1/3 of the uniform distributing load equivalent to the specified train load plus dead weight of bridge girders, over the total length of the bridge girder.

TS 3.06 Design Criteria of Plain and Reinforced Concrete Structures

(1) Materials

Materials to be used in plain and reinforced concrete structures shall confirm with the conditions to be specified in the following paragraphs·

(i) Reinforcement Bars

Reinforcement bars shall be the designation ASTM A615 (Reinforcement round bar for reinforced concrete) or equivalent.

(ii) Concrete

Test results of compressive strength of concrete to be mixed at site should satisfy the following requirements·

– Test results shall not be below than 80% of the design strength σ 28 in the probability more than 1/20.
– Test results shall not be below than the design strength σ 28 in the probability more than 1/4. . . . . .

Note: σ 28 is the basic design compressive strength at the age of 28 days.

(2) Allowable Stresses

(i) In the calculation of cross-sectional area of members, subject to bending moment based on the principle of elasticity, it is assumed that concrete is not subject to tension and that deflection in fibre is proportional to the distance from its neutral axis.

(ii) Young's modulus, between reinforcement bars and concrete to be used in the

calculation of cross-section of members, is usually expressed by n, which is assumed to be 15.

(iii) **Combinations of Loading**

Combinations of loading shall be as specified in the followings. Allowable stresses of structural members shall be the allowable stresses shown in the next table multiplied by the following coefficient.

Combination of Loadings	Coefficient α
(Dead load) + (Train load) + (Impact) + (Centrifugal force) + (Current pressure) + (Earth pressure)	1.0
(Dead load) + (Train load) + (Impact) + (Earth pressure) + (Braking or Starting force)	1.15
(Dead load) + (Train load) + (Impact) + (Centrifugal force) + (Current pressure) + (Earth pressure) + (Wind pressure)	1.25
(Dead load) + (Train load) + (Impact) + (Centrifugal force) + (Earth pressure) + (Thermal effects) + (Braking or Starting force)	1.25

(iv) **Basic Allowable Tensile Stresses of Reinforcement Bars**

Table 3-25 Basic Allowable Tensile Stresses of Reinforcement Bars

(Unit: kg/cm^2)

Item \ Type of Bars	Grade 40	Grade 60
Allowable tensile strength	1,400	1,690

Note: Basic allowable tensile stresses of reinforcement bars conforming with the designation ASTM A615 can be assumed as the same values as shown in the above table.

(v) **Concrete in Reinforced Concrete Structures**

Basic allowable stresses of concrete in reinforced concrete structures shall be basically determined based on the design strength σ 28.

Basic allowable stresses of common concrete shall be determined as follows:

– Basic allowable compressive stress σ_{ca} due to bending (including the case accompanied by axial force), shall be as follow:

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

– Basic allowable shearing stresses σ a shall be assumed below than the following values.

Table 3-26 Basic Allowable Shearing Stresses of Concrete

(Unit: kg/cm²)

Method of Calculation of Diagonal tensile reinforcement bars		in case when σ_{28} = 180	in case when σ_{28} = 210	in case when σ_{28} = 240
When calculation is not conducted for diagonal tention bars	Beams	6	6.5	7.0
	Floors	8	8.5	9.0
When calculation is conducted for diagonal tension bars (excluding cases accompanied by the effects of torsion)		17	18.5	20.0

— Basic allowable bonding stresses shall be lower than as specified in the following table; those stresses can be reduced in case when diameter of bars exceed 32 mm.

Table 3-27 Basic Allowable Bonding Stresses

(Unit: kg/cm²)

	In case when σ_{28} = 180	In case when σ_{28} = 210	In case when σ_{28} = 240
Round Bars	7	7.5	8.0
Deformed Bars	14	15.0	16.0

— Basic allowable compressive stresses σ ca' shall be as follows:

In case when load is applied on whole loading surface

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

In case when load is applied aprtiallu on loading surface

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

where,

A : Total surface area (cm²)

A' : Area exposed to load (cm²)

σ ca' shall not exceed the value of 0.5 x σ_{28}

In case when the surface area to be exposed to compression is well reinforced the basic allowable compressive stress may be determined by the test results so as to maintain the factor of safety to be more than 3.0.

(vi) Allowable Stresses of Concrete in Plain Concrete Structures

Allowable stresses of concrete in plain concretd structures shall be determined by basic design strength σ_{28}. The basic allowable compressive stress σ_{ca}, including cases of eccentric loading, shall be as follow:

$$\sigma_{ca} \leqq \frac{\sigma_{28}}{4} \leqq 55 \text{ kg/cm}^2$$

The basic allowable tensile stress σ_{ta} shall be as follow:

$$\sigma_{ta} \leqq \frac{\sigma_{28'}}{4} \leqq 3 \text{ kg/cm}^2$$

Where, $\sigma_{28'}$ is the basic design tensile stress of concrete.

The basic allowable compressive stress $\sigma_{ca'}$ shall be as follows.

- In cases of full loading on loading surface the basic allowable compressive stress shall be as those to be calculated by the following fromulae.

$$\sigma_{ca'} \leqq 0.3 \quad \sigma_{28} \leqq 60 \text{ kg/cm}^2$$

In such cases if the allowable stress is raised up by arranging spiral reinforcement bars in the bearing surface the basic allowable compressive stress can be raised up to 70 kg/cm^2.

- In cases of partial loading on loading surface the allowable compressive stress shall be calculated by the following formulae:

$$\sigma_{ca'} \leqq (0.25 + 0.05 \frac{A}{A'}) \times \sigma_{28} \leqq 120 \text{ kg/cm}^2$$

where, A is the total loading surface and A' is the net loading surface area to be exposed to the bearing pressure

(3) Design in General

(a) Types of Concrete to be used

Following four types of concrete are used in concrete works according to their purposes in this project:

Tabel 3-28

Compressive Strength at age of 28 days	To be used for
240 kg/cm^2	Reinforced concrete structures heavily reinforced
210 kg/cm^2	Reinforced concrete structures lightly reinforced and/or Plain concrete structures
180 kg/cm^2	Plain concrete structures

(b) Assumption in Calculation of Structural Analysis

(i) (Cases where common concrete is used)

Moment of Inertia

– Moment of inertia to be used in calculation of indeterminate structures may be calculated on the total cross-sectional area of concrete members, neglecting the influence of reinforcement bars;

– Moment of inertia to be used in calculation of deformation under the temporary loading shall be calculated on the total cross-sectional area taking into account the influence of reinforcement bars. In this calculation the actual cross-sectional area of reinforcement multiplied by the Young's modulus ratio n and also the actual cross secrion of concrete are taken into calculation.

Table 3-29 Young's Modulus Ratio between Reinforcement and Concrete

σ 28 (kg/cm^2)	180	210	240
Value of n = E_s/E_c	8.8	8.3	8.3

Note: (1) σ 28 is the basic design strength based on the compressive strength at the age of 28 days.

(2) Value of n is basically different according to the value of σ 28, but it may be assumed as 15 when stresses and cross-sections are calculated.

Young's Mosulus of Reinforcement Bars (Es)

Young's modulus E_s of reinforcement bars is assumed to be 2.1 x 10^6 kg/cm^2.

Young's Modulus E_c of concrete (Ec)

Young's modulus of concrete (E_c) is assumed as follows:

Table 3-30 Young's Modulus of Concrete

σ 28 (kg/cm^2)	180	210	240
E_c (kg/cm^2 2)	2.4 x 10^5	2.6 x 10^5	2.7 x 10^5

Note: σ 28 is the basic design compressive strength of concrete at the age of 28 days.

Poisson's Ratio of Concrete

Poisson's ratio of concrete is assumed to be 1/6 in general, and the ratio of Young's modulus to Coefficient of elasticity in shearing is assumed to be 2.3.

(c) **Standard shapes and Dimensions of Hooks of Reinforcing Bars**

Standar shapes and dimentions of hooks of reinforcing bars to be used in design calculations are as follows:

(i) **In case of Deformed Bars**

- Hooks of deformed bars shall be basically of semicircular shape. Stir-up to be anchored in the compressed portions may be of rectangular hook or bent-hooks of 135 degrees in angle.
- Inner diameter of hooks (D) shall be 4 times of the diameter of reinforcement bar (ϕ).
- The length of end-straight ℓ_1 which stretches out from hook shall be more than 4 times of bar diameter or of more than 6 cm in length. The length of end-straight ℓ_2, which stretches put from right angle hooks or bent-hooks of 135 degrees in angle shall be more than 6 times of bar diameter or of 6 cm in length. (Refer to Fig. 3-7 (a))

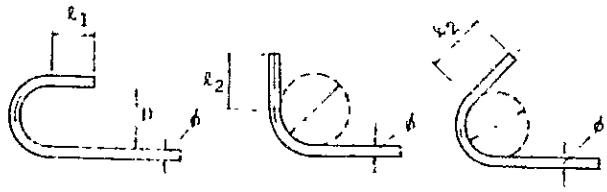


Fig. 3-7 (a)

(d) **Bending Radius of Reinforcement Bars**

- Bending radius of reinforcement bars shall be larger than the five times of diameter of bars (Refer to Fig. 3-7 (b)) Reinforcement situating within (2ϕ + 2 cm) from the concrete surface shall be bent with a radius larger than 7.5 times of ϕ, in which ϕ is the diameter of reinfrocement bar.
- Reinforcement bars situating in exterior corners of framed structures shall be bent with a radius larger than 10 times of the diameter of the said reinforcement bar.

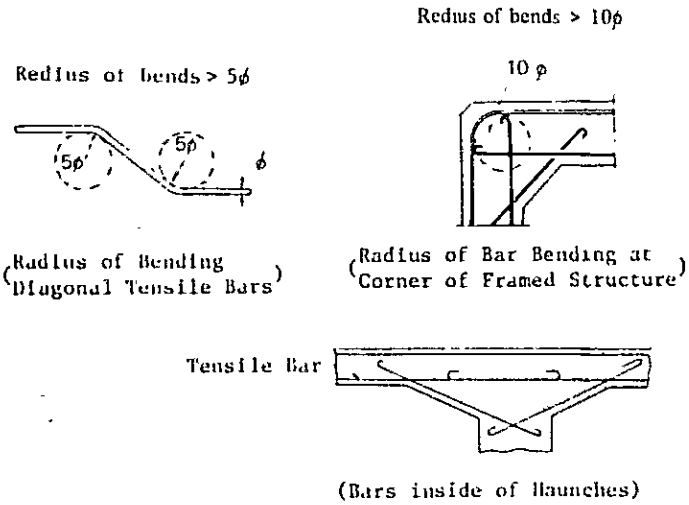


Fig. 3-7 (b)

(e) **Reinforcement in Haunches**

In haunches of framed structures reinforcement bars arranged in them shall not be those bent from tension bars of floor or beams but the separate straight bars to be arranged along the surface of hauches (Refer to 3-7 (b))

(f) Length of Lap Joint of Reinforcement Bars

– The length of a lap joint tension bars shall be longer than the length to be calculated by the following foumulae and also longer than 20 times of the diameter of the said reinforcement bars.

$$\ell = \frac{\sigma_{sa}}{4\tau_{oa}}\phi$$

where,

ℓ : Length of lap joint (cm)

σ_{sa} : Allowable tensile stress of reinforcement bars (kg/cm^2)

τ_{oa} : Allowable bonding stress of concrete (kg/cm^2)

ϕ : Diameter of reinforcement bar (cm)

In case when a semi-circular or a right-angle hooks are provided in the end of bars the length of lap joint may be reduced down to 2/3 of calculated lap-joint length.

– The length of lap joint of compressive bars shall be longer than 80% of the calculated length and longer than 20 times of diameter of the said reinforcement bars. Even in cases where hooks are provided the length of lap joint shall not be reduced.

(g) Anchoring of Reinforcement Bars

– Reinforcement bars shall be anchored in their ends possibly in the compressive portions of structures.

– In anchoring compressive reinforcement bars the effects of hooks shall not be taken into account in calculation.

(4) Safety of Foundation

Designing Conditions

It is requested that the foundations of structure be designed so as to support their superstructures safely and maintain the sufficient safety against failure of supporting ground, sliding and over-turning of structure. Foundations should be designed well taking into account geological complexity of supporting ground, accuracy of calculation, conditions of execution of work and durability of materials to be used.

(a) Calculation of Allowable Bearing Power of Supporting Ground

In selecting the allowable bearing power of supporting ground the allowable bearing power against the failure of ground should be basically applied, which can be calculated by the following formula:

$$q_a = \frac{1}{F_S}[\alpha C N_C + \beta\gamma_1 N_\Gamma + \gamma_2 D_f(N_q - 1)] + \gamma_2 D_f \ldots\ldots \quad (1)$$

where,

q_a : Allowable bearing power (ton/m^2)

C : Adhesive power of ground under the foundaiton (ton/m^2)

γ_1 : Unit weight of ground under the foundation (ton/m^3)
(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 the bottom level of foundation (ton/m^3)
(In the portion under the ground water level, the unit weight of submerged ground is applied.)

α and β : Coefficients variable according to the shape of foundation (Refer to Table 3-33).

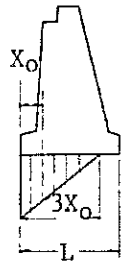
$N_c, N\gamma, N_q$: Bearing coefficients (Refer to Table 3-34).

D_f: Effective depth of foundation where exists a difference between the lowest ground level around foundation the bottom level of foundation (m).

B: Minimum width of foundation bottom (m). In case of circular bottom its diameter is applied, and in case of eccentric loadings as shown in the Fig. 3-8 the minimum width is assumed as $B = 2X_o$.

X_o: Distance of center of gravity of shaded triangle from front edge of foundation (m).

F_s: Factors of safety are as follows:



Factor of safety

	Safety factors
In case of dead load plus live load	2 0
In case of dead load plus flood	1.5

Table 3-33 Coefficients due to Foundation Shape

Coefficient due to Shape of foundation plane	Continuous	Rectangular	Square	Circle
α	1.0	$1 + 0.3 \frac{B}{L}$	1.3	1.3
β	0.5	$0.5 - 0.1 \frac{B}{L}$	0.4	0.3

Note: B : Length of shorter side (m).
L : length of longer side (m)

Table 3-34 Coefficients of Bearing Power

ϕ (degree)	Nc	Nγ	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
more than 40	95.7	114.0	81.2

Note: ϕ is the inner frictional angle of soil of supporting stratum.

