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DESIGN MANUAL
FOR THE CONSTRUCTION OF CULVERTS, SMALL BRIDGES AND SLUICES

GOVERNMENT OF THE PEOPLE'S REPUBLIC OF BANGLADESH
MINISTRY OF LOCAL GOVERNMENT, RURAL DEVELOPMENT
AND CO-OPERATIVES

FOREWORD

A large number of local initiative earthwork projects like canals, roads embankments and tanks are being executed every year all over the country through the Rural Works Programme. The magnitude of the work is staggering and the nature of its direct and immediate development impact on rural Bangladesh is obvious.

However, it is also obvious that many of the earthwork structures need reliable appurtenant structures such as culverts, bridges and sluice gates, to achieve maximum benefit from these efforts. For these reasons a "Design Manual for the Construction of Culverts, Bridges ane Sluices" has been developed in a handy guide book format. The manual incorporates technical instructions related to all phases of project execution, and will enable thana level officers and the peoples' representatives to better understand and properly deal with the technical aspects of planning and execution of their construction projects.

This is an improved and up-dated version of "Hand Book of Construction" published under Rural works Programme of this Ministry.

(A. M. Anisuzzaman)
Secretary,
Ministry of Local Government,
Rural Development and Co-operatives.

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SECTION I

INTRODUCTION TO THE MANUAL

1. Purpose of the Manual

The primary purpose of the Manual is to provide a guide and a source of reference to thana level staff in planning, constructing and maintaining culverts, small bridges and sluiceways of masonry and reinforced concrete construction. A secondary purpose is to provide a training syllabus for local government officials involved in managing rural work project construction.

The contents of the Manual are prepared and presented in such a manner that theyconform to fundamental sound engineering principles and practices. The emphasis, however, has been on providing Circle Officers, Chairman, Thana Dev. Committee, Thana Sub-assistant engineer Supervisors, Overseer' and Work Assistants with an illustrated text which contains simplified and practical techniques for good construction in rural Bangladesh.

2. Scope of the Manual

The Manual presents guidelines for planning, designing, constructing and maintaining the following types of appurtenant structures of masonry construction for field conditions as specified :

A. Culverts :

Type	Channel width at HFL.	Maxm. Channel depth at HFL	Height of the bank from HFL	Soil condition	Approach roadway width
Brick arch culverts	3'-0" 5'-0" 8'-0"	5'-6" 5'-6" 7'-6"	2'-6" 2'-6" 2'-6"	Satisfactory Satisfactory Satisfactory	12'-0" 12'-0" 12'-0"
R. C. Pipe culvert with brick and walls	5'-0" 5'-0"	3'-0" 3'-0"	1,-6" 1'-6"	Satisfactory Not so satisfactory	24'-0" 24'-0"
R.C. Box culvert with brick end walls	8'-0" 8'-0" 12'-0" 12'-0" 12'-0"	5'-0" 5'-0" 5'-0" 5'-0" 7'-0"	2'-6" 2'-6" 3'-0" 3'-0" 3'-0"	Satisfactory Not so satisfactory Satisfactory Not so satisfactory Satisfactory	20'-0" 20'-0" 20'-0" 20'-0" 20'-0"
Open foundation culvert with brick abutments and wingwalls	15'-0" 15'-0"	7'-0" 7'-0"	3'-0" 3'-0"	Satisfactory Not so satisfactory	20'-0" 20'-0"

HFL : Highest Flood Level.

B. Bridges :

Type	Channel width at HFL	Maxm. channel depth at HFL	Height of the bank from HFL	Soil condition	Approach roadway width
R.C. Slab type with brick abutments and wing-walls	20'-0" 20'-0"	7'-6" 7'-6"	3'-6" 3'-6"	Satisfactory Not so satisfactory	20'-0" 20'-0"
R.C.T-beam bridge	20'-0" 20'-0"	7'-6" 7'-6"	3'-6" 3'-6"	Satisfactory Not so satis.	12'-0" 12'-0"
	20'-0" 20'-0"	7'-6" 7'-6"	3'-6" 3'-6"	Satisfactory Not so satis.	20'-0" 20'-0"
	25'-0" 25'-0"	8'-0" 8'-0"	3'-6" 3'-6"	Satisfactory Not so satis.	20'-0" 20'-0"
	30'-0" 30'-0"	8'-0" 8'-0"	3'-6" 3'-6"	Satisfactory Not so satis.	20'-0" 20'-0"
	35'-0" 35'-0"	8'-0" 8'-0"	3'-6" 3'-6"	Satisfactory Not so satis.	20'-0" 20'-0"
	40'-0" 40'-0"	10'-0" 10'-0"	4'-0" 4'-0"	Satisfactory Not so satis.	20'-0" 20'-0"

C. Sluices :

Type	Span	Length	Height	Soil condition
R. C. Pipe	3'-0"	10'-0"	—	Satisfactory
R. C. Box	4'-0"	10'-0"	—	Satisfactory
R. C. Pipe Multiple Vent	5'-0"	10-0"	8'-0"	Satisfactory
	5'-0"	12'-0'	9'-6"	Satisfactory
	3'-0"	10'-0"	—	Satisfactory

R. C. : Reinforced Concrete.

3. How to use the Manual

Step 1 : Determine the type of structure (culvert, bridge or sluiceway) that is required to be built from the considerations of the given conditions and requirements.

Step 2 : Study the fundamental planning, designing and engineering principles applicable to the structure as presented in Section II of the Manual and establish a suitable site and alignment for the structure.

Step 3 : Study the common practices and uses in simple construction works as presented in Section III of the Manual and undertake soil exploration, site surveying and measurements following the procedures laid down in this section.

Step 4 : Assess and synthesize the field data following the procedure presented in Section IV of the Manual leading to selection of an appropriate design example from Section V of the Manual.

Step 5 : Prepare the necessary contract documents for the projects following the insntructions presented in Section VI of the Manual.

Step 6 : Follow the procedures for contract negotiations and awarding the job as described in the same Section VI of the Manual.

Step 7 : Having awarded the job, explain to the contractor the relevant contents of the Manual including the technical details and recommended practices and make it clear to him that job supervision will be done as per the guidelines and instructions given in the Manual.

Step 8 ; Follow the Manual for job supervision and record keeping at every stage of the work upto finishing of the project and commissioning of the structure.

Step 9 : Ensure regular maintenance of the structure as per the guidelines and instructions given in the Manual.

SECTION II

FUNDAMENTAL PLANNING, DESIGN AND ENGINEERING PRINCIPLES APPLICABLE TO THE STRUCTURES INCLUDED IN THE MANUAL

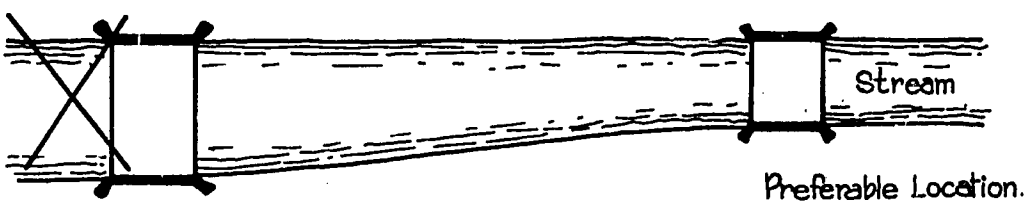
1. CULVERTS :

A culvert is a drainage structure built across an artificial or natural watercourse to carry the roadway over it across the drainage way. Culverts may also be defined as structures used for purposes similar to that of a bridge but having a total lineal opening of 15 feet or less. When the span is 3' and less, it is normally called a ventway.

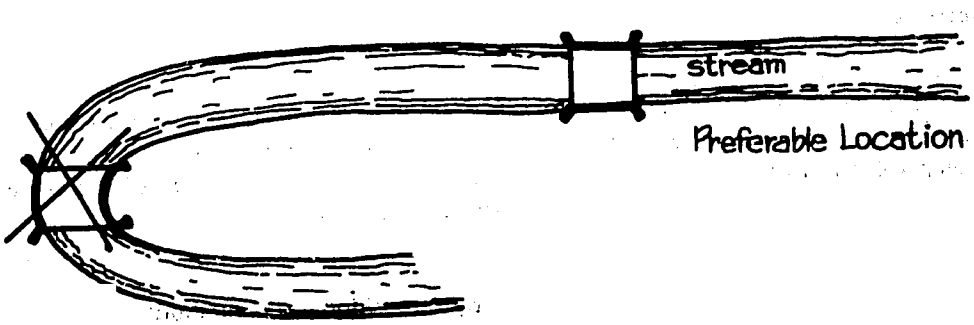
A. Location :

Culverts are usually built across small streams or 'Khals'. In choosing the location for a proposed culvert, the following points should be taken into consideration :

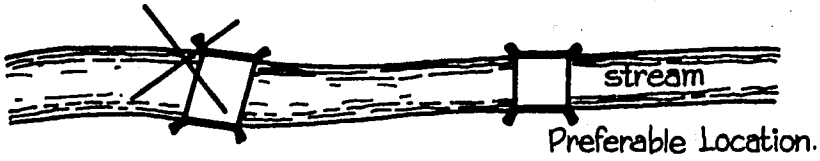
(i) The location should provide a narrow channel width rather than wide one.



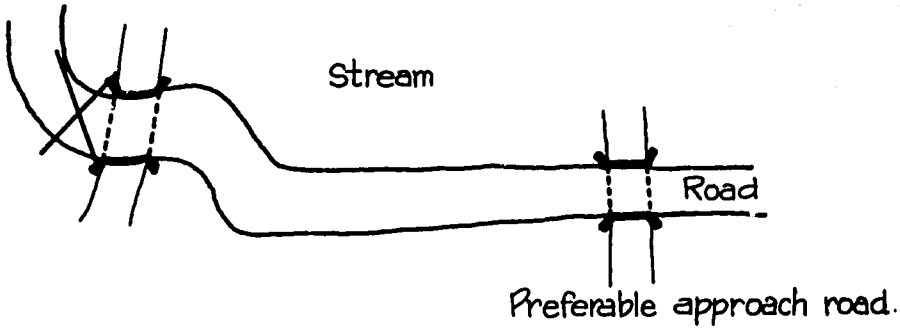
(ii) The location should have a straight stretch of the stream instead of a curve where the stream is likely to cause erosion of the bank along the outside of the curve.



(iii) Alignment of the crossing should be at right angles to the flow of the stream to avoid additional risk of scouring and difficulty in construction and maintenance.



(iv) The approach road on either side of the structure should provide a straight stretch immediate to the structure to reduce risk of traffic hazards.



B. Waterway :

The waterway or drainage opening of a culvert should be sufficient to pass the maximum flow in the stream. The maximum flow, expressed in cubic feet per second (cusec) across a section of the stream will naturally correspond to the highest flood level (HFL) for the section and the corresponding mean velocity of the stream. This maximum flow will dictate the size of the culvert opening which in turn will govern the level of the finished roadway above.

The highest flood discharge (Q) may be estimated by the 'Slope-area method'. Field procedures required to obtain the neccessary data for the slope-area method include :

(i) determination of the mean area 'a' of the channel cross-section at the site upto the HFL.

(ii) computation of the mean hydraulic radius 'r' given

by $= \frac{\text{area (a)}}{\text{wetted perimeter (p)}}$

(iii) determination of the slope (s) of the water surface.

(iv) selection of an appropriate roughness factor 'n'.