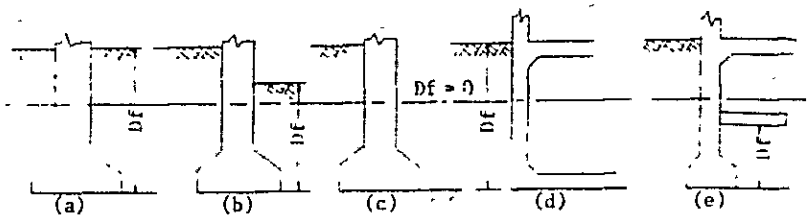


Fig. 3-9 Effective Depth of Foundations

(b) Stability Against Bearing by Ground

- The density of vertical pressure distributed on the bottom plane due to the resultant force acting thereon should not exceed the allowable bearing density of supporting ground.
- In the calculation of stresses to be caused on the bottom plane it is assumed that no tensile stress be caused between the foundation bottom plane and the ground underneath.
- In the calculation of stability against bearing of the ground in case of submerged foundation buoyancy should be taken into account.
- In case where supporting stratum of small bearing capacity exists in the depth deeper than the position of the foundation bottom plane the vertical pressure density distributed on the foundation bottom plane or foundation piles should not exceed the allowable bearing density of the said supporting stratum.

(c) Stability against Overturning of Structure

- It is requested that the location of the point of application of resultant force of load acting to the foundation bottom plane should remain inside of one-third point of the plane from the edge of foundation in case where the structure is constructed on soils, and inside of one-fourth point in case where the structure is constructed on rock or pile foundation or equivalent strong foundation.
- In the calculation of safety against overturning of structure the following factor of safety should be satisfied.
- The resisting moment against overturning should be more than the overturning moment to be caused by external forces multiplied by the following factor of safety:

	Factor of safety
In case of dead load plus live load	1.5
In case of dead load plus flood	1.2

- It is assumed that the center of rotation in case of overturning be the front edge of footing in case of footing and the central point of front-pile row in case of pile foundation. In the following Fig. 3-10 the overturning moment is expressed by the following formula:

$$\left.\begin{aligned} M_r &= W \cdot a + P_v \cdot b + P_p \cdot c \\ M_o &= P_h \cdot d \end{aligned}\right] \quad \cdots\cdots\cdots \quad (1)$$

Where,

P_v: Vertical component of earth pressure

P_h: Horzontal component of earth pressure

W: Weight of structure.
P_p: Resisting earth pressure
M_r: Resisting momnet against the front edge point A of foundation
M_o: Overturning moment

Consequently, the following formula should be satisfied;

$$M_r \geqq F_s \cdot M_o \quad \cdots\cdots\cdots\cdots\cdots\cdots \quad (2)$$

Where,
Fs: Factor of safety against overturning.

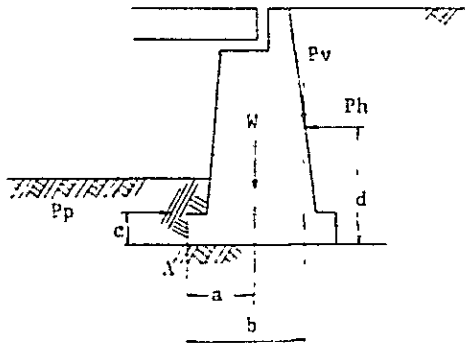


Fig. 3-10

(d) Safety against sliding of Foundation

(i) Resisting force against sliding along the foundation bottom face should be more than the force to be caused by external force multiplied by the following safety factor:

	Safety factors
In case of dead load plus live load	1.5
In case of dead load plus flood	1.2

(ii) Resisting force due to friction of ground is calculated by the following formula:

$$R_f = P_n \cdot \tan\phi' \quad \cdots\cdots\cdots\cdots\cdots\cdots \quad (1)$$

Where,
P_n: Vertical force acting to the sliding plane (ton)
ϕ': Frictional angle of soils on sliding plane which are as shown in following table.

Table 3-35 Values of tan ϕ'

Type of Frictional	Case of Concreting in place	Case of non-concreting in place
Soils and concrete	Tan ϕ	tan (2/3 ϕ)
Rock and concrete	0.6 – 1.0	–

Note: ϕ is the angle of repose of soils due to internal friction.

(iii) Resisting force due to friction of ground in case of cohesive soils can be calculated by the following formula:

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

Where,

R_f: Resisting force (ton)
C': Residting force of cohesive soils against shearing force (ton/m^2)
q_u: Mono-axial compressive strength (ton/m^2)
A: Effective area of foundaiton (m^2)

In case when rubble stones and/or gravels are placed under the bottom of foundation the smaller resisting force between values calculated by formual (1) and (2) is selected.

ST 3.07 Design Criteria of Reinforced Concrete Box Culverts

(1) Type, Shape and Dimensions:
Type shape and dimensions of box culverts shall be determined taking into account terrain, geology, traffic or water flow passing through culverts, situation of embankment, and the way of construction.

(2) Horizontal loading
Loading factors shall be determined taking into account quality of foundation, geology, situation of embankment, materials to be used for construction of culverts, type and dimensions of culverts location relative to ground surface.
The effects of earthquake against culverts shall be determined taking into account qalitities of supporting and surrounding strata and embankment. The horizontal loads acting against culverts due to earthquake as shown in Fig. 3.11 shall be considered:

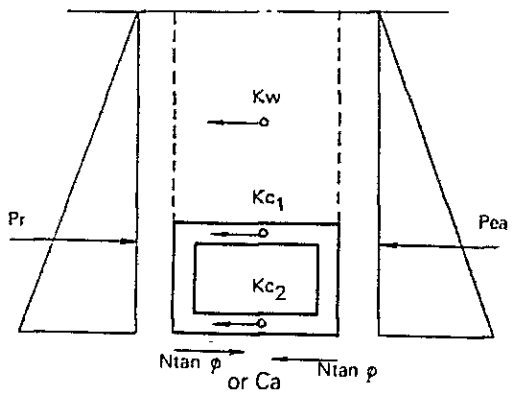


Fig. 3-11 Forces Acting on Box Culvert

$$P_r = Pea + Kw + Kc_1 + Kc_2 - N \tan\phi \text{ (or CA)}$$

Where,

Pea: Major earth pressure at the time of earthquake (ton)

K: Horizontal magnitude of earthquake
W: Weight of earth above culvert (ton)
C1: Weight of upper half of culvert (ton)
C2: Weight of lower half of culvert (ton)
Pr: Resisting earth pressure at the time of earthquake (ton)
N: Vertical force acting on the bottom surface of culvert (ton/m^2)
A: Bottom area of culvert (m^2)
C: Frictional force between culvert bottom and supporting ground (ton/m^2)

(3) Vertical Loads

The earth pressure acting vertically on culvert shall be calculated as follws:

$$p = \gamma \cdot h$$

Where,

p: Earthpressure acting vertically on culvert (ton/m^2)
γ: Weight of earth in unit volume (ton/m^3)
h: Height of embankment above culvert top (m)

If culvert is supported on a pile foundation and it will be affected by settlement of adjacent embankment the value of p shall be appropriately increased.

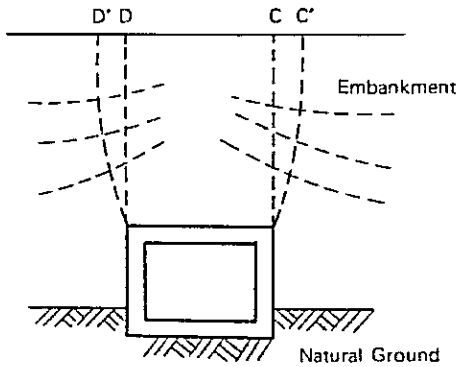


Fig. 3-12 Vertical Loads Acting on Box Culvert

(4) Effects of Live Load

The effects of live load affecting on top surface of culverts may be considered as uniform distributing loads as shown in the Table 3-36.

Table 3-36 Vertical Load Intensity Acting on Culverts Due to Train Loads

(Unit: ton/m^2)

Depth of Earth Cover	1 m	2 m	3 m	4 m	5 m	6 m
In case of single track	5.3	3.6	2.8	2.3	1.7	0.7
In Case of double tracks	5.3	3.6	3.4	2.8	2.6	1.7

Note: In case of double tracks the distance between conterlines of tracks is assumed to be as 3 8 m.
The live load of Cooper E-45 is considered.

(5) **Earth Pressure**

Earth pressure acting on sides of culverts shall be calculated as that acting on fixed wall.

(6) **Ground Reaction in its Longitudinal Direction**

In case when the settlement of ground is anticipated.

The ground reaction to be used in design calculation of bending moment and shearing force in its longitudinal direction shall be determined taking into account the rigidity of culvert and reaction coefficient of ground or pile foundation.

In case when supporting ground or supporting conditions of culvert is different in its longitudinal direction settlement shall be taken into consideration.

TS 3.08 **Design Criteria of Pipe Culverts**

(1) **Scope**

Pipe culverts herewith mentioned are those pipes of precast or fabricated metal pies of the range of inner diameters of 30 cm to 200 cm. for the purpose of irrigation or drainage.

(2) **Diameter of Pipe Culverts**

Diameter of pipe culverts shall be determined hydraulically taking into account water-shed area and quantity of flow.

(3) **External Forces acting on Pipe Culverts**

External forces acting on pipe culverts are:

Vertical forces.

- Vertical earth pressure
- Train load
- Impact due to train load
- Equipment load during construction
- Impact due to equipment load during construction

Horizontal force:

- Horizontal earth pressure

(4) **Minimum Earth Coveringing Depth**

The minimum depth of earth covering shall be determined under the assumption that a pipe culvert will resists against those external forces acting as a unit together with its foundation.

The minimum depth of earth covering case of precasted concrete pipes and reinforced concrete pipes manufactured using centrifugal force can be as follows:

Table 3-37 Minimum Earth Covering of Reinforced Concrete Pipes

a) Minimum Earth Covering of Reinfroced concrete pipes (In case of Double Tracks)

			ϕ 80 cm		ϕ 100 cm	
Depth of Earth Covering	Earth Covering Condition		Case A	Case B	Case A	Case B
	Min.	120° Fixed Foundation	–	–	–	–
		180° Fixed Foundation	7.00*	0.56	7.30*	0.56
	Max.	120° Fixed Foundation	–	–	–	–
		180° Fixed Foundation	No limit	5.00	No limit	4.95

b) Minimum Earth Covering of Reinforced Concrete manufactured using Centrifugal Force (In case of Double Trucks)

		Pipe Size / Conditions of Sand Covering / Conditions of Foundation	φ 80 cm		φ 100 cm	
			Case A	Case B	Case A	Case B
Depth of Earth Covering	Min.	120° Fixed Foundation	4.40*	—	4.70*	—
		180° Fixed Foundation	6.20*	0 40	6.50*	0.45
	Max.	90° Free Foundation	—	—	—	—
		90° Fixed Foundation	—	—	—	—
		120° Fixed Foundation	No limit	—	11.15	—
		180° Fixed Foundation	No limit	6.20	No limit	6.10

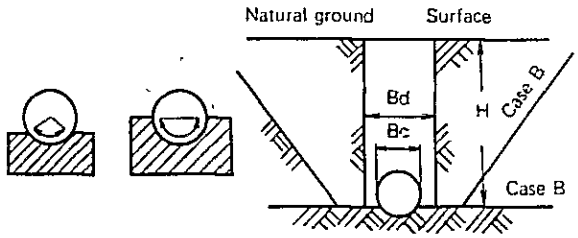


Fig. 3-13

Note: (1) Case A is the case when pipes are laid in a deep excavated trench in which H ≧ Bd.

(2) Case B is the case when pipes are laid on a flat land or in a wide open-cut.

(5) Design of Foundations of Reinforced Concrete Pipe Culverts

a) In cases of free foundation where supporting strata are clay or rock the foundation shall be large enough to distribute vertical loas safely.

b) In cases of fixed foundaiton vertical force V and horizontal force H shall be considered to act as shown in the following Fig. 3.14.
Magnitudes of load acting on pipes per linear meter are shown calculated from cracking strength of pipes are shown in Table 3-38

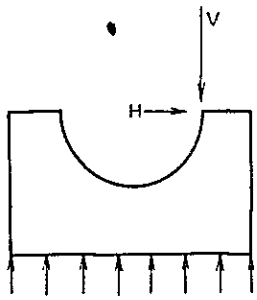


Fig. 3-14

Table 3-38 Loads acting on Reinforced Concrete Pipes In Case of Fixed Foundation

(Unit: ton/m)

Pipe Diameter		ϕ 80 cm	ϕ 100 cm
90° Fixed Foundation	V	2.60	2.84
	H	0.15	0.16
120° Fixed Foundation	V	3.14	3.71
	H	0.30	0.34
180°Fixed Foundation	V	7.35	8.02
	H	1.11	1.22

Note (1):

(Case A) $H \geqq 3$ Bd and/or $Bd \leqq 2Bc$ — In this case in which such two conditions are dsimultaneously satisfied a trench is excavated into well-compacted natural ground carefully and a pipe line is buried and carefully back-filled and compacted as shwon in Fig. 3.15.

(Case B) $H \leqq 3$ Bd and/or $Bd \geqq 2$ Bc — A Pipe line is placed on the natural ground or widely excavated ditch with flatter side slopes, on which embankment is filled up.

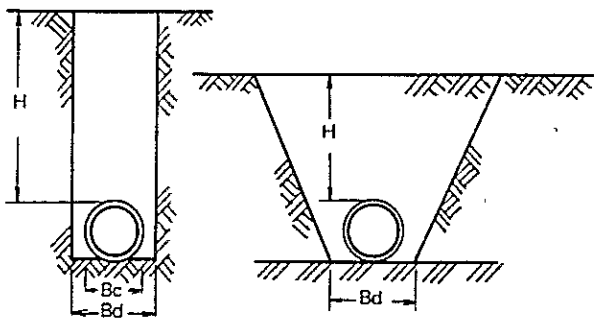


Fig. 3-15

Note (2): In case marked with * calculation of earth pressure acting on pipes may be made by using Marston's formula for earth pressure because conditions of earth covering is considered to be between $H \geqq 3$ Bd and $H < 3$ Bd.

Note (3) In case of ϕ 30 cm, ϕ 45 cm and ϕ 60 cm pipes of 180° fixed foundation under the category of $H \geqq 3$ Bd in which $Bd \geqq 2$ Bc, consequently actual condition of earth covering is considered to be between $H \geqq 3$ Bd and $H < 3$ Bd. Therefore, it is better to calculate their earth pressure acting on pipes by using Marston's formula.

Note (4): Cracking loads acting on pipes are considered as follows:

Table 3-39 Cracking Loads on Reinforced Concrete Pipes
(Pipe Designation: JIS A 5302)

	ϕ 80 cm	ϕ 100 cm
Cracking Load P (ton/m of pipe)	1.96	2.13

Table 3-40 Cracking Loads on Reinforced Concrete Pipes Manufactured by Centrifugal Force
(Pipe Designation: JIS A 5303)

	ϕ 80 cm	ϕ 100 cm
Craking Load P (ton/m of pipe)	2.31	2.50

Note (5) Loading conditions of those cases in tables are assumed as follows:

a) Class of railway track: First class, double tracked.

b) Loading Conditions:
- Track panel: 0.45 ton/m
- Weight of ballast: 1.90 ton/m
- Train load Cooper S-45 load
- Construction equipment load:
  The heaviest equipment is assumed to be motor-scraper the rear axle load of which is 35 tons and distance between rear wheels is 3.6 m.

c) Impact factor:
- In case of Train load: $i_t = -0.25\ (H-3)$
  where, $0 \leqq H \leqq 3$ m
- In case of construction equipment:
  $i_e = -0.375\ (H-2)$
  where, $0 \leqq H \leqq 2$ m

d) Soils condition:
- Type of soils: Sandy soils
- Unit weight of soils: $\gamma = 1.8$ tons/m^3
- Inner frictional angle of soils: $\phi\ 35^\circ$
- Frictional angle between excavated trench wall and filled soils: $\delta = \phi = 35^\circ$
- Foundation type: Flat type
- Earth Pressure is calculated with Marson's formula under the assumption of settlement ratio $\gamma_s = 0.7$

Factors to be paid attention in laying concrete pipe culverts are as follows:
- In case where pipe are laid beneath high embankment or on soft natural ground the inclination of pipe center-line shall be determined taking into account the anticipated final settled positon and shall give an appropriate raise proportinately to the anticipated settlement
- In case where a pipe culvert is laid on steep hill appropriate anti-slipping

devices shall be attached. Expansion joints should be water proofing and of such structure allowing settlement of pipes.

- In back-filling trenches where pipe are laid or filling embankment on pipes it must be executed carefully accompanied with careful and sufficient compaction.
- In excavating trenches for pipe culverts shall be done so as to enable to keep the width of trench as narrow as possible.

(6) **Design Criteria of Corrugated Metal Pipe Culverts**

In cases where corrugated metal pipe culverts are laid baneath embankment which is exposed to train loads, its burying depth form subgrade surface should be determined after conducting appropriate and sufficient tests to confirm its load bearing power.

The following tables show the appropriate relation between diameter and thickness of corrugated metal pipes with appropritate depth of earth covering above the top of pipes, which were determined by Japan Soils Engineering Association based on standards recommended by A.A.S.H.T.O, American Railway Engineering Association and National Corrugated Metal Pipe Association of America.

Figures in the tables show thickness of corrugated metal pipes in case where pipes are laid beneathe railway tracks.

Table 3-41 Minimum Thickenss of Corrugated Metal Pipes Under Various Earth Coverings Under Train Loading

(Thickness: mm)

Diameter of Pipe (mm)	Earth Covering (m)							
	1.6 ~ 3.0	3.1 ~ 4.5	4.6 ~ 6.0	6.1 ~ 7.5	7.6 ~ 9.0	9.1 ~ 10.5	10.6 ~ 12.0	12.1 ~ 15.0
800	2.0	2.0	2.0	2.7	2.7	3.2	3.2	3.2
1000	2.0	2.0	2.7	3.2	3.2	4.0	4.0	4.0
1200	2.0	2.7	3.2	4.0	4.0	4.0		

Note (1): Earth covering means the depth from the upper surface of ties down to the top level of corrugated metal pipe.

(2): In special cases which are not included in tables should be studied separately.

(3): In cases where supporting gound is soft and large settlement of culverts and tension is anticipated in corrugated metal pipe due to anticipate lateral flow of pipe, the situation should be studied separately particularly pipe strength is the direction of axis should be checked.

TS 3.09 **Design Station Buildings and Facilities**

(Refer to Section 9 Station Buildings and Facilities, TS 9, 2.).

TS 3.10 **Design of Railway Communication Telephone System**

(Refer to section 10 Communication Facilities, TS10.02).

TS 3.11 Payment

The preparation of Detailed Drawings is construed to be made 100% when the Contractor submitted all Detailed Drawings accompanied with all affiliated design calculations of stability analyses and stress analyses of structures and estimation of quantities of works by pay item which were made to the satisfaction of the Engineer and obtained the approval of Engineer on contents thereof.

Payment Item No. and Name	Unit of Measurement
311 Preparation of Detailed Drawings	Lump sum

The payment of Preparation of Detailed Drawings in lump sum will be made in the following one installation:

– 100% (Hundred per-cent) on the completion of preparation of Detailed Drawings.

SECTION 4 EARTHWORK

SECTION 4 EARTHWORK

TS 4.01 Scope

Earthwork consists of all necessary work for clearing and grubbing, the excavation of roadway, borrow pits and for foundations of structures, backfilling of structures and removal of landslides etc., including setting out all construction stakes except the alignment survey, all in accordance with these Specifications and in reasonably close conformity with the lines, grades, cross-sections shwon on the drawings or as established by the Engineer. In formulating the execution plan the Contractor shall obtain the approval of the Engineer on balancing between cut and fill based on the earthwork mass curve together with the plan of temporary road and temporary track.

TS 4.02 General

(1) Soils Information

(Refer to General Specification GS. 03 "Records of Explantory Excavations and Borings", GS. 18 "Subsurface Explorations")

(2) Classes of Excavation

Excavation will be divided into the following classes, which are hereinafter described in detail under separate headings:

(a) Common Excavation
(b) Rock Excavation
(c) Structure Excavation
(d) Borrow Excavation

All excavation works shall be carried out in accordance with the specifications for the four classes of excavation named above, and the specifications for other work items involved, and in conformity with the lines, grades, sections and dimensions shown on the drawings or required by the Engineer.

(3) Horizontal and Vertical Alignments

(Refer to Gerneral Specification GS. 17 "Setting out Works, and Staking" and also Technical Specification Section 1 "Surveying Works")

The top of finished subgrade after compaction shall be within a tolerance of plus 2 cm and minus 5 cm of the level shown on the drawings. The profiles shown on the drawings indicate the elevation of the rail top.

(4) Quantities

The quantities of the various classes of excavation and embankment to be measured for payment under the Contract will be limited to the lines shown on the drawings, and will be indicated on approved profiels and cross-sections. Excavation and/or embankment beyond the lines shown on the approved profiles and cross-sections will not be paid for. The Engineer may change the slope of cuts and fills or the formation of benches in the slopes as the work proceeds on the basis of evaluation of soil characteristics.

The actual lines of cuts and fills as made shall be dully measured and recorded by the Contractor. The Engineer will check these records and will approve the measurements, if correct, as a basis of payment.

Excess excavation shall be back-filled, as directed by the Engineer, with ballast without extra payment to the Contractor; excess of fill may be either left in place or re-

moved as required by the Engineer.

(5) Method of Measurement

The quantities of earthwork to be paid for shall be the number of cubic meters of materials measured and computed by the average end-area method, except where the error may exceed plus or minus five per cent as compared with the prismoidal formula, in which case the Engineer will authorize the use of the more accurate method. However, the Contractor shall request such authority before he submits his quantities for approval. Quantities measured on the average end-area basis, once they have been submitted and approved, shall not be subject to review for the purpose of applying a more accurate method.

(6) Removal of Existing Obstructions

The Tender Prices for all classes of excavation shall include the cost of removal of all material, structures and buildings regardless of its nature, encountered within the approval limits for excavation.

Only boulders of an individual size greater than one cubic meter or blocks of masonry of an individual size greater than one cubic meter will be paid for under the respective pay item for "Rock Excavation" shown in the Schedule of Rates. Boulders of size of 0.3 m – 1.25 m in diameter may be upon request by the Contractor, approved by the Engineer to be unsuitable for use in embankment.

(7) Removal or Diversion of Water

Except where provided for Structure Excavation, no separate payment shall be made for control of or removal of water during or after excavation. The costs of sheeting, shorting, pumping and draining, where required in the opinion of the Engineer, shall be included in the Tender Prices for excavation. The Contractor shall provide on his own expenses necessary facilities for dewatering, and for draining or diverting water courses when necessary for the execution and protection of the work or where required by the Engineer.

The Contractor shall provide such drainage outlet ditches as may be necessary to effect proper drainage before rain is to be expected. Such drainage ditches for protection of work during construction and their maintenance and clearing to make them continuously effective during the Work shall be included in the Tender Price. No separate payment for such ditches will be made.

(8) Use and Disposal of Excavated Material

All suitable material excavated within the limits and scope of the project shall, unless provision is expressly made to the contrary in these specifications, or in the Special Specifications, be used in the most effective manner for the formation of the embankment or for back-fill. Any material surplus to these requiremnts, or any material declared in writing by the Engineer to be unsuitable, shall be disposed of by the Contractor outside the right-of-way or as directed by the Engineer in accordance with the provisions of these Specifications, and shall be considered as Common or Rock Excavation as the case may be and paid for at the unit rate for those items, subject to the provisions of Clause TS 4.04 and Clause TS 4.05, respectively, herein, which payment shall include the cost of obtaining the consent of the owner or tenant of the land where the disposal is made.

(9) Ditches

The Contractor shall construct channels, side ditches, intercepting ditches, inlet and

outlet ditches as shown on the drawings or where ordered by the Engineer, whether for temporary or permanent drainage. In order to keep warer away form the embankment and ballast during construction, the Contractor shall at all times insure adequate drinage by so scheduling ditch and outlet construction that the drainage is operative before work is begun on the embankment and track structure. He shall clean and trim all such drainage ditches from time to time so that there may be a a free flow of water throughout the whole Contract Period and Maintenance period. Damage to the work attributable to wetting through failure to provide adequate drainage will result in an order to repair the damage at the Contractor's expense. Ditches shall first be trimmed short of the approved cross-sections, and final trimming, including the repair of any damage that may have been done during the construction work, shall be carried out after the completion of the construction work and shall be a condition for final approval and acceptance.

Payment for the excavation of side ditches, interception ditches and channels for permanent drainage shall be at the unit rate for Common or Rock Excavation, as the case may be, subject to the provisions of Clause TS 4.04 and Clause TS 4.05 respectively.

(10) **Removal of Loose Earth or Rock**

Loose earth or loose rock shall be removed from slopes when required by the Engineer. Payment for such removal shall be at the Unit rate for Common or Rock Excavation, subject to the provisions of Clause TS 4.04 and Clause TS 4.05 respectively.

(11) **Landslides, Benches, Flattening Slopes**

The Engineer may order the removal of material resulting from landslides, the construction of benches in or above the cut slope, or where in his opinion the slope, after cutting, showing signs of instability, irregularity and flattening of the slope. Payment for all such work shall be at the Unit rate for Common or Rock Excavation, as the case may be, subject to the provisions of Clause TS 4.04 and Clause TS 4.05 respectively.

TS 4.03 **Calearance, Grubbing and Demolition**

(1) **Description**

The clearing and grubbing and demolition shall consist of clearing of all trees, down timber, snags, brush, other vegetation, rubbish, and all other objectionable materials, and shall include grubbing stumps, roots, and disposing of all spoil material resulting from the clearing and grubbing in accordance with these Specifications or as directed by the Engineer. It shall also include the removal and disposal of buildings encroach upon, or otherwise obstruct the works except where otherwise provided for in these Specifications or ordered by the Engineer.

(2) **Construction**

Clearing and grubbing shall be executed over a strip in a width as specified in the Drawings.

The Contractor shall preserve all objects designated to remain in station grounds.

It is understood that the area occupied by the existing railway is excluded form the strip considered, and the clearing and grubbing is limited to the surface area directed by the Engineer.

In railway cut areas, all stumps and roots shall be removed to a depth of not less

than 50 cm below the finished sub-grade level.

In areas under railway embankments, all stumps and roots shall be removed to a depth of at least 50 cm below the original ground surface.

Clearing and grubbing of borrow-pit sites will be required only to the depth necessary for the proposed excavation within the areas.

(3) Topsoil Stripping and Use of Topsoil

When the topsoil will be used for dressing of the slopes of the embankment only as indicated on the drawings, this work will be considered as formation of embankment and shall conform to the requirements of Clause TS 4.08 of these Specifications for construction, measurement and payment. In this case the placing of topsoil will not be measured for direct payment, but will be considered as a subsidary obligation of the Contractor covered by the Schedule item "Embankment with material from Common or Borrow Excavation".

(4) Method of Measurement

The quantities of clearing, grubbing and demolition to be paid for according to these Specifications or as directed by the Engineer shall be the number of square meters acceptably cleared, grubbed and demolished within the limits directed by the Engineer.

Clearing, grubbing, and demolition required for permanent structures will be measured for payment.

Clearing, grubbing and demolition for temporary roads, temporary tracks, borrow areas and all temporary construction will not be measured for payment.

(5) Basis of Payment

The quantities of clearing, grubbing and demolition, whether or not water of any depth is present, determined as provided above, shall be paid for at the unit rate for each of the particular pay items listed below that are shown in the Schedule of rates and Payment shall constitute full compensation for all the costs indicated in General Specifications Clause GS. 35 and all other costs necessary or usual for the proper completion of the work prescribed in this Clause.

Schedule Item No. and Name		Unit of Measurement
411	Clearing and grubbing in sparse forest	Square meter (m^2)
412	Clearing and grubbing in thick forest	Square meter (m^2)
413	Topsoil stripping	Square meter (m^2)

TS 4.04 Common Excavation

(1) Description

Common Excavation shall comprise all excavation that is not Rock Excavation, Structure Excavation or Borrow Excavation.

(2) Applicable Provisions

The applicable provisions of Clause TS 4.02 "General" shall be read into and become part of this Clause TS 4.04 "Common Excavation".

(3) Removal and Disposal of Unsuitbale Material

When so directed in writing by the Engineer, the Contractor shall remove material

unsuitable for use in the embankment and shall dispose of it on adjacent land out of right-of-way as provided in Clause TS 4.02 (8).

When unsuitable material is ordered to be removed, the material shall be removed down to 50 cm in depth from the subgrade level over a width of 1.90 m to both sides from the centerline of track in straight portions, the soil left in place after the removal of the unsuitable material shall be compacted to a depth of 15 cm, to a density of 95 per cent of the maximum dry density determined according to AASHTOT99-74 (or JIS-A-1214). Payment for such compaction shall be included in the Unit Price for Common Excavation.

(4) Conglomerate

When the material in cuts is conglomerate that, in the opinion of the Engineer, is not so firmly consolidated as to require drilling and blasting, the Contractor shall use an excavator with suitable steel tines, or other appropriate equipment for its removal. Such work shall be cansidered as Common Excavation. If the conglomerate required blasting, the work shall be considered as Rock Excavation.

(5) Intercepting Ditches

An intercepting ditch shall be excavated behind each cut slopes of roadway at a distance more than 2 m away from the cutline on the natural ground as shown in the drawings in order to prevent landslides, falling earth and erosion of the cut slope by intercepting the surface water flowing down from the background slope. Such intercepting ditches shall be appropriately led to side ditches, or streams without passing on side slopes as directed by the Engineer.