The data are used in Manning's equation given below to determine the mean velocity of flow.

$$V = \frac{1.486}{n} \cdot r^{\frac{2}{3}} \cdot s^{\frac{1}{2}}.$$

Multiplying this value of 'V' with the mean area 'a', we obtain Q, the highest flood discharge rate in cusec.

Now the required culvert waterway in square feet can be estimated on the basis of the following considerations :

(i) Consider the surface of the stream for the maximum discharge to be upto 1/2 of the height of the culvert opening when the approach channel is wide and shallow.

(ii) Consider the surface of the stream for the maximum discharge to be upto 3/4 of the height of the culvert opening when the banks are steep and the channel is narrow.

(iii) Assume a maximum allowable velocity of 5 feet per second through the culvert opening.

Needless to say that the procedure mentioned above for determining the required sectional area of the culvert opening often too complex to be used in the field and perhaps unnecessary for the small structures discussed in this Manual. Instead the following simplified procedures can be found convenient and appropriate enough for the purpose of this Manual :

The sectional waterways required for culverts and small bridges may be foundout from the following formula :

$$S = CA^{3/4}$$

Where S=area of the opening required in square feet.

A=area of the drainage basin in acres.

C=co-efficient varying with slope of the ground, character of the soil and character of vegetation on the basin and may be taken from 1 to 2/3 for steep and rocky ground, 1/3 for rolling agricultural country, 1/5, to 1/6 where the length of the valley is several times its width.

Again, for a flat country like Bangladesh, some engineers suggest the following practical rules :

Provide 50 sq. ft. per square mile when the catchment area is under 1 sq. mile.
45 sq. ft. per mile when the catchment area is under 2 sq. miles.
38 sq. ft. per square mile when the catchment area is between 2 to 5 sq. miles.
35.5 sq. ft. per square mile when the catchment area is between 6 to 10 sq. miles.

For areas over 15 square miles, the waterway is to be found by elaborate and complicated calculations.

C. Types of culverts and design considerations :

Culverts are commonly of the following four types :

- — Brick arch culverts
- — Reinforced concrete pipe culverts
- — Reinforced concrete box culverts
- — Open foundation culverts

Brick Arch Culverts :—This type of culvert is appropriate when the watercourse is less than about 10-12 feet in width. Arched culverts are more economical than any other form although they require highly skilled brick masons and are difficult to build.

In this type of culverts, the main components are :

(i) Brick arch spanning the waterway

(ii) Brick abutments supporting the arch

(iii) Splayed wingwalls in brick masonry

The strongest form of arch is that in which the rise is between 1/3rd to 1/4th of the span. Arches with rise from 1/2 to 1/5 of the span are in general use. The springs of arches should be kept atleast 1 foot above the highest recorded flood level and afflux, if any. The thickness of arch rings may be taken as follows :

Span, Upto 5'-0" : 10"

Span, 6 to 10 feet : 15"

There should be a cushion of atleast 1'-6" above the arch ring.

The minimum top thickness of the abutments will be 18". Thickness at springing in feet when the height does not exceed 1½ times the width at the base is given by : Ts= Radius/5+Rise/10+2.

Thickness of the abutment at G.L. (ground level) in feet is given by :

(i) For light type : S/3+1

(ii) For heavy type : S/3+1 where S=span

The front face of the abutments should be vertical and the back face should have a batter of 1 in 4.

Splayed wing walls in culverts are preferable to straight return walls, as the former reduce the velocity at the exit and thus prevent erosion or scouring of the ground there. The length of the return walls, measured from the face of the abutment, should generally be made 1½ times the height of the roadway from the bed or ground level so that the front slope of the earth bank spilling along the face of these walls may remain at a slope not steeper than 1½ : 1. This slope should be protected by pitching. The splay of a wing wall should be around 1 : 1. Design example is given on page V-1 For a small culvert (e. g. a 3' waterway opening) where the flow of water is not very fast, straight return walls may be conveniently used without any adverse effect as shown below :

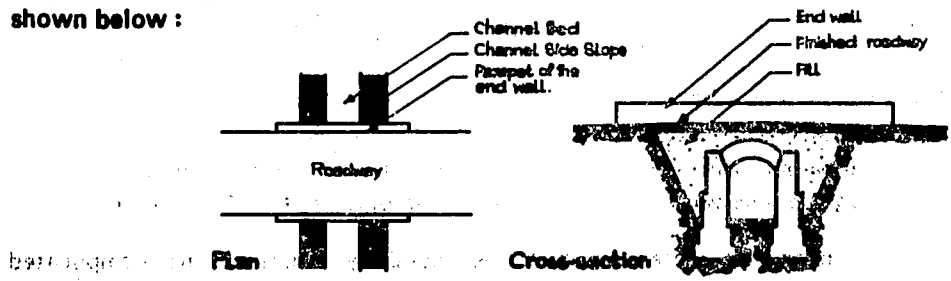


Fig. II-1 : Brick Arch Culvert

R. C. Pipe Culverts : This type of culvert is appropriate when the watercourse is a narrow stream with a mean width of 5' or less ; when the peak flow is small and when suitable R. C. pipe sections are readily available.

In this type of culvert, the main components are :

(i) R. C. pipe sections

(ii) Concrete base slab (when soil conditions are poor)

(iii) Straight endwalls of brick masonry.

The pipe sections are normally 3'-0" in the inside diameter and 4'-0" in length with standard bell and spigot jointing system. The length of the pipeway will not be less than the normal width of the road at the top. The pipeway should be laid on a firm base and to a careful grade, commonly 1 in 30 in plains and 1 in 12 in hilly regions.

The concrete base slab will be cast on the channel bed (when the soil condition is poor) to a proper grade and with a mean thickness of about 1'-0", one side being thicker than the other for maintenance of the grade. The width of the baseslab will be about 1'-0" wider than the outside diameter of the pipe.

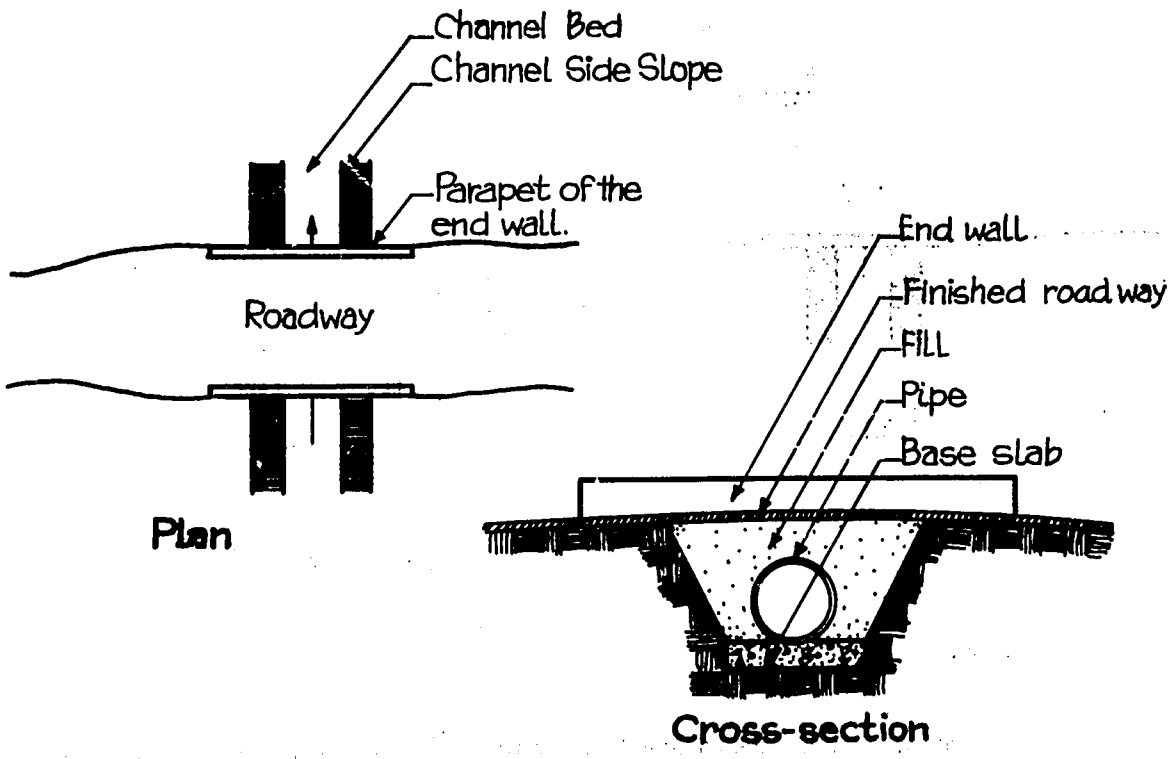


Fig. II-2 : Pipe Culvert

The straight end walls of brick masonry should extend high enough to carry the fill and should be carried down far enough to prevent the water from following along the outside of the pipe. The end walls can be of 10" brick masonry on brick footing. Over the pipe, there should be a cushion of minimum 1'-0" sand fill which should be carefully compacted before building the finished road surface. The fill helps distribution of the load imposed on the roadway. Usually the depth of the fill is equal to half of the diameter of the pipe with a minimum of 1'-0".

R. C. Box Culverts : This type of culvert is suitable for spans from 2'-0" to about 10'-0" particularly when the soil condition is rather unsatisfactory with a degree of scouring (erosion due to flow of water) problem. The top of the culvert is sometimes used as the roadway while shallow fill on the top of the culvert is also a common practice.

In this type of culvert, the main components are :

(i) R. C. floor slab.

(ii) R. C. vertical walls.

(iii) R. C. covering slab.

(iv) Straight endwalls of brick masonry.

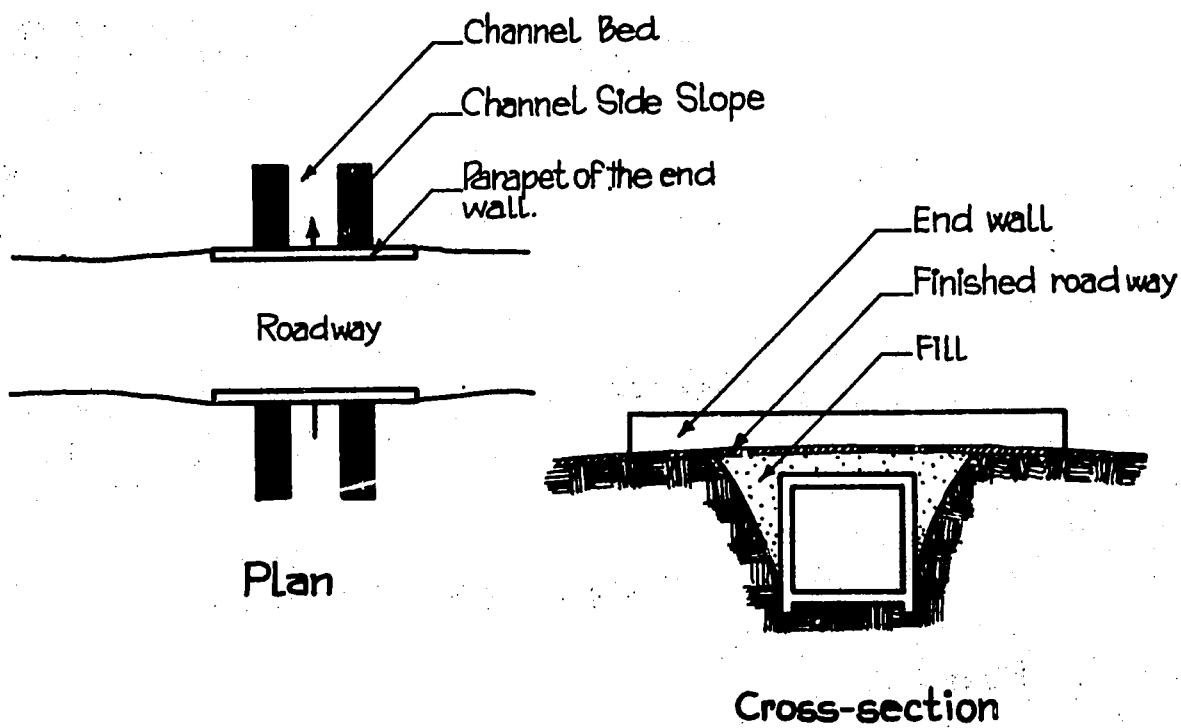


Fig. II-3 : Box Culvert

The R. C. floor slab is cast on the channel bed to a proper grade (slope from one side to the other), 1 in 30 in plains and 1 in 12 in the hilly regions. The length of the floor slab will be atleast equal to the normal width of the roadway at the top. The width of the slab will conform to the width of the channel bed.