(6) Method of Measurement

The quantity to be paid for shall be the number of cubic meters of material acceptably excavated as hereinbefore prescribed. The material shall be measured in the original position in the natural ground after clearing and grubbing.

The volume of material already excavated for the temporary roads and/or tracks constructed by the Contractor that fall within the width affected by the excavation of the railway, its side-tracks and station grounds will not be measured for direct payment, since this work is covered by the price tendered for "Construction, Maintenance and Protection of Traffic".

Profiles and cross-section, to an approved scale and showing the required details, shall be drawn on transparent tracing paper by the Contractor, and shall be reviewed and checked by the Engineer, and if in accordance with the specified requirements, approved by him, they shall then become the basis of the quantities to be measured for payment. The Contractor shall provide the Engineer with three copies of the approved tracings and of the detailed quantity computation sheets.

The measurement shall include the unavoidable overbreakage due to the landslides when not atrributable to carelessness of the Contractor and are approved by the Engineer.

(7) Basis of Payment

Common Excavation, inlcuding work defined as Common Excavation in Clauses TS 4.04 and elsewhere in these Specifications whatever the haulage distance of the excavated material shall be paid for separately in the following cases:

(a) When the materials resulting from the excavation made for the construction of the railway is declared in writing by the Engineer to be unsuitable for use

in embankment;

(b) When the material resulting from the excavation made for the construction of the railway is surplus to the amount required for the construction of the embankment, provided, however, it is not material rendered surplus by reason of the Contractor's having opened borrow pits solely for his own conveniences as provided in Clause TS 4.07 of these Specifications.

Without prejudice to the provisions of Clause TS 4 02 of these Specifications, it is understood that the balance of the Earthworks for the determination of the quantities of cut that exceed or fall short of the quantities shall be made by conventionally adopting the value 0.85 for shrinkage factor of earth material and the value of 1.10 for swell factor for rock material, which values allow for the changes in density of these materials before excavation and after incorporation in embankment. But these factors are subject to change by the Engineer after conducting tests of soils at Site.

Where the Engineer orders the use of material obtained from Common Excavation for the execution of other works (such as stone masonry or aggregates for concrete) the Common Excavation shall not be paid for separately but shall be considered as a subsidiary obligation of the Contractor covered under the Unit Prices paid for the other works in which the material is employed.

The quantities, determined as provided abvoe whatever the haulage distance of the excavated material are not paid for directly except for 'Common Excavation, Waste', but shall be considered as a subsidary obligation of the Contractor covered under the Contract Prices for performance of work under Clause TS 4.08.

The Contract Price of 'Common Excavation, Waste' shall be full compensation for all costs indicated in Clause GS 35 of General Specifications, and all other costs or usual for the proper completion of the work prescribed in this Clause

Schedule Item No. and Name		Unit of Measurement
421	Common Excavation, Waste	Cubic meter (m^3)

TS 4.05 **Rock Excavation**

(1) **Description**

Rock excavation shall consist of the excavation from the main track, its side tracks and station grounds of boulders one cubic meter in volume or greater and all rock in ledges, bedded deposits and conglomerate deposits which, in the opinion of the Engineer, would normally be removed by drilling and blasting.

(2) **Applicable Provisions**

The applicable provisions of Clause TS 4.02 shall be read into and become part of this Clause TS 4.05 "Rock Excavation".

(3) **Explosives**

(a) The Contractor shall provide suitable building or warehouses in appropriate locations for the storage of explosives, which shall be stored in the manner and quantity approved by the Engineer. Such storage places shall be accessible only to authorized personnel. They shall be properly marked, and all doors or accesses thereto shall be provided with secure locks and all necessary means of preventing access by unauthorized persons.

(b) The Contractor shall be reaponsible for the prevention of any unauthorized issue or improper use of any explosives. The handling of explosives shall be entrusted only to experienced and responsible men, shall be to the statisfaction of the Engineer, and in conformity with the statutory regulations.

(c) All drilling and blasting shall be done in such a manner as to bring the excavation as close as possible to the required grade lines, and to disturb as little as possible the material to be left in place. Blasting by means of drill holes, or any other similar method shall be performed at the entire risk and responsibility of the Contractor, who shall have no claim to payment for any extra work occasioned by breakage outside the approved or revised cross-sections.

(d) The greatest care shall be taken by the Contractor during all blasting operations to insure that no injury to be done to persons to the finished work Shots shall be properly loaded and capped, and only appropriate charges shall be used in each hole. A register of all explosives used, showing locations and amounts, shall be kept by the Contractor for checking by the Engineer.

(e) Where directed by the Engineer, the Contractor shall provide appropriate measures for protection of persons, properly and the work during the excavation. If found necessary, blasting shall be restricted to times prescribed by the Engineer.

(f) The Engineer may prohibit blasting and order the rock to be excavated by other means, if, in his opinion, it would be dangerous to persons or adjacent structures, or is being carried out in a reckless manner. If traffic on the existing railway or any road has to be interrupted, the Contractor shall obtian approval of his schedule for such interruption from the proper authorities and shall satisfy the Engineer that he has obatined it.

(4) Subgrade Level in Rock Cuts

Rock cut for the main track and its side tracks shall be excavated to the subgrade levels indicated on the drawings and provided in Clause TS 4.02 (2) and TS 4.05 (2) of these Specifications.

(5) Method of Measurement

The quantity to be paid for shall be the number of cubic meters of material acceptably excavated as hereinbefore prescribed. The material shall be measured in the original position in the natural ground after topsoil stripping and removal of common excavation and after construction of the temporary roads and/or temporary tracks.

(6) Basis of Payment

Rock excavation, including work defined as Rock Excavation in Clause TS 4.02 and elsewhere in these Specifications, shall be paid for separately only in the following cases:

(a) When the material resulting from the Rock Excavation is declared in writing by the Engineer to be unsuitable for use in the embankment,

(b) When the material resulting from the Rock Excavation is surplus to the amount required for the construction of the embankment, provided, however it is not material rendered surplus by reason of the Contractor's having opened borrow pits solely for his own convenience as provided in Clause TS 4.07 (4) of these Specifications.

Where the Engineer orders the use of material obtianed from Rock Excavation for the execution of other works (such as stone masonry as aggregates for concrete) the Rock Excavation shall not be paid for separately but shall be considered as subsidiary obligation of the Contractor covered under the unit rates for the other works in which the material is employed.

The quntities, determined as provided abvoe whatever the haulage distance of the excavated material are not paid for directly except for 'Rock Excavation, Wast', but shall be considered as a subsidary obligation of the Contractor covered under the Contract Prices for performance of work under Clause TS 4.08 "Embankment".

The Contract Price of 'Rock Excavation, Wast' shall be full compensation for all costs indicated in Clause GS 35 of General Specifications, and all other costs or usual for the proper completion of the work prescribed in this Clause.

Schedule Item No. and Name	Unit of Measurement
431 Rock Excavation, Waste	Cubic meter (m^3)

TS 4.06 Structure Excavation

(1) Description

Structure excavation shall consist of excavation in earth or rock, within the limits of the work as specified herein or as shown on the drawings, that is made for structures. Any excavation defined as Common Excavation or Rock Excavation shall not be Structure Excavation.

Structure Excavation shall be limited to excavation for the footing or foundation of bridges or for culverts, or retaining walls, wing walls, and other structures not otherwise provided for in these Specifications. It shall include backfilling with suitable material accepted by the Engineer, desposing of surplus material, all necessary draining, pumping, bailing, sheeting, shoring, the construction of cribs and cofferdams and their subsequent removal, and the removal of old structures or parts thereof.

(2) Applicable Provisions

The applicable provisions of Clause TS 4.02 (2) shall be read into and become part of this Clause TS 4.06 "Structure Excavation".

(3) Classification

Structure excavation shall be classified for measurement and payment as:

(a) Structure excavation

(b) Structure excavation in rock, which shall consist of excavation of material that normally or in the opinion of the Engineer, requires drilling and blasting with explosive or hammer drill for its removal;

(c) Structure excavation where water is present or executed to a depth greater than 20 cm below the constant level to which the water naturally rises in a foundation pit.

(4) Excavation

(a) General

The Contractor shall notify the Engineer sufficeintly in advance of the be-

ginning of any excavation so that cross-sectional evevations and measurements may be taken of the undisturbed ground. The natural ground adjacent to the structres shall not be disturbed without the permission of the Engineer. Trenches or foundation pits for structures or structure footings shall be excavated to the lines and grades or elevations shwon on the drawings or as directed by the Engineer. They shall be of sufficient size to permit the placing of structures or structure footings of the width and length shown. The elevations of the bottoms of footings as shown on the Basic Drawings shall be considered as approximate only and the Engineer may order, in writing, such changes in dimentions or elevations of footings as may be deemed necessary to secure a satisfactory foundation.

Boulders, logs, and any other objectionable material encountered in excavation shall be removed.

After each excavation is completed, the Contractor shall notify the Engineer to that effect, and no footing, bedding material or pipe culvert shall be placed until the Engineer has approved the depth of excavation and the character of the foundation material.

All rock or other hard foundation material shall be cleaned of all loose material and cut ot a firm surface, either level, stepped, or serrated as directed by the Engineer. All seams or crevices shall be cleaned and grounted. All loose and disintegrated rock and thin strata shall be removed. When the footing is to rest on material other than rock, excavation to final grade shall not be made until just before the footing is to be placed. When the foundation material is soft or mucky otherwise unsuitable, in the opinion of the Engineer, the Contractor shall remove the unsuitable material and backfill with grade sand, gravel, slag, or stone. This foundation fill shall be placed and properly compacted in 15 cm layers up to the foundation elevation at the density required by the Engineer.

It is in any case understood that, during the execution of excavations, the Contractor shall take steps on his own initiative to ensure the natural drainage of the water flowing on the surface of the ground, in order to prevent is running into the excavations that have been opened.

(5) Utilization of Excavated Materials

All excavated material, os far as suitable shall be utilized as backfill or embankment. The surplus material, whether or not temporarily allowed to be placed within a stream area, shall be disposed of finally in such a manner as not to obstruct the stream or otherwise impair the efficiency or appearance of the structure. No excavated material shall be deposited at any time so as to endanger the partly finished structure.

(6) Preservation of Channel

Unless otherwise permited, no excavation shall be made outside of caissons, cribs, cofferdams, or sheet piling, and the natural stream bed adjacent to the structure shall not be disturbed without the approval of the Engineer. If any excavation or dredging is made at the site of the structure before caissons, cribs, or cofferdams are sunk in place, the Contractor shall, after the foundaiton base is in place, backfill all such excavation to the original ground surface or stream bed with material satisfactory to the Engineer.

Material deposited within the stream area from foundation or other excavation or from the filling of cofferdams shall be removed and the stream area free from ob-

struction thereby.

(7) **Backfill and Embankments for Structures**

Excavated areas around structures shall be backfilled with approved material in horizontal layers, not over 30 cm in depth, to the level of the original ground suface. Each layer shall be thoroughly compacted with mechanical tampers. Where backfill forms a part of the railway embankment, the backfill shall be compacted in accordance with the provisions of Clause TS 4.08.

In backfilling of abutments the Contractor shall backfill with such select materials as GW, GC, GM, SW, SM and SC soil groups in Cassagrande Classification of balanced grading in such a form as shown in drawings and shall compact them satisfactorily with mechanical vibrating compactor or tamper.

In placing backfills or embankment, the material shall be placed simultaneously as far as possible to approximately the same elevation on both sides of an abutment, pier, wall or culvert. If conditions require placing backfill or embankment appreciably higher on one side than on the opposite side, the additional material on the higher side shall not be placed until permission shall have been given by the Engineer so that the masonry has attained sufficient strength to withstand nay pressure created by the methods used and materials placed without damage or strain beyong a safe factor.

Backfill or embankment shall not be placed behind the walls of concrete culverts or abutments of rigid frame until the top slab is placed and cured. Backfill and embankment behind the sidewall of culverts, shall be carried out simultaneously behind opposite sidewalls.

All embankments adjacent to structures shall be constructed in horizontal layers and compacted as prescribed in Clause TS 4.08, except that mechanical tampers may be used for the required compaction. Special care shall be taken to prevent any wedging action against the structure and all slopes bounding or within the areas to be filled shall be benched or serrated to prevent wedge action. The placing of embankment and the benching of slopes shall be continued in such a manner that at all times there will be a horizontal bench of throughly compacted material for distance at least equal to the height of the abutment or wall to be backfilled against except insofar as undisturbed material obtrudes upon the areas. Adequate provisions shall be made for thorough drainage. Rock fragments or coarse sand and gravel shall be provided for a drainage filter at weeps as shwon on the drawings.

(8) **Method of Measurement**

The quantity of Structure Excavation to be paid for shall be the number of cubic meters of material measured in its original position and shall be computed by the average end-area method.

The volume of earth or rock to be measured for Structure Excavation shall consist of a prismoid bounded by the following planes:

(a) Above the horizontal plane reproducing the perimeter of the foundation and passing through the lowest point of the natural ground along the perimeter; therefore, above this plane, the excavation shall be considered as common Excavation in earth or in rock at the case may be and shall be measured and paid for accordingly;

(b) The base of foundation; and

(c) The vertical planes coinciding with the perimeter of the footing.

Measurement for Structure Excavation shall not include material removed below the footing grade and beyond the specified limits of the excavation to compensate for anticipated swell or as a result of effective swell duirng pile driving or additional material resulting from slides, slips, cave-ins, siltings or filling whether due to the action of the elements or to carelessness of the Contractor.

Where the Engineer orders the excavation after the embankment has been placed, this embankment will be measured for payment as structure excavation as otherwise provided in these Specifications.

The volume of structure excavation where water is present will be measured for payment with additional price, only for the excavation executed to a depth greater than 20 cm below the constant level to which the water rises in the foundation pit.

The Structure Excavation of precasted concrete pipe of corrugated metal culvert pipe shall not be paid for separately but shall be included in the unit rate per linerar meter of the length of those pipe culverts.

(9) Basis of Payment

The quantities, determined as provided above, whether the haulage distance of excavated material, shall be paid for at the respective unit rate of the items listed below and are listed in the Schedule of Rates and payment shall be full compensaiton for all the costs, backfill, shoring, cribbing and related works, and for all other cost included in Clause GS .35 of General Specification, and all other costs necessary or usual for the proper completion of the work prescribed in this Clause.