The R. C. vertical walls will be monolithic with the floor slab and will be of such height as to generate a squre box section over the floor slab.

The straight end walls can be of brick masonry and should extend high enough to carry a shallow fill (3' to 4' maximum). The end walls should be continued on both sides atleast 3—4 feet beyond the points where the road level intersects the natural side slopes of the channel.

Open Foundation Culverts :— These types of culverts are infact short bridges. These will be appropriate when the mean channel width is between 10 and 20 feet.

The main components of this type of culverts are :

(i) Brick abutments
(ii) Brick wingwalls
(iii) R. C. slab deck

The abutments will support the R. C. Slab Dack. The top width of the abutment should provide enough space for the slab deck seat and for the construction of a dwarf wall for protection of the deck edge. For small structures, this top width of the abutment should be atleast 25" (15" for deck seat 10" for dwarf wall). For large structures (over 40' spans and 20' heights), the thickness of the top of the abutment can be estimated using Trautwine's formula :

$$T = \frac{r}{10} + 2 \quad \text{(in feet)}$$

where, T— thickness of the top of the abutment in feet.
r—rise of the abutment above footing.

The length of the abutment will be equal to the normal width of the roadway at the top and it will have a vertical or battered (inclined) front face with the rear face always battered. Trautwine recommends a batter of 1 in $\frac{24x \text{ rise}}{\text{Span}}$ for masonry abutments. Weepholes are to be kept at places at different levels to provide a free passage for the rainwater to escape from the embankment.

The foundation should be taken down to a depth below the maximum high flood level, one-third greater than the calculated depth of the maximum scour, subject to a minimum depth below the scour line of 4'.

The maximum depth of scour in a stream can be computed using the formula :

$$D = 0.473 \left(\frac{Q}{F}\right)^{\frac{1}{3}}$$

where, D =normal depth of scour below HFL (highest flood level).
Q =the design discharge in cusec (which can be determined as explained in page II-4)
F =Lacey's silt factor which, for medium silt as at Ganges Canal distributeries, will have a value of 0.85 and this may be used as an approximate value for our purposes.

After obtaining the normal scour depth as discussed above, the maximum depth of scour is to be taken as follows :

(i)	In a straight reach	: 1.27 D
(ii)	At a moderate bend	: 1.50 D
(iii)	At a severe bend	: 1.75 D
(iv)	At a right angled bend	: 2.00 D
(v)	At noses of piers	: 2.00 D
(vi)	At upstream noses of guide banks	: 2.75 D

For the small structure covered within the scope of this Manual, the following thumb rules for determining the maximum depth of scour can be found to be adequate enough most often:

Nature of the stream		Contraction	Maximum depth of scour
Bed	Current		
Average	Straight	Slight	1.6 D' or 2.5 R 1.3 d.v'/v or 2.1R.v'/v
Bad site	Diagonal	Contracted	2.1 D' or 4R 1.5 d.v'/v or 2.9R.v'/v

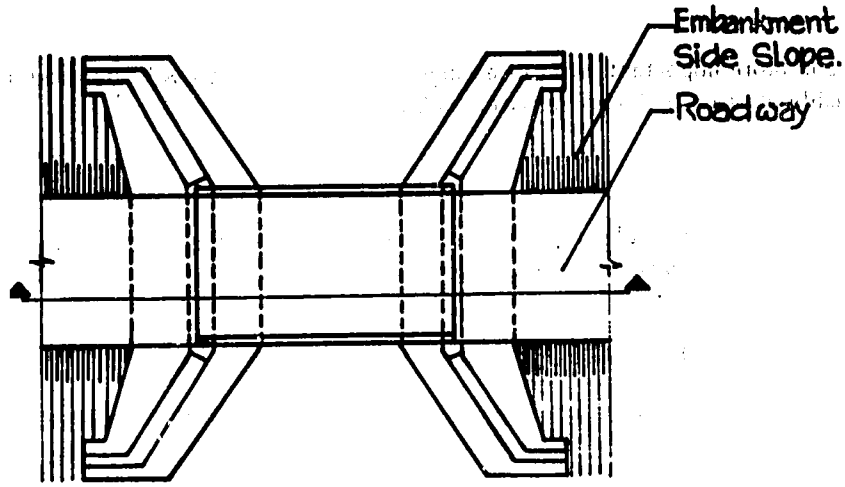
Here, D'=depth of scour (level) below the average bed level.
R =hydraulic mean radius.
v =average velocity of the stream during floods.
v' =average velocity below the culvert or bridge.
d =maximum depth of flood in the stream (without the culvert or bridge).

Wingwalls will commence from abutment ends with a splay of 45° in general. This affects smooth entry and exit of the current. The splay may be changed studying the contour of the country, sometimes even curved to suit the requirements. The front face of the wing wall may be vertical or battered with the rear face always battered in conformity with the abutment faces. The footings of the wing walls should go to the level of the abutment footing.

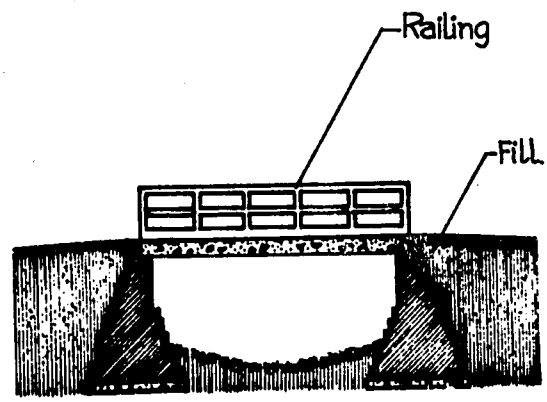
The R.C. slab deck is simply supported on the abutment at the two ends. The calculation of the required thickness for a R. C. slab deck will involve estimation of total dead weight, equivalent lane loading and impact factor and these data will be used to compute the maximum shear and bending moment for the proposed span which, in turn, will dictate the depth of the slab deck. The detailed calculation procedure is outside the scope of this Manual. Some guidelines, however are given in a tabular form as below which, it is believed, will be helpful for the purposes of this Manual:

Road way	Span in feet	Thickness of the slab deck in inches
20 feet wide	8 12 16 22	8.0 10.5 13.0 17.0
24 feet wide	6 14 20 24	7.0 12.0 15.5 19.0

The slab deck is normally provided with railings on the two lateral sides.



Plan



Cross-section

Fig. II-4 : Open Foundation Culvert

2. BRIDGES

A bridge may be defined as a drainage structure with a total lineal opening of more than 15 feet and carrying a roadway across the channel.

Bridges may also be overhead structures carrying traffic across obstructions such as railway tracks, other roadways etc.

Location :

Being bigger and more important structures than culverts, bridges will demand more elaborate locational considerations which can be listed as below :

(i) The location should provide for the central line of the bridge to coincide with the central line of the roadway which, as far as practicable, should be at right angles to the flow of water of the channel.

(ii) The location should be at a straight stretch of the channel.

(iii) The location should ensure high permanent banks i. e. the banks should not slip nor should the flood water overflow the same.

(iv) The soil of the location must offer adequate security to the foundation. Also the approaches to the bridge should be formed on hard and dry soil which should be capable of taking the weight of the earthwork embankment over it without excessive settlement.

(v) At the approach to the bridge, sharp curves and steep gradients should be avoided.

(vi) The velocity of the stream at the location should be moderate because a high velocity will cause scours and a low velocity will induce deposit of silt. Also there should be no serious cross currents or whirls.

(vii) The location should provide a minimum of work under water to allow construction of the foundation.

(viii) Width of the waterways at the location is also an important point of consideration but the shortest possible crossing should not be given over emphasis because for an important structure like a bridge other factors may be of more importance and significance.

Waterway :

The waterway of a bridge should be sufficient to pass the maximum discharge of the channel. As the area of the natural waterway is restricted, a higher velocity of water flow is produced at the bridge site and this should not endanger the structure. Usually, the maximum allowable velocity is about 8 feet per second.

For determining the required size of the bridge opening for the waterway, the simplified formula or the practical rules discussed in connection with the waterway of culverts may be used.

Having determined the area of the opening, the dimensioning of the bridge opening can be worked out on the basis of the fact that for small bridges, the economic span normally follows the relationship $S = 1.5\ H$ where S is the clear span (distance between supports) in feet and H is the height of the abutment from the bottom of the footing. The clearance of the bridge deck from the HFL of the channel water should also be checked while dimensioning the opening on a trial and error method. For a bridge over a channel used for navigation, the minimum clearance requirement above HFL is about 12'-0".

Types of Bridges and design considerations :

In conformity with the stated scope, this Manual includes only the following two types of bridges for consideration :

R. C. simply supported slab bridge
R. C. simply supported T-beam bridge

The loading requirements for these structures can be specified as follows :

Dead Load : The dead load shall include the weight of the structure complete, including pavement and other wearing surface. In computing dead load, the following unit weights shall be used : Steel, 490 lb/cft. ; Concrete (plain or reinforced), 150 lb/cft. ; Earth fill, 100 lb/cft. ; Gravel, 125 lb/cft. ; Brick, 150 lb/cft.

Live Loads : For the floor and its supports, a load of 100 lb/sq. ft. of total floor surface or a 15-ton motor truck with axles spaced 10', wheels 6' centres, with 10 tons on the rear axle and 5 tons on the front axle is to be considered. The truck is to occupy a space, 10' wide and 30' long. The rear wheels are to have a width of 15" each. Girders are to be designed for a uniform load of 100 lb/sq. ft.

Impact Stress : Provision for the increment of stress that may be expected in the members due to dynamic action shall be made by an impact allowance expressed as a fraction of the live load stress. This fraction can be determined by the following formula which is applicable for spans between 10' and 150'.

$$\text{Impact Factor Fraction} = \frac{15}{20+L}$$

where, L is the length of the span in feet.

R. C. Slab Bridge : R. C. simply supported slab bridges are well adapted for spans of from 10 feet to about 20 feet. They are simple in design and easy to construct. Slab bridges of spans upto about 20 feet are found to be economical although the thickness of the slab deck is considerable and the amount of steel and concrete required are generally more than girder decks.

The main components of a slab bridge and the design considerations involved are very much the same as those for an open foundation culvert. As already mentioned, and open foundation culvert is a smaller version of a slab bridge or vice versa.