Schedule Item No. and Name		Unit of Measruement
441	Structure excavation in earth to a depth of 4.00 m, waste	Cubic meter (m^3)
442	Structure excavation in earth more than a depth of 4.00 m, Waste	Cubic meter (m^3)
443	Structure excavation in rock to a depth of 4.00 m, Waste	Cubic meter (m^3)
444	Structure excavation in rock more than a depth of 4.00 m, Waste	Cubic meter (m^3)
445	Addition to the prices of Items Nos. 441; 442; 443; and 444 for Structure Excavation where water is present	Cubic meter (m^3)

TS 4 07 Borrow Excavation

(1) Definition

Borrow Excavation shall consist exclusively of material from borrwo pits, and shall exclude all excavation of material in cut made for the main track, its side tracks and station grounds.

(2) Applicable Provisions

The applicable provisions of Clause GS 4.02 (2) shall be reach into and become part of this Clause GS 4.07 "Borrow Excavation".

(3) Materials

When the embankment is to be formed of materials taken from borrow excavation, only such materials approved by the Engineer.

(4) Use of Borrow Pits

Material from borrow pits shall normally be used for construction of the embankment when there is no suitable material available from cuts made for the main track, its side tracks and station grounds. However, the Contractor may, if he so chooses and for his own convenience, obtain material for use in the embankment by opening pits rather than by hauling it from cuts. Permission to use such pit borrow, including advice as to its suitability, shall first be obtained in writing from the Engineer. Nevertheless, the total amount of the material from cuts made for the main track, its side tracks and station grounds after deduction of the material declared unsuitable by the Engineer, shall be considered to be available for use in the embankment, and any surplus material resulting from the Contractor's having used pit borrow in its place shall not be measured for payment as Common or Rock Excavation under Clause TS 4.04 and TS 4.05 of these Specifications.

Perimeter of borrow pits shall be at least 6 m away from the toes of embankment and the depth of borrow pits to be excavated shall not exceed 2 m.

Their distance from th work site shall not be grounds for extra-payment or revision of the Contract Price. In making his Tender the Contractor shall visit the Site and form his estimate of the hauling costs on the basis of his own survey of the possible nature and locations of the borrow pits.

(5) Payment to Others

The consent of the landowner or tenant for the digging and taking of material for borrow shall be secured by the Contractor, who shall, if required, pay for such concession. The pit shall be left in a condition acceptable to the owner and to the Engineer.

(6) Method of Measurement

Borrow Excavation shall not be measured for direct payment.

(7) Basis of Payment

Performance of this work under the Contract is not payable directly but shall be considered as a subsidary obligation of the Contractor covered under the Contract Prices for performance of work under Clause TS 4.08 "Embankment".

TS 4.08 Embankment

(1) Common Embankment

(a) Description

This work shall consist of the construction of embankment of railway roadbed and approach roads of railway crossings in accordance with these Specifications and the Specifications for other work items involved and in close conformity with the lines, grades, sections, and dimensions of the main track, its side tracks and station grounds shown on the drawings or as requried by the Engineer.

(b) Sources and Use of Material

Material for embankment shall consist of suitable material approved by the Engineer, excavated under the foregoing Clauses TS 4.04; TS 4.05 and TS 4.07. Pit borrow, however, shall only be used when there is not suitable material available from cuts made for the main track, its side tracks and

station grounds, or under the provision of Clause TS 4.07 (4) Surplus or unsuitable material shall be disposed of as provided in Clause TS 4.02 (8).
Unsuitable materilas for embankment are such as top soils containing much organic matters, whitish acid soils, bentonite, weathered serpentine and wet soils the rate of natural water content of which exceeds the rate of liquid limit thereof.

(c) **Foundation of Embankment**

Before beginning the construction of embankment, the Contractor shall fill the holes caused by the removal of the roots with suitable material approved by the Engineer on all the areas which have been cleared and grubbed, and such areas shall be suitably levelled.
This work shall not be paid for directly, but shall be considered a subsidary obligation of the Contractor covered by the Contract Prices for "Embankment".

(d) **Placing and Compaction**

(i) Material for embankment, obtained and approved as provided above, shall be placed in horizontal layers of uniform thickness over a width determined by the Engineer and in conformity with the lines, grades, sections, and dimensions shwon on the drawings. The layers of loose material other than rock shall be not more than 20 cm thick, unless the compacting equipment used is capable of compacting a depth greater than 20 cm to a uniform density throughout the full depth which is acceptable to the Engineer, in which case the Contractor may place and compact the material other than rock in layers of any thickness he chooses. After adjustment of the moisture content to that required to attain maximum desnity, the loose material shall be compacted to the required density.

(ii) Where embankments are located on hillsides, or where new fill is to be compacted against existing embankments, or where new fill is constructed on half width at a time, the original slope of the hillside, of the old shall be cut into a distance sufficient to accommodate the width of the compacting equipment as the new fill is placed in horizontal layers, and this materal cut shall be incorporated and compacted with the new fill. In the measurement of the work no allowance will be made for the volumes of material cut from the hillside or from the old fill to accommodate the compacting equipment, but will be calculated only on the net volume of fill placed against the original hillside, the old embankment or the first half width fill.

(iii) To avoid interference with the construction of bridges, abutments and wing walls the Contractor shall, at points to be determined by the Engineer, suspend work on embankments forming the approaches to any structures until such time as the construction of the latter is sufficiently advanced to permit the completion of the approaches without the risk of interference or damage to the bridge works. The cost of such suspension of work shall be included in the Contract unit Price for Embankment.
In carrying embankment up to or over bridges, culverts, or pipe drains care shall be taken by the Contractor to have the embankments brought up equally on both sides and over the top of any such structures.

(iv) Material for embankment at points inaccessible to normal compacting equipment shall be placed in horizontal layer of loose material not

more than 20 cm thick and thoroughly compacted by the use of mechanical tampers.

(e) **Allowance Filling of High Embankment**

In case of high embankment to be filled with such soils where the shrinkage of embankment is anticipated noticeable the Contractor shall give additional height in embankment as directed by the Engineer. In such case the Contractor shall broaden the width of Foundation of embankment as directed by the Engineer to cope with the additional filling. Increases of embankment quantity compared with the original corss-sections due to such additional filling are subject to payment on approval by the Engineer.

(f) **Compaction Trials**

Before the formation of the embankment the Contractor shall construct trial lengths for companction as directed by the Engineer. The soils used in the trial shall be those encountered along the main track and its side tracks and station grounds and the compacting equipment shall be the same equipment that the Contractor will use for the main work and has been accepted by the Engineer.

The object of these trials will be to determine the optimum moisture content and the relationship between the number of passes of compacting equipment and the density obtained for the soil types under trial. No separate payment will be made for this work, which will be regarded as a subsidary obligation of the Contractor under Schedule Item 451.

(g) **Required Densities and Their Controls**

The required densities to which embankment layers shall be compacted and their controls are as follows:

(i) **Layers more than 30 cm below subgrade level**

- Densities shall be tested by JIS-A-1214 (Density of Soils in-place by Sand Cone Method) in the frequency of once at three locations such as on the centerline and both sides as directed by the Engineer on the compacted layers in every thickness of 1.5 m of embankment per 100 m in length of embankment.
- Sandy soils, when used for embankment, shall be compacted up to more than such dry density as specified by the Engineer after the compaction trials.

  Sandy soils means such soils groups as GW, GP, GM, GC, SW, SP, SM and SC in Cassagrande Classification.
- Cohesive soils, when used for embankment, shall be compacted up to such a bearing power measured with a cone penetrometer exceeding 5 kg/cm^2, in which the bearing power of said soil sample means the value of resistance (qc) of said soil sample using a cone of 30 degrees of cone surface to cone axis with a cross-sectional area of 3.2 cm^2 in bottom thereof and being penetrated into soils at a speed of one centimeter per second. The value of qc is the arithmetrical mean of values measured at such depths as 10 cm, 20 cm and 30 cm from the surface of the layer into which the cone is penetrated.

Cohesive soils means such soils groups as ML, MH, CL, CH, OL, and OH in Cassagrande Classification.

– The maximum dry density thus obtained shall be adjusted for such oversize material as directed by the Engineer. Subsequent layers shall be placed and compacted unless their previous layer has been properly compacted and accepted by the Engineer.

(ii) **Layers 30 cm or less below subgrade level** shall be compacted to 95 per-cent of the maximum dry density determined according to AASHTO-T99-74 (or JIS-A-1214).

(h) **Moistrue Content**

Embankment material that does not contain sufficient moisture to obtain the required compaction shall be given additional moistrue by means of approved sprinklers and mixing. Material containing more thatn the amount of moisture necessary to obtain the required compaction may not, without approval of the Engineer, be incorporated in the embankment until it has been sufficiently dried out. The drying of wet material may be expedited by discing or other approved methods.

The compaction of the embankment shall be carried out at the optimum moistrue content consistent with the available compacting equipment. In forming the embankment the Contractor shall take steps to insure that the work can be drained free of rain water, and he shall make due allowance in the height and width of the work for swelling or shrinkage.

(i) **Rock Fill**

(i) No rock fill shall be placed until after the Contractor has discussed his plans for the work of cut and fill with the Engineer and obtained the latter's approval. In order to provide a suitable grade level, material for covering the rock fill shall be reserved from the excavation of cut. Should such material be available and not be so reserved by the Contractor, so that borrow material has to be used for forming the grade level, such borrow shall be supplied and placed without extra payment to the Contractor.

(ii) Rock fill shall be placed in loose layers not to exceed 60 cm in thickness and compacted as herein provided. The top layer of this fill shall be not more than 30 cm thick and the interstices shall be thoroughly filled with clean small spalls, shale, gravel or similar approved material and thoroughly compacted to the satisfaction of the Engineer.

(iii) Rock in fill shall be considered as rock only when the earth or other finer material uniformly distributed throughout is considerably less than sufficient to fill the voids so that the rock particles shall be in intimate contact and not separated by earth or similar materials. Otherwise, the fill material shall be handled and considered as earth fill to be placed and compacted as specified in Clause TS 4.08.

(iv) Where rock is to be incorporated in fill or portions of fill, composed largely of earth or friable material, the rock shall be reduced to a maximum size not exceeding 75 per-cent of the thickness of the layer being placed. But any rock or boulder should not be contained in embankment within one meter depth beneath the finished sub-

grade.

(v) A surfficient cover of earth over rock fill shall be used to uniform grade level.

(j) Mixed Material in Fill

When materials of widely divergent characteristics, such as clay and chalk or sand, drawn from different sources, are to be used in the embankment, they shall be deposited in alternate layers over the full width of the embankment to depth approved by the Engineer.

Rock, clay or other material shall be broken up, and no accumulation of lumps or boulders at the toe of the embankment will be permitted.

(k) Levelling of Existing Embankment

Before fill is placed on the existing roadbed, the existing embankment may be levelled by cutting, rooting, or scarifying with approved mechanical means to level to be determined by the Engineer. The earth, or other material obtained as a result of this operation will be declared by the Engineer to be either suitable or unsuitable for use in the embankment. In the first case it shall be used in and adjacent embankment as directly by the Engineer, and payment shall be as provided in this Clause for Embankment. In the second case the material shall be disposed as provided in Clause TS 4.02 (8), and payment shall be as provided for Common Excavation in Clause TS 4.04 (6).

(l) Finishing Subgrade

(i) Final Grade Level

When an embankment requires the addition of material to a depth of not more than 30 cm to bring it up to the required grade level, the top of the embankments shall be thoroughly scarified before the additional material is placed.

The final grade level, to the profile indicated shall conform to the provisions of Clause TS 4.02 (3) of these Specifications.

(ii) Slopes

Side slopes shall be neatly trimmed to the lines and slopes shown on the drawings or as directed by the Engineer, and the finished work shall be left in a neat and acceptable condition.

When indicated on the drawings or ordered by the Engineer, the slopes shall be dressed with topsoil material as described in Clause TS 4.03 (3) of these specifications.

(iii) Stability

The Contractor shall be responsible for the stability of all embankment and shall replace any portions that have been damaged or displaced due, in the opinion of the Engineer, to carelessness or neglect on the part of the Contractor, or to such actural causes as storms, but not to unavoidable movements of the natural ground upon which the embankment is made. During construction the subgrade shall be kept in shape and drained at all times. When unsuitable material has been placed in the embankment by the Contractor, he shall remove it without extra payment.

(m) **Method of Measurement**

The quantities to be paid for shall be the number of cubic meters after the execution of clearing and grubbing as prescribed in Clause TS 4.03 of these Specifications in the volume of compacted embankment accepted by the Engineer formed with materials resulting from Common Excavation, Rock Excavation or Borrow Excavation, as hereinbefore prescribed. The average end-area method shall be used in computing the quantities, except when the error exceeds plus or minus 5 per-cent as compared with the prismoidal formula, in which case the Engineer will direct the use of the more accurate method. However, the Contractor shall request such direction before he submits his quantities for approval. He will not be allowed to seek revision of quantities calculated on the average end-area basis which have been approved by the Engineer. Profiles and corss-sections shall be submitted ot the Engineer as provided for Common Excavation in Clause TS 4.04 (2).

The volume of embankment already executed by the Contractor for the temporary rocks and/or temprorary tracks, will not be measured for payment if these roads fall within the area occupied by the embankment. The dressing of the slopes with topsoil will be measured and paid for as Embankment under Schedule Item 451.

(n) **Basis of Payment**

The quantities, determined as provided abvoe including the supply of the materials whatever their hauling distance, shall be paid for at the applicable unit rate for each of the particular pay items listed below that are shown in priced Bill of Quantities. Items Nos. 451 and/or 452 shall be applied to Embankment formed with materials resulting from Structure Excavation, even though the excavation of this material has already qualified for payment under Pay Items Nos. 441, 442, 443, 444 and 445. These prices and payments shall be full compensation for the compaction in layers at the prescribed density, including wetting and drying if necessary, and including the shaping of the slopes and the compaction trials if required, as well as for all the costs indicated in Caluse GS 35 of the Specifications, and all other costs necessary or usual for the proper completion of the work prescribed in this Clause. In case when backfill of structure is executed using such earth exacavated from structure foundation, such quantity shall be paid for at the Contract Price per unit measurement for the pay items 451 Emabnkment with materials from common excavation (E.W.M.F.C.E.) or 452 Embankment with materials form rock excavation (E.W.N.F.R.E.), as the case may be.

Pay Item No.	Pay Item	Unit of Measurement
451	Embankment with materials from common excavation (E.W.M.F.C.E.)	Cubic meter (m^3)
452	Embankment with materials from rock excavation (E.W M.F.R.E.)	Cubic meter (m^3)
453	Backfill of structures with selected materials (B.S.W.S.M.)	Cubic meter (m^3)

	Embankment with materials from borrow excavation (E.W.M.F.B.E.)	Cubic meter (m^3)

(2) **Embankment in Swampy Areas**

(a) **Description**

By swampy areas are understood those areas where the embankment is to be constructed across low swampy ground permanently or seasonally under a level of water or subject to the action of water that, given the topography of the area, in the opinion of the Engineer cannot be drained and dried out with methods envisaged in the Specifications.