R. C. T-beam Bridge. This is the most common type of bridge. This type of bridge is economical for spans from 20 feet to 40 feet. A T-beam bridge is well adapted where headroom is not limited and where a wide roadway is required.

The main components of a simply supported T-beam bridge are :-

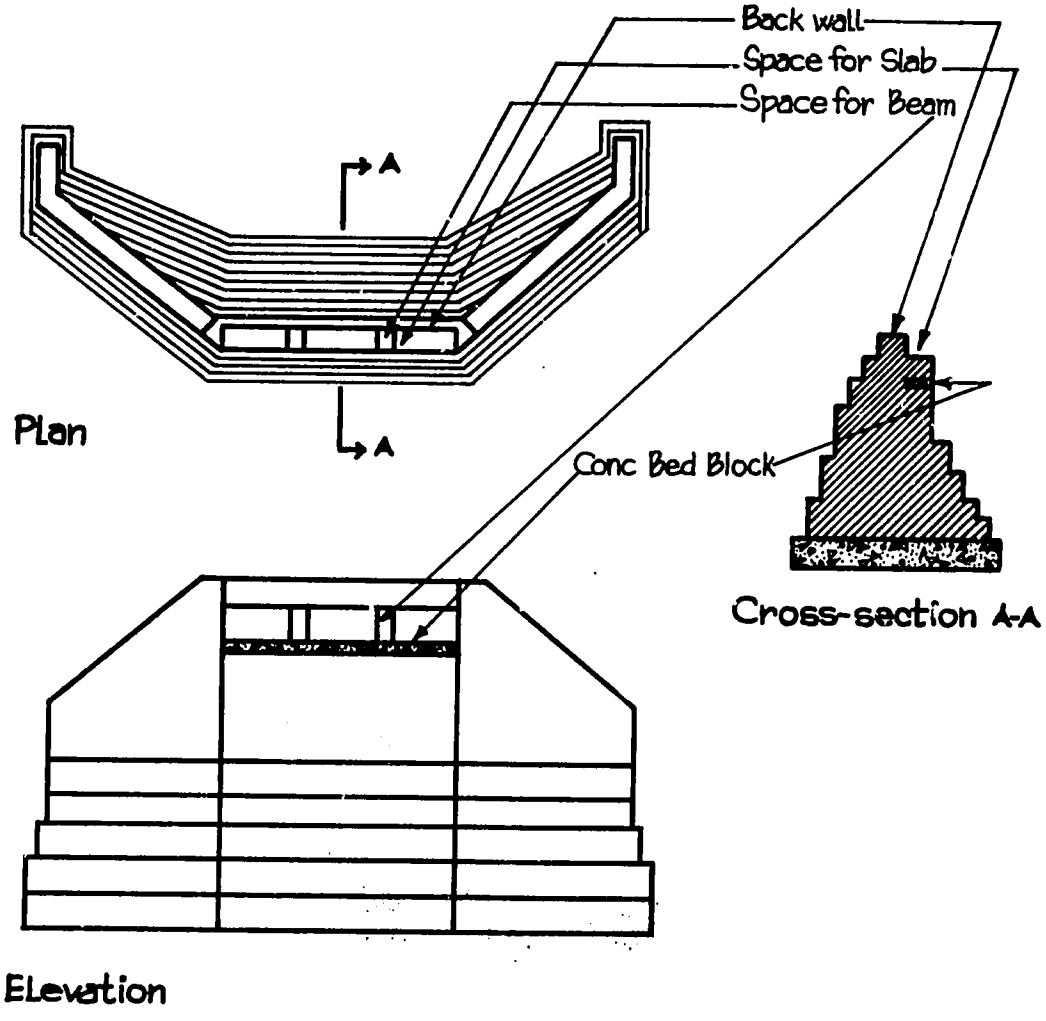
(i) Brick or R. C. abutments and wing walls
(ii) R. C. T-beams
(iii) R. C. floor Slab

A bridge abutment must be stable against :-

(i) overturning
(ii) sliding
and (iii) crushing the materials on which the abutment rests or the masonry in the abutment.

When the abutment is made of brick masonry, the top width should provide enough space for the bridge seat and a short back wall for protecting the edge of the bridge deck and maintaining a gap in between for temperature expansion of the deck, if any. The front and the rear faces of the abutment may be appropriately battered to get wider sections towards the base for structural and stability reasons. The wingwalls should be splayed, generally at 45 degrees, having faces battered in conformity with the abutment faces and the ends of the wingwalls should be returned parallel to the road and built to a height of about 3'.

The Length of the wingwall depends upon the configuration of the country, the object being to protect the earth work in the slope of the embankment. A rough rule sometimes adopted to arrive at the length of the wingwall is that it should be 1½ times the height of the road way above the bed of the river.



Elevation

Fig. II-5 : Brick Abutments and Wingwalls for T-beam Bridge

When R. C. abutments are used, the deck beams rest directly on the bridge seat with transverse diaphragm walls between the beams to hold back the earth above the bridge seat. The diaphragms are thin walls, 6" or 8" in thickness with a nominal amount of reinforcement. The abutment and wingwalls are constructed monolithically for small structures and can be of uniform section down to the top of the footing.

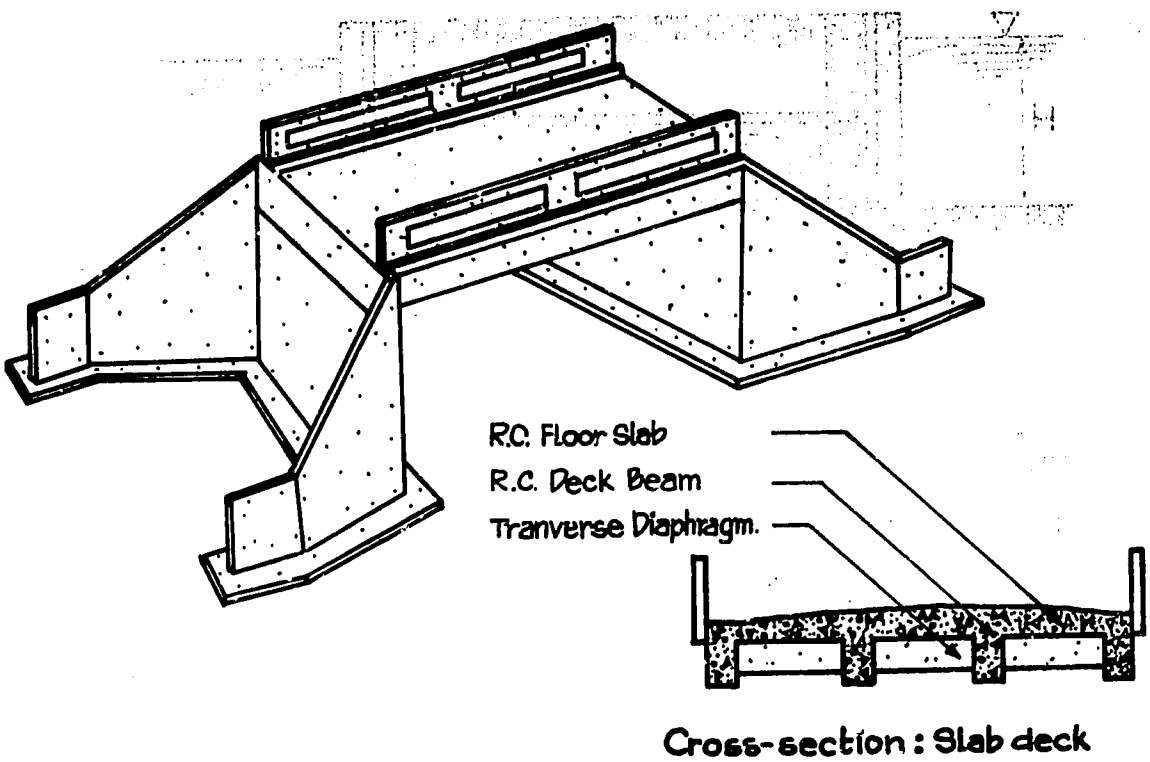


Fig. II-6 : R. C deck with R. C. adutments and wingwalls.

3. SLUICES

Sluices are drainage structures normally built through or underneath embankments and with or without control gates. Although discharge through a sluice vent is similar to culvert discharge, the structure forms an unique type of construction with rather complicated flow characteristics because the flow is controlled by many variables such as inlet geometry, size, roughness, head-water and tailwater levels etc. Depending on these variables the sluice may act as an orifice, a pipe, a weir or an open channel.

A. Location

If the purpose of the sluice is to drain a basin, it must obviously be located at or near the bottom level of the basin. However, the intake end of the conduit should not be so placed that there will be a tendency for silt and submerged debris to collect in front of it. Thus locations in deep pockets should be avoided in fovour of open level areas, wherever possible.

B. Waterway :

Flow through a sluice may be classified into two general types depending upon the existing head water and tailwater levels. If the inlet and outlet are submerged, the sluice vent will flow full like a pipe. If the inlet and the outlet are not submerged, the vent will flow partially full and will act as an open channel. For practical purposes, the two general types can be broken down into four specific types of flow as follows :

- Type I : Inlet and outlet submerged
- Tyye II : Inlet submerged,outlet not submerged, vent hydraulically short.
- Type III : Inlet not submerged, high tail water.
- Type IV : Inlet not submerged, low tail water.

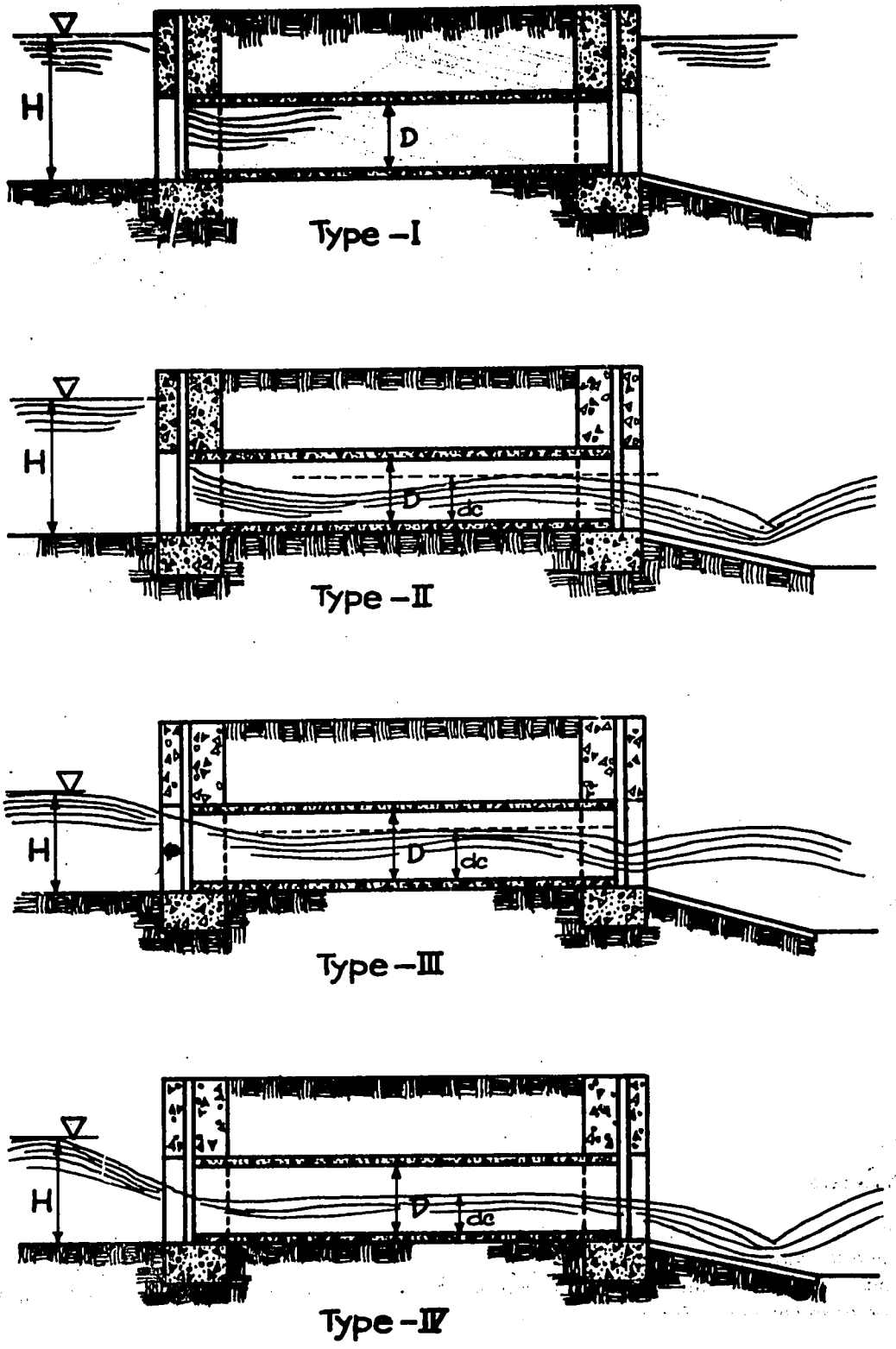


Fig. II-7 : Conditions of Flow through Sluices

To illustrate how sluice discharge may pass through the four conditions of flow listed above, let us assume a basin with one sluice discharging to an adjacent river. Also assume that it is near the end of the monsoon season and the basin is flooded from the catchment of monsoon rains. Until now, there has been no release of water because the river flood stage has been higher than the basin Storage level which is assumed to be above 1.5 times the vent height.

When the river stage falls to slightly below the basin storage level, the gates are opened and discharge begins. Since the river stage in higher than the vent soffit, Type I flow will take place and the vent flows full.

As the river stage continues to fall, the basin storage level will also drop, but usually at a lesser rate. When the river stage drops below the soffit level, the outlet is no longer submerged. Air will enter from the outlet end at the soffit line and will push into the vent causing a separation between the soffit and the water surface in the vent. At this point, one of two things may happen. If the headwater depth is still greater than 1.5 times the vent height, the inlet remains sealed by water and flow Type II takes place. If, however, the headwater depth has dropped to less than 1.5 times the vent height, the air within the vent will be able to push past the entrance breaking the water seal and the flow Type III will result.

As the riverstage continues to fall, the fall of the basin storage level may lag behind sufficiently so that enough energy is available for the flow to pass through critical depth. Flow type IV then takes place and hydraulic jump will occur down stream.

It may however be pointed out at this point that the above sequence of flow types may not necessarily take place. The determining factor is the relationship between the head water and the tailwater levels at any instant and they are not directly dependent on each other. The sluice capacity is the determining factor.

Flow types I and II are similiar to discharge through an orifice. If it is required to determine the size of the conduit to give a known discharge under a known existing head, the chart given below may be used in the manner explained :

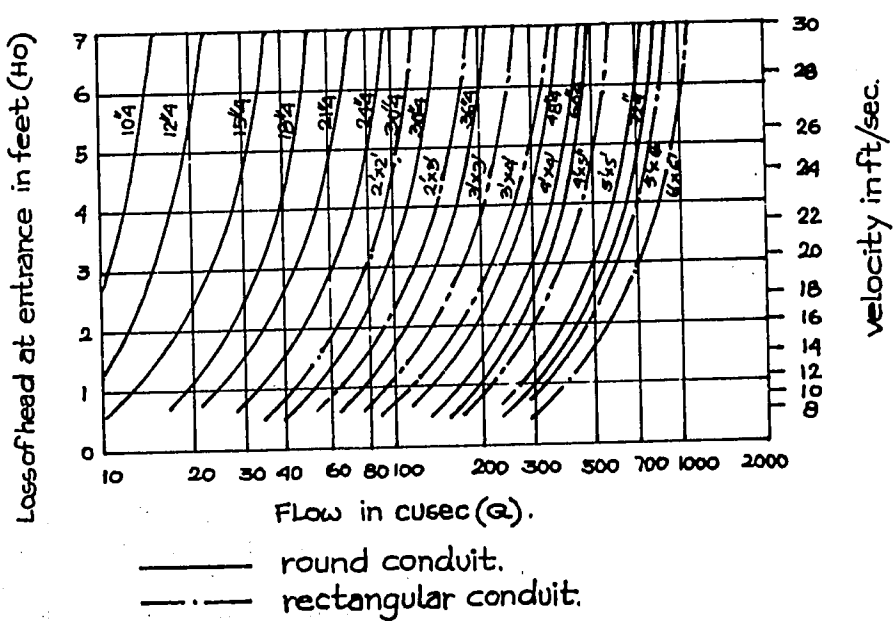


Fig. II-8 : Flow - Velocity - Head loss Curves.

(source : LOW DAMS, A MANUAL OF DESIGN FOR SMALL WATER STORAGE PROJECTS. U. S. Govt. Printing Office, Washington 1939 ; page 112)

Step 1 : Deduct from the existing head (height of water of the entrance) an approximate value (say 1 foot) for the entrance loss and convert the remaining head into velocity, using $v = \sqrt{2gH}$

Step 2 : Enter the above diagram from the right with this velocity to find the nearest conduit size that will give the required capacity.

Step 3 : Also find the entrance loss from the diagram and compare it with the original assumption. If the two values are not reasonably close, make a new assumption guided by the first result and repeat the calculation. The conduit size which has the required capacity and for which the sum of the 'velocity head loss' and the 'entrance head loss' (neglecting the friction head loss since the vents are rather short) does not exceed the gross head available gives the desired answer.

Flow types III and IV are similar to open channel flow with vertical sides. The maximum discharge capacity through such sluices will be given by the following formula. This formula can also be used for dimensioning a sluice for a given discharge :

$$Q = 3.087\ c.\ b.\ H^{3/2}$$

Where Q=rate of discharge in cusec.

b=width of the channel

H=depth of water above channel bottom at entrance

and C=Coefficient of discharge varying from 1.0 for the perfect entrance of smooth curves gradual transition to 0.82 for the more abdrupt type such as a rectangular shaped masonry structure with square corners.

Types sluices and design considerations :

Sluices can normally be of the following three types :

R. C. pipe type

R. C. box culvert type

Openchannel type

R. C. Pipe type : In this type, the sluice way is made of R. C. pipe sections with standard bell and spigot joints. The main components of this type of sluice will be the same as those for a R. C. pipe culvert with a concrete base slabs along with the addition of R. C. guide frames for gates at the two ends of the sluiceway. There will also be a concrete apron at the outlet end for energy dissipation as shown in the figure.

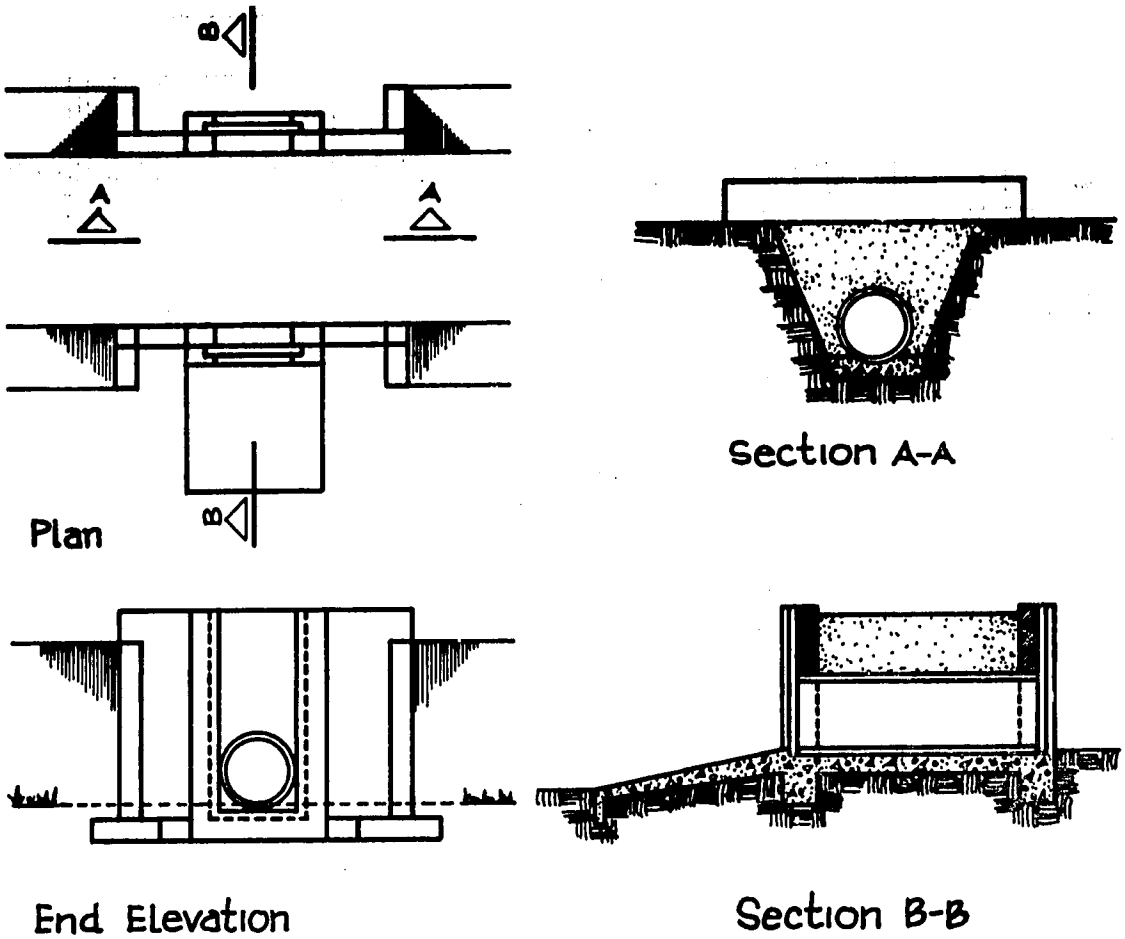
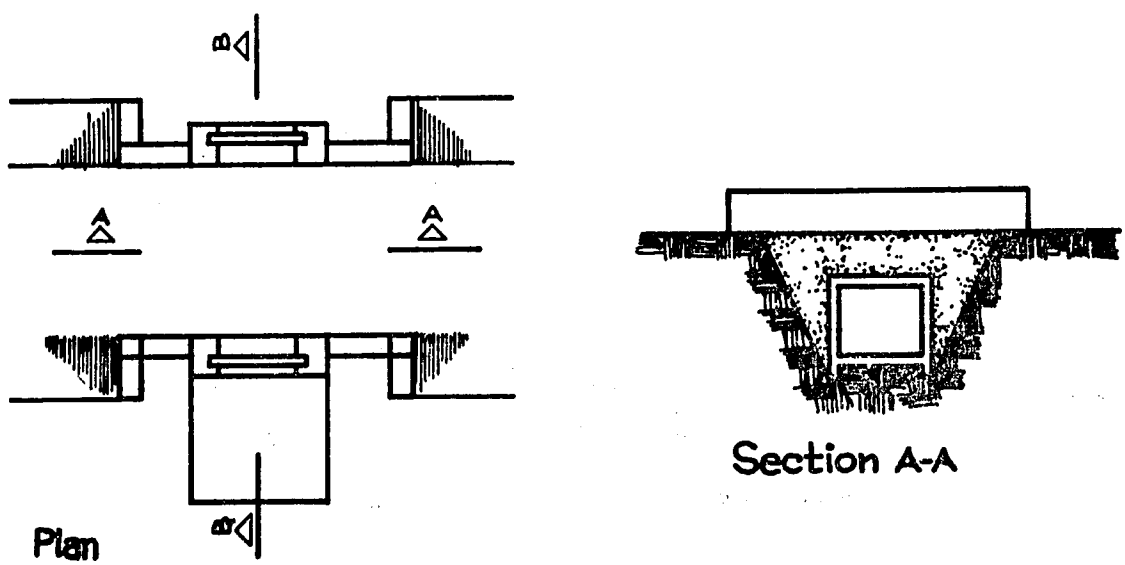


FiG. II–9 : Plan, Elevation and Section of a R. C. Pipe Sluice

R. C. Box Culvert Type : This type of sluice way will be very much the same as a box culvert with the addition of R. C. guide frames for at the two ends of the sluice way along with concrete apron at the outlet end for energy dissipation as shown in the figure II– 10.