(b) **Construction**

The embankment shall be executed to a height. Where ordered by the Engineer, before the construction of the embankment is begun, clearing and grubbing shall be executed and a layer of topsoil shall be removed of the thickness shwon on the drawings or as ordered by the Engineer.

The removal of such unsuitable materilas will be paid by the pay item 421 Common Excavation, Waste.

The Contractor shall build a supporting grade, if required, up to an appropriate height on which the embankment is to be built. Compaction shall be commenced by the Contractor at an appropriate elevation above water level using equipment approved by the Engineer in advance. Compaction shall be continued until when it is confirmed that there exists not more deformation beneath the equipment or roller after the settlement of embankment is no more recognized. The density of compacted soils above the water level shall conform with the requirements provided in Clause TS 4.08 (1) (g)

(c) **Method of Measruement**

The quantity to be paid for shall be measrued on the volume of embankment above the ground level after the unsuitable soils were removed.

(d) **Basis of Payment**

The quantities, determined as provided above, shall be paid for at the Contract Price per unit measurement for the pay items listed below, which price and payment shall be full compensation for supply of the material, whatever the haulage distance, placing of the material, formation and compaction of the embankment as per drawings or as ordered by the Engineer including all the costs indicated in General Specificaions Clause GS 35 and all other costs necessary and usual for the proper completion of the work prescribed in this Clause.

Pay Item No.	Pay Item	Unit of Measurement
421	Common excavation waste	Cubic meter (m^3)
451	embankment with materials from common excavation (E.W.M.F.C.E.)	Cubic meter (m^3)

	454	Emabnkment with materials from borrow excavation (E.W.M.F B.E.)	Cubic meter (m^3)

TS 4.09 **Demolitions**

(1) **Description**

This work shall consist of the removal, wholly or in part and satisfactory disposal of blcok of masonry of an individual size greater than 1.00 m^3, of all buildings fences, structures, and any other obstructions which are not designated or permitted to remain, except for the obstructions to be removed and disposed of under other items in the Contract Documents. It shall also inlcude the salvaging of designated materials and backfilling the resulting, trenches, holes and pits.

(2) **Work Requirement**

(a) General

The Contractor shall perform the work described above, within and to adjacent to the main track, on the right-of-way, as shown on the drawings or as directed by the Engineer. All materials recovered from demolition shall remain in the property of the Employer unless specifically provided otherwise in the Contract Documents except materials resulting from the demolition of substructures and buildings. All designated salvable material shall be removed, without unnecessary damage, in sections of pieces which may be readily transported, and shall be stored by the Contractor at specific places on the project as directed by the Engineer. Basement or cavities left by structure removal shall be filled with acceptable material to the level of the surrounding ground and, if within the prism of construction, shall be compacted in accordance with Clause TS 4.06 (7)

(b) Removal of Bridges, Culverts, and Other Drainage Structures

Bridges, culverts, and other drainage structures in use by the existing railway or roads shall not be removed until satisfactory arrangements have been made to accommodate their traffic.

Unless otherwise directed, the substructures of existing sturctures shall be removed down to the natural stream bottom and those parts outside of a stream shall be removed down to at least 30 cm below natural ground surface. Where such portions of existing structures lie wholly or in part within the limits for a new structure, they shall be removed as necessary to accommodate the construction of the proposed structure.

Steel bridges and wooden bridges, when specified by the Engineer to be salvaged, shall be carefully dismantled without damage. Steel members shall be match marked, unless such match marking is waived by the Engineer. All salvaged material shall be stored as requested by the Engineer.

Balsting or other operations necessary for the removal of an existing structure or obstruction, which may damage new construction, shall be completed prior to placing the new work, unless otherwise provided in the Contract Documents.

Unless waived in writing by the Engineer, all concrete removed that is of suitable size for riprap and not needed for such use on the project, shall be stockpiled at locations indicated in the Contract Documents for use by the

Employer.

(c) Performance of that work under the Contract is not payble directly but shall be considered as a subsidary obligation of the Contractor covered under the contract price for Grubbing and Demolition in Clause TS 4.03 (5).
The obligation will also included salvage of materials removed, their custody, preservation, storage on the right-of-way, and disposal as provided herein, except for the structures and building materials.

SECTION 5 PIPE CULVERT

SECTION 5 PIPE CULVERT

TS 5.01 Applicable Scope of Work

This item shall consist of corrugated sheet metal pipe and pre-cast concrete pipe shown on the plans, furnished and installed at such places as are designated on the plans or by the Engineer, in accordance with these specifications and other related specifications.

The item shall inlcude, in the bid price per linear meter of pipe in place, the cost of common excavation and backfill, the cost of furnishing and installing all temporary facilities, all fittings and materials required to complete the pipe drain, as shown on the plans, and the material for and the making of all joints, inlcuding all connections to existing drainage pipes and structures.

The contractor shall submit to the Engineer for approval, the data relative to the materials intended to be used for the pipe culvert construction, prior to its use, however, the Contractor shall assume full responsibility for the materials concerned

The Contractor shall submit to the Engineer for approval a shop draieng showing the type the pipe connections.

TS 5.02 Materials

(1) Corrugated Metal Culvert Pipe

Corrugated metal culvert pipe shall conform to the requirements of AASHTO M 36 or its equivalent.

(2) Pre-cast Concrete Pipe

The reinforcing steel bar to be incorporated in the manufacture of the pre-cast concrete pipe shall conform to the requirements of ASTM A615 and the quality of the concrete shall be better then Class "B" specified in TS 6.01 (b)

(3) Mortar

Mortar for connections to drainage structures shall be composed of 1 part by volume of portland cement and 2 parts of fine aggregate. The quality of materials shall conform to the requirements specified in TS 6.

TS 5.03 Application

(1) Equipment

All equipment necessary and required for the proper construction of pipe culvert for drainage and underdrain shall be on the project, in first class working condition, and shall have been approved by the Engineer before construction is permitted to start.

The Contractor shall provide such hand tampers and pneumatic tampers which have been approved to obtain the compaction of the base and the backfill as specified.

(2) Excavation

The contractor shall do all excavation to the depth shown on the drawings, after excavated, the base shall be provided with a cushion at least 7 cm thick. The cushion shall consist of clean sand or equivalent granular materials.

Excavated material not required or acceptable for backfill shall be disposed of by the Contractor as directed by the Engineer. The excavation shall not be carried below the required depth; when this is done, the excessively excavated portion shall

be backfilled at the Contractor's expenses with material approved by the Engineer and compacted to the density of the surrounding earth material.

When directed, unstable soil shall be removed for the full width of the trench and replaced with sand or with approved granular material. The Engineer shall determine the depth of removal of unstable soil and the amount of backfill necessary. The backfill shall be thoroughly compacted and shaped to form the bed for the pipe.

The depth of cut shown on the plans is from the surface grade to the invert of the pipe line.

The minimum width of the trench at the top of the pipe, when placed, shall be a width which will permit the proper construction of joints and compaction of backfill around the pipe, but shall at least equal to the outside diameter of the pipe plus 18 cm on each side of the pipe. The trench shall be excavated so that at least a 15 cm space will exist between the side of the trench and the side of the pipe. The sides of the trenches shall be vertical, unless otherwise approved by the Engineer. The maximum allowable width of trench shall not exceed 25 cm on each side of the pipe when placed, unless otherwise approved by the Engineer.

The bed for the pipe shall be so shaped that at least the lower quarter of the pipe shall be in continuous contact with the bottom of the trench.

The Contractor shall do such trench bracing, sheathing, or shoring necessary to perform and protect the excavation.

(3) Placing Pipe

Proper facilities shall be provided for lowering the pipe when it is to be placed in a trench. The pipe shall be laid carefully and true to lines and grades on a bed which is uniformly firm throughout its entire length. Any pipe which is unsatisfactorily installed or shall be taken up and relaid or replaced.

Where structing of round pipe is shown on the plans, the vertical diameter shall be increased 5 per-cent by means of suitable jacks applied after the entire length of the culvert has been placed in the prepared bedding and before any fill is palced. The 5 per-cent increase shall be uniform for the full length of the culvert except that, when so indicated on the plans, it may be reduced gradually under the embankment side slopes to zero at the culvert ends. The pipe shall be maintained in this shape by means of sills and struts or by horizontal ties in accordance with details shown on the plans.

Where structing of factory-formed elliptical pipe is called for on the plans, no additional increase of the vertiel diameter will be required, but the pipe shall be structed or tied in accordance with the details shown on the plans.

(4) Mortar

Mortar shall be mixed in a ratio of 1 part by volume of protland cement and 2 parts by volume of fine aggregate. The mortar shall be of the desired consistency for calking and filling between the pipe and the drainage structures. Mortar that is not used within 45 minutes after water has been added shall be discarded. Retempering of mortar will not be permitted.

(5) Backfilling

All trenches and excavation shall be backfilled in a reasonable time after the pipes are installed therein unless otherwise directed by the Engineer. Backfill material containing stones or rock exceeding 8 cm in diameter shall not be used adjacent to the pipe or until the fill over the top of the pipe exceeds 25 cm. Special care shall be taken in palcing the backfill. Great care shall be used to obtain thorough compaction

along the sides to the top of the pipe.
The backfill shall be placed in loose layers not exceeding 20 cm in depth under and around the pipe, and not exceeding 20 cm over the pipe. Successive layers shall be added and thoroughly compacted by hand and pneumatic tampers, approved by the Engineer, until the trench is completely filled and brought to the elevation specified so that an unfavorable influence is effected to the pipe.

(6) **Connections**
Where the plans call for connections to other structures, these connecions shall be watertight and so made that a smooth uniform flow line will be obtained throughout the drainage system.

(7) **Cleaning and Restoration of Site**
After the backfill is completed, the Contractor shall dispose of all surplus material, dirt, and rubbish from the site.

(8) **Inspection**
The Engineer shall make a thorough inspection, by an appropriate method, of the entire installation. Any indications of defects in material or workmanship, they shall be corrected by the Contractor without additional compensation, and as directed by the Engineer.

TS 5.04 **Method of Measurement**

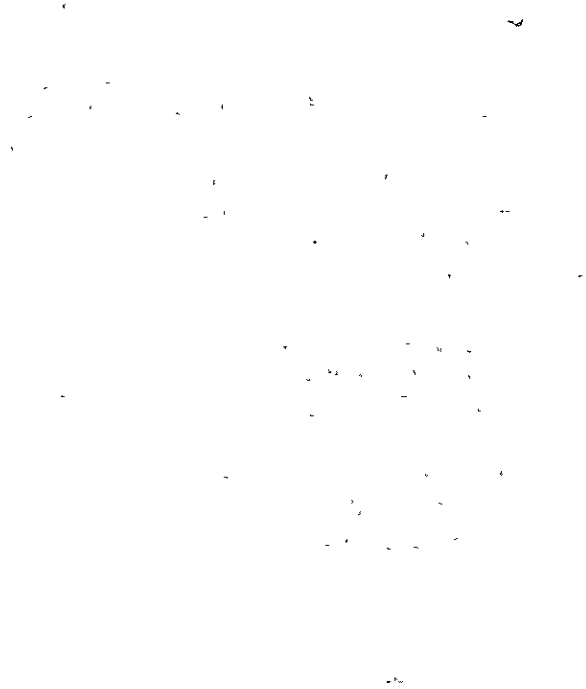
(1) The pipe to be paid for shall be the number of linear meter of pipe in place completed and approved; measured along the centerline of the pipe from end or inside face of structure to end, or inside face of structure, whichever is applicable. The several classes, types, and sized shall be measured separately.

(2) Rock required to be removed shall be computed by the cubic meter for the specified width of the trench and to a depth of 10 cm below the bed of the pipe.

TS 5.05 **Basis of Payment**

(1) Payment shall be made at the contract unit price per linear meter for culvert pipe of the type, class and size designated; at the contract unit price per cubic meter for rock and common excavations. These prices shall be full compensation for furnishing all materials; for all preparation, excavation and installing these material and backfilling; and for all labor, equipment, tools and incidentals necessary to complete the item.

Pay Item No.	Pay Item	Unit of Measurement
511	Corrugated metal pipe culvert of 800 mm in dia.	Linear meter (m)
512	Corrugated metal pipe culvert of 1000 mm in dia.	Linear meter (m)
513	Corrugated metal pipe culvert of 1200 mm in dia.	Linear meter (m)
521	Pre-cast concrete pipe culvert of 800 mm in dia.	Linear meter (m)
522	Pre-cast concrete pipe culvert of 1000 mm in dia.	Linear meter (m)



SECTION 6 CONCRETE STRUCTURE

SECTION 6 CONCRETE STRUCTURE

TS 6.01 Applicable Scope of Work

This work shall consist of massive concrete (without reinforcing steel bar) and reinforced concrete for bridge girder, bridge abutment, box culvert, open culvert and retaining wall relative to their materials and construction.
The work shall be carried out strictly in accordance with the contract documents.

TS 6.02 Class of Concrete

The class of concrete used in each part of the structure shall be as follows:

Class	Type of Structure
Concrete class "A"	Concrete structure consisting of relatively large amount of reinforcing steel bars.
Concrete class "B"	Concrete structure consisting of relatively less reinforcing steel bars, or
Concrete class "C"	Massive conrete having no reinforcing steel bars
Concrete class "D"	Levelling concrete for structural foundations.

TS 6.03 Proportions & Mixing

(1) **Porportions**
The standard proportions of concrete shall be as tabulated in Table 6-1 mentioned hereunder. The contractor shall made a trial proportions based on the Standard Proportions to make sure of the quality required and submit to the Engineer for approval his proportions.

Table 6-1 Standard of the designated proportions of concrete

Class	Compressive Strength at the age of 28 days	Maximum size of Coarse Aggregate	Slump (cm)	% of Air Entraining
A	240 kg/cm^2	1–1/2" – No. 4	7 ± 3	5
B	210	"	"	"
C	180	"	"	"
D	160	"	"	"

(2) **Adjustment of Proportions**
In the opinion of the Engineer, if the originally designated concrete proportions are likely unable to obtain the concrete having the specified placability and workability, he may authorize the Contractor to make variations in the weight of aggregate as necessary, provided that the originally specified volume of cement remain unchanged.

(3) **Strength Requirements**
The final strength of concrete shall be determined based on a test specimen prepared in accordance with AASHTO T141 (ASTM C172) and ASSHTO T23 (ASTM C31).

The test cylindrical concrete piece to be prepared in a laboratory shall conform to the requirements of AASHTO T126 (ASTM C192). The compression test for the cylindrical concrete shall be carried out in accordance with ASSHTO T22 (ASTM C39).

The final compressive strength for the cylindrical concrete at the age of 28 days shall be as shown in Table 6-2.