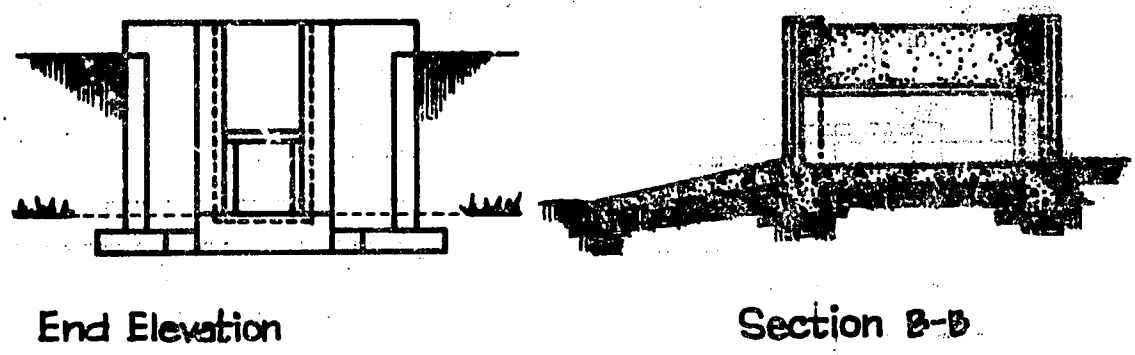


Fig. II-10 : Plan, Elevation and Section of a R. C. Box Culvert Sluice

Open Channel Type : In this type, an open channel with vertical side walls and wingwalls of brick masonry, on R. C. base slab and R. C. guide frames for gates at the two ends of the channel are constructed. The base slab is extended well beyond the outlet end in the form of an apron for energy dissipation as shown below :

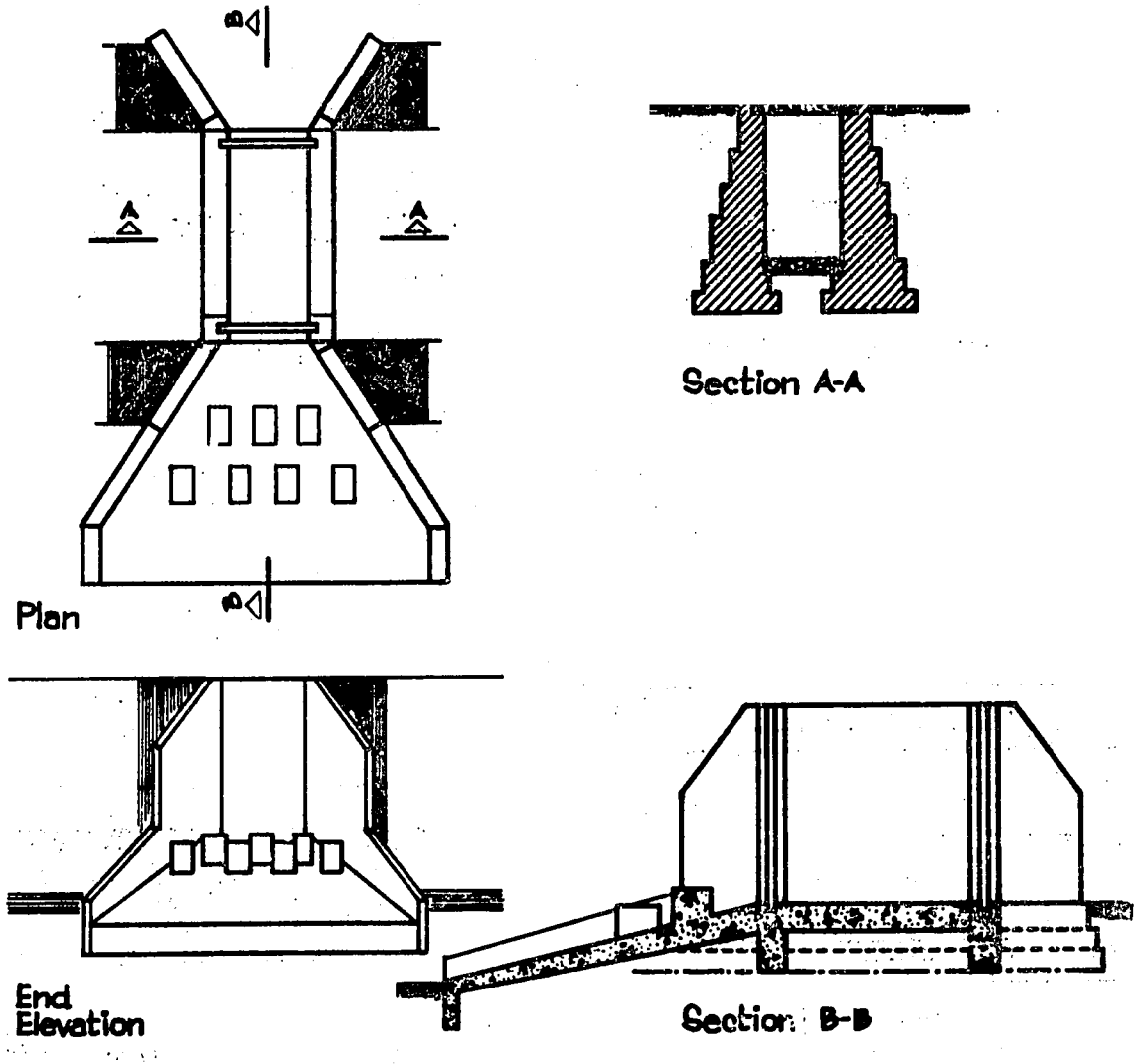


Fig. II-11 : Plan, Elevation and Section of an Open Channel Sluice

Control of the discharge through sluiceways is an important factor for which gates of the following types may be used :

(i) **Wooden Shutters** : In this type, timber planks of at least 2" thickness and upto about 12" depth are placed one above the other in the guiding vertical groves on the walls of the sluiceway spanning the opening. The timbers are placed and removed individually by hand.

(ii) **Wooden Fall Boards** : In this type, rectangular wooden lift gates span horizontally between guide grooves. The gates can be made of layers of wooden planks held together by stiffeners and through bolts from top to bottom and water tightness is increased by the use of spliced joints. The gates should be from 2" to 4" thick depending on the height. For raising and and lowering the gates, simple overhead hoists may be adopted.

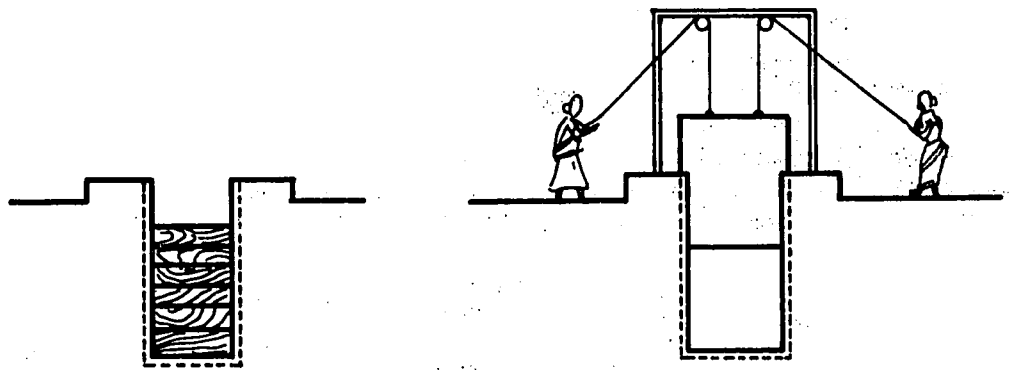


Fig. II-12 : Wooden Shutters and Wooden Fall Board with simple overhead hoist

SECTION III

COMMON PRACTICES IN CONSTRUCTION OF STRUCTURES INCLUDED IN THE MANUAL

1. Materials collection and storing.

Proper care in the collection and storing of materials must be given due importance as a pre-requsite to progress and quality of the actual construction work. For the type of construction work presented in this manual, the materials required may be broadly divided into two categories—structural materials shuttering and falsework materials, and, for the sake of convenience, those two categories are discussed here separately. Quality check and security against damage and theft constitute the central theme of this aspect of the project.

A. SRTUCTURAL MATERIALS.

a. Timber Pile :

'Shalballah' piles are normally used. Piles shall be checked for defects such as crooks, knots etc. as well as for conformance with the requirements of taper, limiting sizes of butt and tip, general soundness and treatment requirements, if any. Timber piles are normally treated by impregnating with Creosote Oil with not less than 15 lb. of oil per cubic foot of timber. Unsatisfactory piles shall be rejected and stacked seperately while the rest are stacked conveniently in the work site.

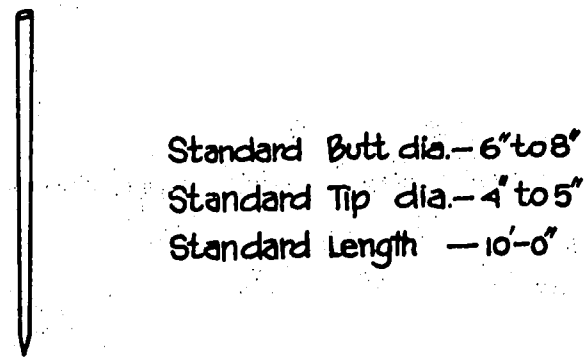


Fig. III-1 : Standard Timber Pile

Timber Piles are used :

(i) To increase the bearing capacity of the soil by distributing the load on piles which in turn transfer the load to the soil through skin friction, when there is no solid substratum at a resonable depth. In this situation, piles are driven into the soft ground 3 feet to 4 feet apart centre to centre in a grid fashion.

(ii) To transfer the load to the hard bed below when the hard bed is within a resonable depth, say 10 feet to 30 feet.

The number and length of piles can be determined by test driving along with the help of the following two specifications :

(i) The maximum load on a pile shall not exceed the load given by the formula :

$$P = \frac{2.w.h}{s+1}$$

where, P=allowable load on pile in pounds ; W=weight of drop hammer in pounds ; h=height of free fall of hammer in feet ; s=average penetration of the pile for the last six blows of the hammer.

(ii) Piles shall have a penetration of not less than 10 feet in hard ground and not less than 15 feet in soft ground.

For the structure cover in this Manual and for the site conditions that are likely to be encountered, a standard specification of pile foundation consisting of 6" to 8" diameter piles, 10' in length and arranged in a grid pattern at 3'-0" centres should meet most requirements.

b. R. C. Piles :

The R. C. C. piles shall normally be cast at the job site although in some cases they may be cast elsewhere and brought to the site, ready for driving.

When cast at the job site, careful check must be maintained throughout their manufacture so that the pile forms are properly founded, adequately tied and braced and straight ; that reinforcement is properly tied and correctly centered and that concrete is mixed, placed and cured as required. To save, framework and materials, concrete piles may be cast in tiers provided that the foundation can support the added weight of the tier construction and provided satisfactory means for curing and inspection are provided. The pile casting area may be conveniently selected close to the worksite.

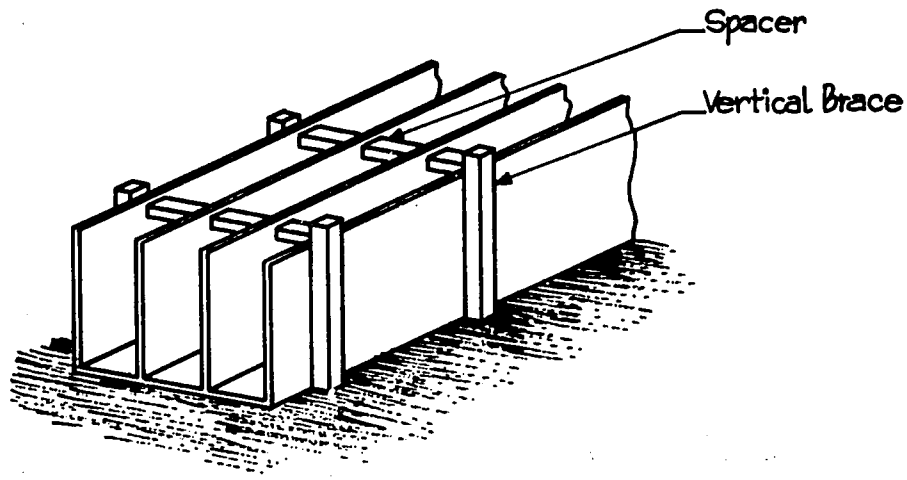


Fig. III-2 : Concrete Pile Casting in Tiers

c. Bricks :

Burnt clay bricks shall be used. All bricks used shall be of first class quality, i.e. they shall have the following characteristics :

(i) Uniform shape and size, 9½"x4½"x2¾"

(ii) Uniform colour and degree of burn. Colour would be deep red.

(iii) Give metallic sound when struck against one another.

(iv) Water absorbance not more than one-sixth (1/6) of their dry weight

(v) Check the homogeneity of clay by breaking a brick.

(vi) Will not break when dropped from a height of 4'-0" on top of another brick on a hard ground.

Quality check shall be made for each sample lot. Good quality bricks shall be stacked conveniently at the worksite while the unsatisfactory ones shall be separated and used in making Khoa.

d. Cement :

All cement used shall be portland cement. Bags of cement stamped or certified as pre-tested should ideally be used. Bags of cement shall be closely field-inspected for damage and hardening. Tampered sacks or fractional sacks shall not be accepted.

Cement stored at the site shall be well protected from moisture and weather conditions. When storing cement on the ground, it is important that the bags do not touch the ground. Boards placed on the ground with spaces between the boards to allow for air circulation will help prevent moisture from gathering in the cement bags. If the pile is to be more than 7 or 8 bags high, arrange the bags in header and stretcher fashion so as to tie the piles together and lessen the danger of toppling over.

Cement shall be stored for a maximum of six months under good conditions and the storage shall be so arranged that the cement longest on the job shall be used first. Cement with lumps may be used only if the lumps can be easily crushed between the fingers.

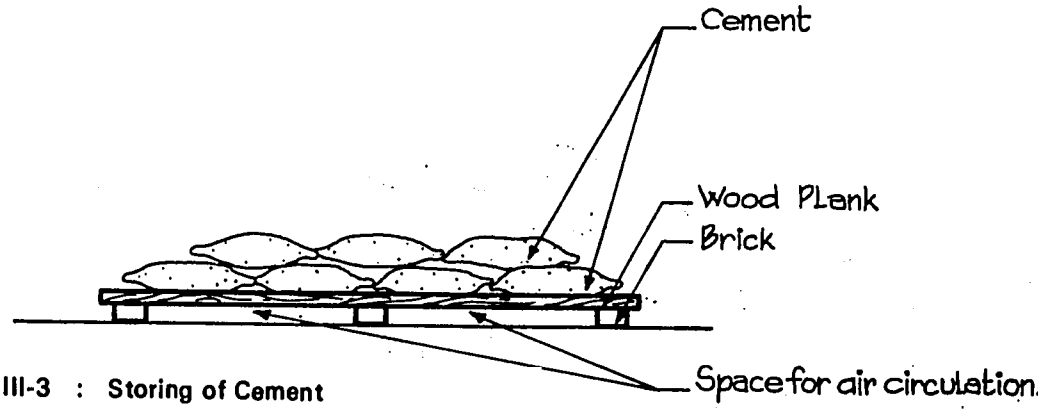


Fig. III-3 : Storing of Cement

e. Khoa/Stonechips :

Khoa are brick chips used as an aggregate in the concrete, and give the concrete its overhall strength. It must be emphasised that the concrete will be no stronger than the khoa used. The Khoa shall comprise 75% chips of Ist or 2nd clas bricks and 25% chips of Jhama brickswill be 100% picked jhama (over burnt bricks). The fused over burnt bricks with pores should be avoided.

The khoa shall be prepared at the site, the sizes of the chips varying from a minimum of ¼" to a maximum of 1".

If stone chips are available, it shall be ensured that the chips are hard and varying in sizes between a minimum of ¼" to a maximum of 1".

Khoa or stone chips may be conveniently stored in heaps on the site in the open.

f. Sand :

Sand is another important component of concrete. Sand shall be free from organic impurities and other foreign materials and shall vary in sizes from a fine particle to ¼" maximmm, with ⅓ of the total amount between these two sizes. Sand having these qualities would be a mixture of 50% local sand and 50% Sylhet sand. The sand should be coarse and free dust and finer materials.

The characteristic of a given speciman of sand is commonly specified in terms of an empirical figure, fineness modulus (FM), obtained by totaling the cumulative percentages of aggregates retained on the following different sieves and divided by 100. The sieves are Nos. 100, 52, 25, 14, 7, 3/16", 3/8", 3/4", 1½", 3" and 6". There is no fixed fineness modulus for each maximum aggregate size, but values within a suitable range are likely to give the best results. For the purpose of constructions covered in this Manual, FM-value for sand can be between 2 and 3. Like Khoa sand may be conveniently stored in heaps on the site in the open.

g. Steel :

Steel bars of the required sizes and quantities shall be received at site and stacked conveniently on the site in the open.

h. Water :

Water which is fit to drink is good for mixing concrete. It shall be free of oil, salt or other contaminating materials. In the absence of any suitable surface water supply, sinking of a tube-well may be the answer. Temporary masonry water reserviors may be constructed at the site as per requirement. The Contractor shall, prior to the start of construction, ensures himself that sufficient quantity of water for both mixing and curing of the concrete, are available at the construction site.

(B) Shuttering and Falsework Materials

a. Bamboo Poles :

Strong and stout varieties of bamboo shall be used. The bamboo poles shall be in an assortment of sizes and lengths and shall be stacked conveniently on the site in the open.

b. Wooden Boards/Sawed Timber Pieces :

Wooden boards need not be of first class quality or finished timber but must be free of cracks and large holes through which water and concrete may run out. The boards shall be in an assortment of sizes but generally with a uniform thickness and having straight edges and square ends. The boards shall be conveniently stacked on the site in the open but above ground and away from moisture to avoid warping.

Sawed timber pieces of rectangular cross-section with an assortment of sizes shall be obtained for uses as bracers, spacers etc. and shall be stacked separately.

c. **Corrugated Iron Sheets/Plain Sheets :**

C. I. Sheets or plain sheets may be used in lieu of shutteing boards for slab work. The sheets shall be free from large holes and such other defects and and shall preferably be stacked in a dry place under cover.

d **Bamboo Mats :**

These are used on top of the C. I. Sheets in the form work slab casting and may be stored conveniently along with the C. I. Sheets. It should be noted, however, that bamboo mats are not acceptable in the form work for the conduit in a syphon or box culvert. The rough concrete surface this material produces will increase the skin friction and thereby the head loss through the syphon.

2. Soil Exploration.

Information relating to foundation conditions are essential for any civil engineering construction including drainage structures. The nature and scope of the structures that this Manual is concerned with, will limit soil exploration to field observation and testing only. For a systematic presentation, soil exploration may be discussed in two parts, namely, surface exploration and subsurface exploration.

(A) Surface Exploration.

Surface exploration consists of the following :

a. Identification of the soil types from the physical features with a view to form some understanding of the soil's behaviour.

b. Visual inspection of erosional features, boundaries of soil deposits and rock outcrops, location of fault zones or other visible geologic irregularities with a view to identifying readily apparent geological conditions which will require further investigation.

Most soils have characteristics sufficiently apparent and well enough understood so that use of the terms, such as clay, silts, sand, etc. conveys some understanding of the soil's behaviour. The following table identifies the main types of soil with some readily recognisable characteristics :

Table III—1 : Soil Types and Characteristics

Type of soil	Particle size and general appearance of the soil	Squeezed in hand and released		Soil ribboned between thumb and finger when moist.	Load bearing capacity
		When nearly dry.	When wet		
Sand	Rough appearance, granuler, free-flowing when dry.	Will not form a ball and will fall apart when pressure is released	Forms a ball which will crumble when lightly touched.	Cannot be ribboned	Good when dry and compact.
Silt	When dry it may be cloudy ; readily breaks up to powder with a soft feel	Forms a ball which can be handled without breaking	Forms a ball which can be freely handled; when wet it readily puddles.	Has a tendency to ribbon with cracks ; feels smooth	Satisfactory when dry and compact
Clay	Cannot see each soil particle, breaks into very hard lumps when dry difficult to break into a soft powder when dry ; sticky when wet.	Forms a stiff ball which can be freely handled without breaking.	Forms soft ball which can be freely handled without breaking.	Forms long thin ribbons can be worked into a compact ball ; plastic like.	Unsatisfactory.
Organic Soils	The soil is made of what was once grass, leaves bushes and trees. The plant remains or sometimes the woody structure can easily be seen. Soil colour ranges from brown to black. They occur in low lands or swamps. They have high shrinkage on drying.				Poor

Visual inspection of the readily apparent geological conditions should be recorded on a sketch map of the site which should also mark the positions for subsurface explorations along the proposed alignment.

(B) Sub Surface Exploration

Sub-surface explorations are for estimating bearing capacities of the soil along the alignment of the structure, particularly at the locations of the sub-structures. Simplified field procedures for sub-surface exploration may consist of the following.