The compressive strength at 7 days shall correspond to 70% of the 28 days compressive strength value. Should the 7 days strength indicate lower than those specified, the cause of such low value shall be investigated and the Contractor may not be authorized to place concrete continuously until such time that the Contractor can surely produce the concrete by taking appropriate action, in accordance with the specifications to the satisfaction of the Engineer. Should the concrete become unable to attain the designed strength and/or specified strength, the Contractor shall add the cement volume as directed by the Engineer.

No compensation shall be made to the Contractor on the ground of the additional volume of cement used.

Table 6-2 Classes of concrete and compressive strength

Class	Minimum Compressive Strength at the age of 28 days (kg/cm^2)
A	240
B	210
C	180
D	160

TS 6.04 Materials

(1) Cement

Portland cement shall conform to the requirements of AASHTO M85. Portland blast-furnace slag-cement shall conform to the requirements of ASSHO M151. Air-entraining Portland cement shall conform to the requirements of AASHTO M134. Unless otherwise permitted by the Engineer, the product of only one mill of any one brand type of Portland cement shall be used on the project, except for reduciton of any excessive air entrainment where air-entraining cement is used.

However, in the event of using the air-entraining cement to redue the excessive amount of the air-entraining admixture, the descriptions referred to above may not be limited.

Unless otherwise specified, the Contractor may use any type of cement conforming to the requirements of AASHTO M85, except type IV and V.

In the event the Contractor elect to use an air-entraining admixture, he shall con-Cement may be shipped form pre-tested and approved bins or the mill. The cement shall be well protected from rain and moistrue, and any cement damaged by moisture or which fails to meet any of the specified requirements shall be rejected and removed from the work. Cement stored by the Contractor for a period longer than 60 (sixty) days shall require the Engineer's approval before being used on the work. Cement of different brands, types, or from different mills shall be stored separately. The use of cement reclaimed from discarded or used bags will not be permitted. Any cement taken from the used cement bag or discarded cement bag shall not be approved.

(2) **Air-entraining Admixture**

In the event the Contractor elects to use an air-entraining admixture, evidence based on tests made in a recognized laboratory shall be submitted to the Engineer. When the Contractor proposes to use an air-entraining admixture which has been previously approved, he shall submit a certification stating that the admixture is the same as that previously approved.

(3) **Water**

Water used in mixing, curing, or other designated applications shall be resonably clean and free of oil, salt, acid, alkali, sugar, vegetable, or any other substance injurious to the finished product. Water will be tested in accordance with, and shall meet the suggested requirements of AASHTO T26. Water known to be of potable quality may be used without test. Where the source of water is relatively shallow, the intake shall be so enclosed as to exclude silt, mud, grass, or other foreign materials.

(4) **Fine Aggregate**

The fine aggregate for concrete shall consist of natural sand or subject to approval of the Engineer, other inert materials with similar characteristics, having durable particles. Fine aggregate from different sources of supply shall not be mixed or stored in the same pile nor used alternately in the same class of construction without permission from the Engineer.

The fine aggregate shall not contain deleterious substances in excess of the following percentages.

Table 6-3 Limits of the injurious amounts of organic impurities

	AASHT Test Method	Percentage by Weight
Clay lumps	T 112	1
Coal and lignite	T 113	1
Material passing No. 200 Sieve	T 11	3

All fine aggregate shall be free from injurious amounts of organic impurities. Aggregates subjected to the colormetric test for organic impurities, AASHTO T21, and producing a color darker than the standard shall be rejected unless they pass the mortar-strength test. Should the aggregate in tests conducted during progress of the work show a color darker than that of samples originally approved for the work, its use shall be discontinued until tests satisfactory to the Engineer have been made to determine whether the increased color is indicative of an injurious amount of deleterious substances.

When the fine aggregate is subjected to five alternations of the sodium sulphate soundness test, using AASHTO T104, the weighted percentage of loss shall be not more than 10 percent. Fine aggregate failing to meet the requirement for soundness may be accepted provided it can be shown by evidence satisfactory to the Engineer. Motor specimens containing the fine aggregate, when tested according to AASHTO T71, shall develop a compressive strength higher than 95% at the age of 3 days, when using type III cement, or at 7 days when using type I or II cement after washing with 3% hydrated natorium solution and furthermore washing with water thoroughly.

Type I, II and III cements shall conform to AASHTO M85. The fine aggregate sahll be uniformly graded and shall meet the following grading requirements:—

Table 6-4 Gradation

Sieve designation	Percentage by weight Passing square-mesh sieves (ASSHTO T 27)
3/8 inch	100
No. 4	95 – 100
No. 10	45 – 80
No. 50	10 – 30
No. 100	2 – 10

Fine aggregate failling to pass the minimum requirement for material passing the No. 50 and No. 100 sieves may be used provided an approved inorganic fine inert material is added to correct the deficiency in grading.

The gradation requirements given above are the extreme limits to be used in determining the suitability of material from all possible sources of supply. The gradation of materials from any one source shall not vary in composition beyond the range of values that govern the selection of a source of supply. For the purpose of determining the degree of uniformity, a fineness modulus determination shall be made upon representative samples, submitted by the Contractor, from such sources as he proposes to use. Fine aggregate from any one source having a variation in fineness modulus greater than 0.20, plus or minus, form the avergae fineness modulus of the representative sample submitted by the Contractor shall be rejected. The fineness modulus of fine aggregate shall be determined by adding the cumulative percentages, by weight, of material retained on each of U.S. Standard Sieves Nos. 4, 8, 16, 30, 50 and 100, and dividing by 100.

(5) Coarse Aggregate

The coarse aggregate for concrete shall consist of crushed stone, gravel, blast-furnace slag, or other approved inert material of similar characteristic having durable pieces, free from undesirable adherent coatings. The coarse aggregate of different sources shall not be mixed and shall not be used in the same class of concrete unless approved by the Engineer. Crushed stone or crushed gravel shall be used for classes "A" and "B" concrete. The coarse aggregate shall not contain deleterious substances in excess of the following percentages:—

Table 6-5 Limits of the injurious amounts of organic impurities

	ASSHTO test method	Percentage be weight
Caly lumps	T 112	0.25
Materials passing No. 200 sieve	T 11	1
Thin or elongated piece (length greater than 5 times maximum thickness)	–	10

Table 6-6 Grading Requirements for Coarse Aggregates

Size Number	Nominal Size (Sieves with Square Openings)	Amounts Finer than Each Laboratory Sieve (Square Openings), Weight Percent												
		4 in. (100 mm)	3½ in. (90 mm)	3 in. (75 mm)	2½ in. (63 mm)	2 in. (50 mm)	1½ in (38.1 mm)	1 in. (25.0 mm)	¾ in. (19.0 mm)	½ in. (12.5 mm)	3/8 in. (9.5 mm)	No. 4 (4.75 mm)	No. 8 (2.36 mm)	No. 16 (1.18 mm)
1	3½ to 1½ in. (90 to 37.5 mm)	100	90 to 100	...	25 to 60	...	0 to 15	...	0 to 5	...	...	...	..	...
2	2½ to 1½ in. (63 to 37.5 mm)	...	...	100	90 to 100	35 to 70	0 to 15	...	0 to 5	...	...	...	...	...
357	2 in. to No. 4 (50 to 4.75 mm)	...	...	...	100	95 to 100	...	35 to 70	...	10 to 30	...	0 to 5	...	...
467	1½ in. to No. 4 (37.5 to 4.75 mm)	...	...		...	100	95 to 100	...	35 to 70	...	10 to 30	0 to 5	...	...
57	1 in. to No. 4 (25.0 to 4.75 mm)	...	...	...	...	...	100	95 to 100	...	25 to 60	...	0 to 10	0 to 5	...
67	¾ in. to No. 4 (19.0 to 4.75 mm)	...	...	...	...	...	...	100	90 to 100	...	20 to 55	0 to 10	0 to 5	. .
7	½ in. to No. 4 (12.5 to 4.75 mm)	...	...	...	...	..	...	...	100	90 to 100	40 to 70	0 to 15	0 to 5	...
8	3/8 in. to No. 8 (9.5 to 2.36 mm)	...	...	...	..	...	..	...	...	100	85 to 100	10 to 30	0 to 10	0 to 5
3	2 to 1 in. (50 to 25.0 mm)	...	. .	...	100	90 to 100	35 to 70	0 to 15	...	0 to 5	...	...	...	...
4	1½ to ¾ in. (37.5 to 19.0 mm)	...	...	...	...	100	90 to 100	20 to 55	0 to 15	...	0 to 5	...	..	...

The coarse aggregate shall not have a percentage of wear of more than 50 at 500 revolutions as determined by AASHO T96.
When the coarse aggregate is subjected to five alternations of the sodium sulphate soundness test, using the samples described in AASHO T104, the weighted percentage of loss shall be not more than 12 percent. Coarse aggregate failing to meet the requirement for soundness may be accepted provided it can be shown by evidence satisfactory to the Engineer that concrete of comparable proportions made from similar aggregates from the same source has been exposed to weathering under conditions similar to those occurring at the site of the structure for a period of at least 5 years without appreciable disintegration. The requirements for soundness may be waived by the Engineer when the aggregate is to be used in structures or portions of structures not exposed to weathering. Coarse aggregate shall conform to the requirements of Table 6.1 for size or sizes designated and shall be uniformly graded between the limits specified

(6) Joint Fillers
The Contractor shall propose to the Engineer for approval a joint filler material which is to be applied at the place where indicated on the plan and appropriate to the structure.

(7) Curing Materials
Curing materials shall conform to the following requirements as specified;-

–	Cotton mats for curing concrete	AASHTO M73
–	Burlap cloth made from jute or kenaf	AASHTO M182
–	Waterproof for curing concrete	AASHTO M139 (ASTM C171)
–	Liquid membrane-forming compounds for curing concrete	AASHTO M148
–	White polyethylene sheeting (film) for curing concrete	AASHTO M171

TS 6 05 Construction

(1) General
The Contractor shall determine the proportions of concrete for approval of the Engineer, taking into consideration the conditions of the materials at site and measuring method so as to obtain the concrete specified in paragraph TS 6.03 of this Specification.

(2) Batching

(a) Cement
If the weight per a sack of cement indicates larger than an average of ten (10) sack of cement, no measurement of cement is necessary. Bulk cement shall be weighed on an approved weighing device.

(b) Admixtures
The admixture shall be weighed on weighing device, however, it may be measured by volume approved by the Engineer.

(c) Agrregates
Fine aggregate and coarse aggregate shall be weighed on an approved weighing device and shall be indicated by weight.

(d) Water
The water shall be weighed on weighing device, however, it may be measured by volume if approved by the Engineer.

Each material shall be measured in every batching. The meaduring of aggregates shall be so conducted as to result within a 3 percent tolerance fo weight. So far as the cement and the admixtures are concerned, they shall be within a range of 2 percent and 1 percent respectively. Each weighing device shall be accurate wihtin 0.5 percent throughout the range of use, and shall be inspected, tested, and sealed as often as the Engineer may deem necessary to assure continued accuracy. The Engineer may permit the use of weighing devices for a reasonnable period prior to sealing, provided field testing indicates consistent compliance with the limits of accuracy specified herein. In batching aggregates for structures containing less than 25 cubic meters of concrete, the Contractor may substitute approved volumetric measuring devices in lieu of weighing devices.
In such event, weighing will not be required but the volumes of coarse aggregate and of fine agrregate measured into each batch shall be those designated by the Engineer.

(3) Mixing

Concrete shall be mixed in a batch mixer of an approved type and capacity. The mixing time shall be determined based on the test results. Water shall first be added prior to the cement and aggregates are charged into the mixer.
The mixer shall be operated at the drum speed as shown on the plate on the mixer. It is a foundamental policy to charge all materials uniformly at the same time. The mixing shall not be conducted longer than three times as compared to the specified time. No new materials shall be charged into the mixer until the materilas left inside of the mixer are thoroughly discharged.
The mixer shall be thoroughly cleaned before and after the operations. Any concrete which has started an initial setting after mixing shall not be used repeatedly. In case of an emergency, the concrete may be mixed manually, provided that it is approved by the Engineer. In this case, concrete shall be thoroughly mixed to such extent than an uniformity of concrete can be obtained.

(4) Slump Test

Slump shall be measured to confirm the consistency of the mixed concrete in accordance with AASHTO T141 in sampling and T119 in field testing. The measurement shall be taken every batch.

(5) Compression Test

The characteristic strength of the various classes of concrete is determined on the basis of the results of a set of compression tests performed on test cylinders taken from the same sample.
The concrete test cylinders will be tested by the Engineer at a conveniently loacated and properly equipped laboratory approved by the Engineer.
In order to determine the safe bearing capacity of the concrete during construction, the Contractor shall prepare test cylinders which will be cured and tested at 7 days or 28 days as determined by the Engineer, or at any other interval that may be necessary to determine the strength of the concrete. Test cylinder specimens shall be made and cured in accordance with the "Standard Methods of Making and Storing Specimens of Concrete in the Field" AASHTO T23 (ASTM C31) and tested in accordance with AASHTO T22 (ASTM C39).
Six (6) test cylinders shall be made from each sample of concrete and there shall be not less than 6 cylinders made for every 50 cubic meters of concrete or fraction thereof placed during one day's run or as deemed necessary by the Engineer. Three of the above six specimens shall be tested at 7 days and the other three at 28 days. Irrespective of the quantity, every day's production of concrete shall be tested both

for strength and for slump are every structure and every component of every structure shall likewise be so tested for strength and slump. The checking and testing of the concrete shall be the prerogative of the Engineer, and he may increase the number of tests to be made or make other tests as he may deem necessary to ensure that the concrete is of the specified strength and condition as required for the project.

The characteristic strength of the various classes of concrete is determined on the basis of the results of a set of compression tests performed on test cylinders taken from the same sample.

The compressive strength test value shall fulfill the following conditions:

(i) The test value should not below more than 1/20 of 80% for the designed standard strength

(ii) The test value should not below more than 1/4 of the designed standard strength.

In the event of doubtful results, the Engineer will proceed to check the simple compression strength by means of crushing tests performed on test cylinders taken with a rotary core borer at suitable points indicated by the Engineer on structures already constructed. Such tests shall be carried out by an agreed authority having suitable test facilities. If such tests show strength in compliance with the requirements herein specified, the concrete will be considered satisfactory. If such tests do not comply with the reqirements, the Engineer may direct the Contractor to cut out and make good the defective work at the Contractor's expense.

The Contractor shall provide stout, substantial packing cases for the transportation of the test specimens from the site to the laboratory and the cost of providing such packing and cases and the cost of shipping or transporting the test specimens from the site ot the laboratory shall be included as part of the price bid for concrete. The Contractor shall take, on his own responsibility, every precaution to prevent injury to the test cylinders during handling, transporting and storing.

The records of all tests shall be kept by the Engineer but results shall be available at all times to the Contractor. The Contractor shall be responsible for making such adjustments as may be necessary to produce specification concrete and the test results shall indicate whether or not the concrete is satisfactory. When the results of the 28-day tests, as represented by tests on cylinder specimens, fail to give the required strength, the Engineer with the concurrence of the Contractor may order the concrete, to be removed from the work. If the Contractor disputes the results of such tests the Engineer may require the Contractor to have confirmatory tests made at the Contractor's expense.

Such confirmatory tests shall consist, according to the Engineers instructions, of cores of set concrete cut form the portion in dispute of the structure already poured and cured or of non-destructive compressive strength tests, performed with the sclerometer, on the finished structure, whether reinforced or not.

Each non-destructive test or measurement shall be performed as follows:

- around the point selected by the Engineer, an area not larger than 0.1 sq.m^2 shall be fixed, on which 10 blows with the sclerometer shall be made, and the values of the index, read each time, shall be recorded;
- the artithmetic mean of such values shall be determined;
- values which differ from the arithmetic mean by 15 hundredths of the total range of the sclerometer scale shall be discarded;
- from the values not discarded the arithmetic mean shall be obtained, which, by means of the calibration table of the sclerometer, will give the compressive strength of the concrete.

Generally, for each type of sclerometer the calibration table supplied by the manufacturer will be used. Nevertheless, the Engineer will have the right, and when he shall think fit, to perform the calibration of the scalerometer directly on specimens which will afterwards be subjected to the crushing tests by simple compression.

(6) Scaffoldings and Forms Work

(a) Scaffoldings

The scaffoldings shall be on foundations of sufficient strength to carry the loads without appreciable settlement. The scaffoldings shall be designed to carry the full loads coming upon it. Detail drawings of the scaffolding shall be submitted to the Engineer. Arch centring shall be so constructed as to permit its being lowered gradually and uniformly.

(b) Concrete Forms

Forms shall comply with the requirements below: Forms shall be mortar-tight and sufficiently rigid to prevent distortion due to the pressure of the concrete and other loads incident to the construction operations, including vibration. Forms shall be so constructed and maintained as to prevent the opening of joints due to shrinkage of the lumber.

Form materials. The surface contacting the concrete structure shall be dressed smooth, with a plane so as to produce mortar tight joints and even concrete surface.

(c) Metal Ties

Metal ties or anchorages within the forms shall be so constructed as to permit their removal to a depth of at least 2.5 cm from the face without injury to the concrete. Should wire ties be permitted, suitable cones shall be provided. The cavities shall be filled with cement mortar and the surface left sound, smooth, even and uniform in color.

Surface Treatment. All forms shall be treated with an approved all prior to the use and, in addition, wood forms shall be flushed with water immediately before placing concrete. No material or treatment that will adhere to concrete or discolor concrete shall be use.

Metal Form. The specifications for forms, as regards design, mortar-tightness, filleted corners, bevelled projections, bracing, alignment, removal, reuse and oiling, apply to metal forms.

Permanent or stay-in-place metal forms will not be permitted under deck slabs unless shown on the plans. The metal used for forms shall be of such thickness that the forms will remain true to shape. All bolt and rivet heads shall be countersunk. Clamps, pins or other connecting devices shall be designed to hold the forms rigidly together and to allow removal without injury to the concrete. Metal forms which do not present a smooth surface or do not align properly shall not be used. Care shall be exercised to keep metal forms free from rust, grease or other foreign matter.

(7) Placing Concrete and Removal of Forms

Concrete shall not be placed until forms and reinforcing steel have been checked and approved by the Engineer. The forms shall be cleaned of all debris before concrete is placed. The method and sequence of placing concrete shall be as approved by the Engineer.

The external surface of all concrete shall be thoroughly worked during the placing by means of tools of an approved type. The working shall be such as to force all coarse aggregate from the surface and to bring mortar against the forms to produce a smooth finish, substantially free from water and air pockets, or honeycombs.

(a) Hauling

The equipment to be used in hauling concrete, such as bucket, push-cart, lorry, truck, etc, shall be such type that the separation of the material does not take place.

The structure of the bucket shall be such type that no separation of materials takes place when the bucket is lowered and concrete is discharged, and yet it operates promptly. In the event of using a push-cart or lorry, an even graded access path shall be provided to ensure no separation of concrete takes place while it is being hauled. The truck for hauling concrete shall be such type that concrete can be unloaded easily. If the hauling distance is relatively long, an agitating equipment shall be provided to the truck. In the event of using a belt conveyor, it shall be set at an appropriate location so as not to impair the quality of concrete and furthermore, at the end of the belt conveyor, a buffle plate and funnel shall be provided to prevent the materilas from separation. In the event of using a shute, a longitudinal shute shall be used as a principle. The longitudinal shute shall consist of several pieces of funnels connected together and shall be such type that no significant separation of materials takes place. Only with an approval of the Engineer, an inclined shute may be made available. The inclined shute shall be provided an inclination uniformly throughout the entire length of the shute. The inclinatin shall be such that no concrete materials are separated. At the outlet of the shute, an appropriate type of funnel shall be provided. The height between the bucket or hopper outlet and the concrete furface in place shall be within 1.5 m.

No concrete shall be placed on a rainy day unlesses approved by the Engineer. The form shall not be jarred and no strain shall be placed on the ends of projecting reinforcement.

(b) Compaction

Unless otherwise directed, the concrete shall be consolidated with approved mechanical vibrators operating within the concrete. When required, vibrating shall be supplemented by hand spading with suitable tools to assure proper and adequate compaction.

Vibrators shall be of an approved type and design. Vibrators shall be so manipulated as to work the concrete thoroughly around the reinforcement and embedded fixtures and into corners and angles of the forms. Vibrators shall not be used as a means to cause concrete to flow or run into position in lieu of placing. The vibration at any point shall be of sufficient duration to accomplish compaction, but shall not be prolonged to the point where segregation occurs.

(c) Construction Joints

Construction joints shall be located where shown on the drawings or permitted or instructed by the Engineer. Construction joints shall be perpendicular to the principal lines of stress and in general shall be located at points of minimum shear.

At horizontal construction joints, gage strips 4 cm thick shall be placed inside the forms along all exposed faces to give the joints straight lines. Before placing fresh concrete, the sufaces of construction joints shall be sandblasted or washed and scrubbed with a wire broom, drenched with water until saturated, and kept saturated until the new concrete is placed. Immediately prior to placing new concrete the forms shall be drawn tight agianst the concrete already in place and the old surface shall be coated thoroughly with a very thin coating of neat cement mortar. Concrete in substructures shall be placed in such a manner that all horizontal construction joints will be truly horizontal and, if possible, in locations such that they will not be exposed.

(d) **Expansion Joints**

The location, type of joint filler and construction method of the expansion joint shall be approved by the Engineer.

(e) **Anchor Bolts**

All necessary anchor bolts in piers, abutments or pedestals shall be accurately set in the concrete as it is being placed. Anchor bolts shall be set accurately and fired with cement mortar completely filling the holes

The cement mortar shall consist of one part Portland cement and one part fine-grained sand.

(f) **Removal of Forms and Scaffoldings**

Forms and scaffoldings shall not be removed without the consent of the Engineer. The Engineer's consent shall not relieve the Contractor of responsibility for the safety of the work. Blocks and bracing shall be removed at the time the forms are removed and in no case shall any protion of the wood forms be left in the concrete.

(g) **Curing Concrete**

(i) **Wet Curing Method**

In the event of using an ordinary Portland cement, all concrete shall be cured at least 5 days with wet curing method.

All exposed surface of concrete shall be covered with a wet straw matt, cloth, sand, etc. or water shall be spreaded.

(ii) **Membrane-Forming Curing Compound**

Curing compound may be used if approved by the Engineer. All surfaces shall be given the curing compound immediately after the removal of the concrete forms or as soon as the surface film of water is disappeared. Any coating marred, or otherwise disturbed, shall be given an additional coating

The concrete surface applied with the curing compound, in the event of using an ordinary Portland cement, shall be protected from travelling over the surface at least 48 hours

After the expiration of the above mentioned period and if the Contractor wishes to utilized the surface for the purpose of executing the project, he shall obtain an approval of the Engineer. In this case, the surface shall be protected by putting earth or sand.

(iii) **Curing Under High Temperature**

In the event that concrete is completed placed or stopped the work, the concrete surface shall be protected from direct sun-shine and/or avoid wind so as to maintain the wet condition.

(h) **Concrete Surface Finish**

The concrete surface shall be finished in accordance with the following:

(i) **Surface contacting the forms**

a) Steel wire, metal rod, etc, used in supporting the concrete form, any projection from the concrete surface thereof shall be cut and removed.

b) Any small concaves, spaces discovered after removing the concrete forms shall be filled with cement mortar consisting one part of Portland cement and two parts of fine aggregate. The filled surface shall be finished smooth to the original concrete without appreciable difference in the eveness, which shall be done with a wooden trowel carefully in a workmanlike manner.

c) Any concrete surface presenting an excess extent of honycombs shall be re-worked by the Contractor, by removing the defect at his own expenses.

(ii) **Surface not contacting the forms**

After concrete has been compacted and brought to level as specified elevation shall not be finished until the surface water is disappeared or treated. In finishing the concrete surface, it shall be done with a wooden trowel or an appropriate finishing equipment. Care shall be exercised so as not to excessively finish.

Should a smooth and dense surface be required, the surface shall be finished with a steel trowel with force as late as possible, within an allowable range.

(i) **Quality Control**

The Contractor shall carry out a "quality control" in order to control the quality of the aggregates and concrete.

The necessary facilities required for the purpose of the quality control tests shall be provided at the expense of the Contractor. The quality control shall be carried out as spelled out in the introduction of the General Specifications GS25 in accordance with the instructions given by the Engineer.

(j) **Backfilling and Loading onto the Structures**

The timing of backfilling shall be determined by the Egnineer taking into account the results of the trial mix as well as the site conditions.

For any concrete structure, no loading shall be added in the following period of time.

Ordinary Portland cement:	21 days
High-early strength cement:	7 days

(k) **Method of Measurement**

Concrete will be measured by the cubic meter in accordance with the dimen-

sions shown on the drawings or ordered and accepted by the Engineer. No deduction will be made for the volume occupied by pipes less than 20 cm in diameter nor for reinforcing steel, anchors, conduits, weep holes piling except that deductions will be made for the volume of structural steel, including steel piling encased in concrete The measurement will not include any concrete used in the construction of cofferdams or falsework, or the volume of forms of falsework.

No pay allowance will be made for any increase in cement content, for any admixtures,nor for any finsihing of any description of concrete or concrete floor. Any class A concrete permitted to be constructed where class B or C concrete was specified will be measured for payment as class Bor C concrete.

The quantities of reinforcing steel and other Contract Items which are included in the completed and accepted structure will be measured for payment in the manner prescribed for the several items involved.

When estimated quantities, required for structure work, are shown on the drawings as "final quantities", these quantities will be the final quantities for which payment will be made unless the dimensions of structure work shown on the drawings are revised by the Engineer. If the dimensions of structure work are revised and such revisions reuslt in an increase or decrease in quantities, the final quantities for payment will be revised in the amount represented by the change in quantities subject to the provisions stipulated in the Contract.

(l) Basis of Payment

The accepted quantities of structural concrete, dtermined as provided above, will be paid for at the contract unit price per cubic meter, as indicated in the Schedule, complete in place. The supply, fixing and finishing expansion joints will not be paid for separately and is included in the unit rates for concrete. The unit prices will be full compensation for pumping of water, furnishing and placing all materials, including water stops weep holes, and rock backing and expansion joints: for all forms; formwork; falsework (scaffolding and supporting) including piling of formwork for beams and slabs for mixing, placing finishing and curing the concrete; and all other costs necessary or usual for the proper completion of the work prescribed in this Section.

Schedule Item No. and Name		Unit of Measurement
611	Structural concrete, class A, including formwork	Cubic meter (m^3)
612	Structural concrete, class B, including formwork	Cubic meter (m^3)
613	Structural concrete, class C, including formwork	Cubic meter (m^3)

TS 6.06 **Reinforcing Steel**

(1) **Description**

This work shall consist of furnishing and placing reinforcing steel in accordance with these Specifications and in reasonably close conformity with the drawings.

(2) Materials

Reinforcing steel shall conform to the requirements of the following AASHTO Specifications except for the standard size and unit weight as per table 8.4.

Reinforcement, intermediate grade (ASTM A615)

(3) Protection of Materials

Reinforcing steel shall be protected at all times from damage and shall be stored on blocks to prevent mud caking Prior to placing concrete, reinforcing steel which is to be embedded shall be free form heavy rust, dirt, mud, loose scale, paint, oil, or any other foreign substance.

(4) Bending

Unless otherwise permitted, all reinforcing bars requiring bending shall be bent cold and shall be bent in radius specified in Fig. 3-6 (a) & (b) and in accordance with American Concrete Institute procedures unless otherwise detailed. Bars partially embedded in concrete shall not be bent except as shown on the drawings or otherwise permitted. Qualified men shall be employed for cutting and bending accurately.

(5) Assembling

All reinforcing steel shall be accurately placed and during the palcing of concrete, firmly held by approved supports in the position shown on the drawings. Reinforcing bars shall be securely fastened together. Reinforcement placed in any member shall be inspected and approved before any concrete is placed.

(6) Splicing

All reinforcement shall be staggered splicing, which shall be approved by the Engineer.

(7) Method of Measurement

Reinforcing steel will be measured by the kilogram, based on the theoretical number of kilograms complete in place as shown on the drawings or placed as ordered

The quantities of materials furnished and placed will be based upon the calculated weights of the reinforcing steel actually placed in accordance with these Specifications. The weights calculated will be based upon the following table:

Table 6-7 Table of Weight of reinforcing steel bar

Bar size dia. mm	6	8	9	10	12	13	14	16	18
Weight per linear meter in Kg.	0.221	0.392	0.499	0.613	0.882	1.04	1.201	1.568	1.985
Bar size dia. mm	19	20	22	24	25	26	28	29	30
Weight per linear meter in Kg.	2.23	2.450	2.965	3.539	3.85	4.141	4.803	4.974	5.514

The length to be taken in calculating the weight for the purpose of payment shall be those shown on the drawings or ordered in writing by the Engineer.
No measurement or payment will be made for splices added by the Contractor for his convenience or for splices which are not shown on the drawings and are not approved by the Engineer.
Whenever there are no Schedule Items provided for reinforcing steel, costs will be considered as incidental to other Schedule Items.

(8) Basis of Payment

The accepted quantities of reinforcing steel, determined as provided above, will be paid for at the Contract Price per kilogram, completion in place. No allowance will be made for clips, wire or other material used for fastening reinforcement in place.
Payment will be made under:

Pay Item No. and Name	Unit of Measurement
621 Reinforcing steel	Kilogram (kg)