(a) Probing
(b) Test pits.
(c) Auger boring
(d) Test rods or sounding rods

Probing : A pipe or ¾" or 1" in diameter, is driven into the ground by means of a sledge hammer or a drop weight. The nature of the soil in terms of looseness or compactness is estimated by the effort required to drive as well as to twist. The rod is pulled up every few feet to inspect the soil sticking to the end in order to see if the soil is a sand, silt or clay and if the pipe is wet. The results of probing when matched with the information given in the Table III-1 can give some idea about the bearing capacity of the soil strata as well as an indication of the underground water level.

Test Pits : Test pitting is an effective means of exploring and sampling earth foundations. The depth of a test pit is usually limited to a few feet below the underground water table, and the recommended cross-section for a hand-dug pit is 3' by 5'. From the effort of digging indicating the compactness or looseness of the soil as well as from the readily recognizable soil characteristics including wetness or dryness, and estimate as to the bearing capacities of the various strata can be made with the help of the Table III-1.

Auger boring : Auger borings often provide the simplest method of soil investigation and sampling. With a hand auger, one can dig a hole and lift out soil samples which may be inspected as per the Table III – 1 to identify the soil type and its various characteristics. Also the looseness or compaction of the soil can be estimated from the efforts required to turn the handle. The information when matched with the contents of the Table III-2 which follows, can give an indication of the strength of the soil. Hand operated augers, 4 to 12 inches in diameter can be used for exploration upto about 20 feet of depth.

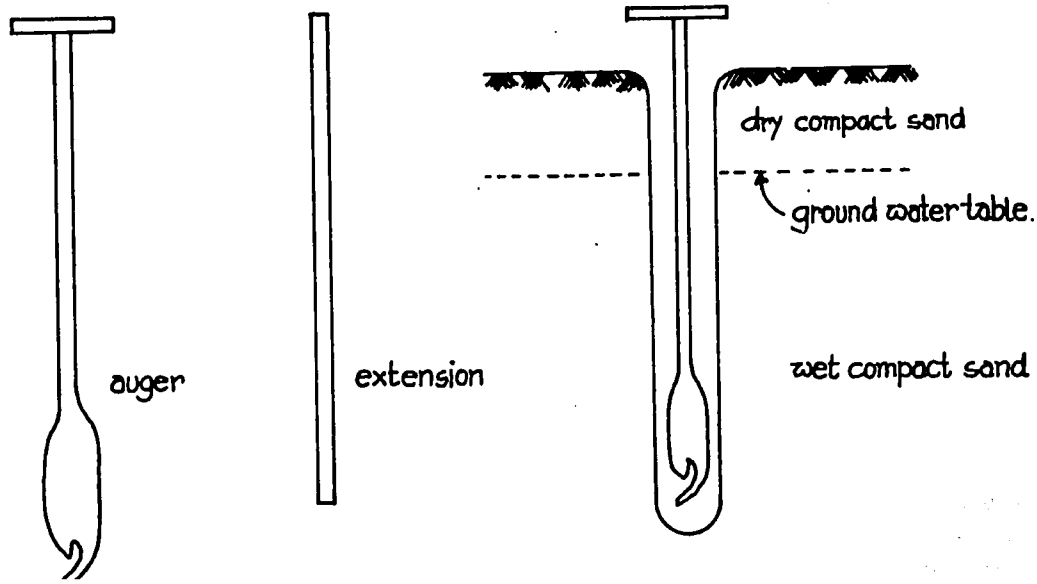


Fig. III-4: Auger and Auger boring.

Test Rods or Sounding Rods:- This Type of exploration is similar to probing with a steel rod or pipe, 3/4" to 1" in diameter. The difference is that the rod or pipe consists of 4 or 5 feet sections which are connected together by recessed couplings and driven deep into the soil to investigate soil resistance. They can be useful in estimating the length of a pile or the depth of a well foundation that will be required before adequate soil resistance is obtained.

Table III-2 : Safe Permissible Loads on Different Soils

Description of Soil		Safe Load in Tons Per. Sq. Feet.	General assessment for Foundation.
1. Sand :	(a) Dry Compact	2.00	Satisfactory
	(b) Dry loose	1.00	Satisfactory
	(c) Wet Compact	1.00	Satisfactory
	(d) Wet loose	0.50	Unsatisfactory
2. Silt :	(a) Dry Compact	1.50	Satisfactory
	(b) Dry loose	1.00	Satisfacfory
	(c) Wet compact	0.75	Not so satisfactory
	(d) Wet loose	0.50	Unsatisfactory
3. Clay	(a) Wet pastry, muddy or marshy	0.25	Unsatisafctory
	(b) Clay—sand loams with about 30% of sand.	0.75	Not so satisfactory
	(c) Moist clay, stiff but can be indented with thumb	1.00	Satisfactory
4. Sandy silt :	(a) Dry compact	1.75	Satisfactory
	(b) Wet compact	1.00	Satisfactory
5. Sandy graved or kankar		2.50	Satisfactory
6. Organic soil, loose or spongy		—	Not fit ofr foundation

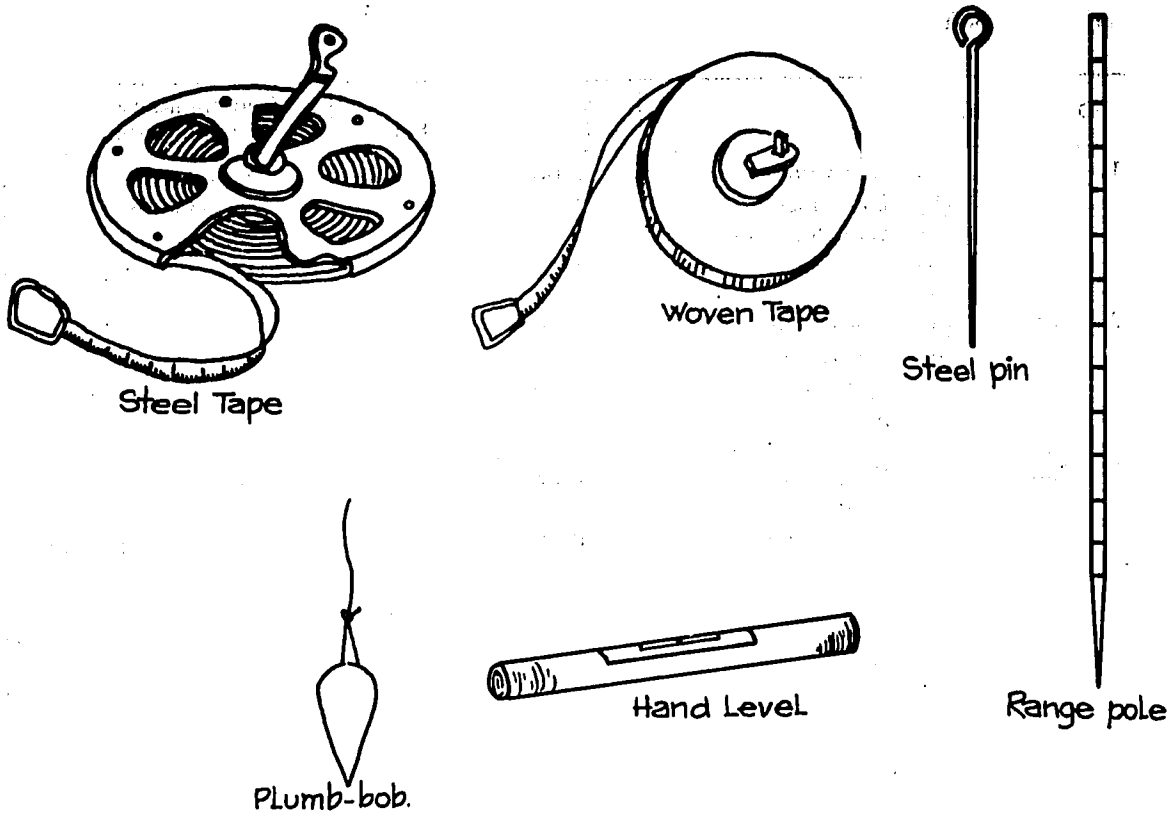
3. Layout Measurements and Marking

Layout measurements and markings precede the actual construction work in all civil engineering projects. Simplified field procedures for layout measurements and markings include measurements and markings include measurement of distance, angle layout, leveling and marking by batter boards.

A. Measurement of Distance :

Taping is the common means of measuring distances. Taping meansuring of distances between two points in a horizontal straight line.

The more common instruments used in measuring distances are shown in the figure below. The **steel tapes** are 66 ft. or 100 ft. long and are more accurate. **Woven** (cloth) Tapes (2) are more common, but less accurate because they stretch under tension. The **steel pins** (3) are used for marking the ends of the tape when measuring. The **range poles** (4) are used to keep the tape on the line of measurement. The **plump bob** (5) is used to transfer the position of the end of the horizontally held tape on to the ground where a steel pin is set to mark the point. The **hand level** (6) is used for horizontal holding of the tape.



For a taping operation over level ground, the party consists of 2 persons, a head and a rear tapeperson. The equipment includes a tape, a set of taping pins, and two range poles. The range poles are stuck in the ground at each end of the line to be measured as markers. The head tapepersons moves with the zero end of the tape forward along the line and steps at the call of the rear tapeman when the full length of the tape is out. He then quickly aligns himself with the markers with the aid of right or left signals from the rear tapeman. Slight tension is applied to the tape which is laid falt on ground, and the ends of the tapes are marked on the ground with the taping pins and measurement proceeds.

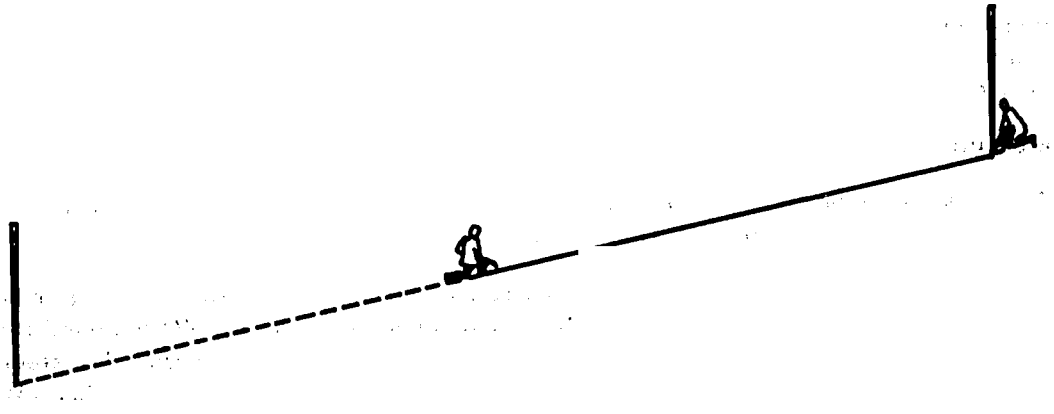


Fig. III-6 : Taping on level Ground

For taping over slopping or uneven ground, the markers are placed along the line of measurement. If the slope is downhill, the head tapeperson estimate the steepness of the slope and holds his end of the tape up checking the level of the tape with the hand level. It is not convenient or good practice to hold the tape more than about 5' above ground, and hence if the slope is more than 5 ft. per tape length, it is necessary to "break" tape i. e. measure in shorter lengths. With the tape stretchad horizontally, the head tapeperson holds the plumb-bob cord and the tape pinched together by the thumb and forefinger, and transfers the position of the end of the tape to the ground where a pin is set and measurement proceeds.

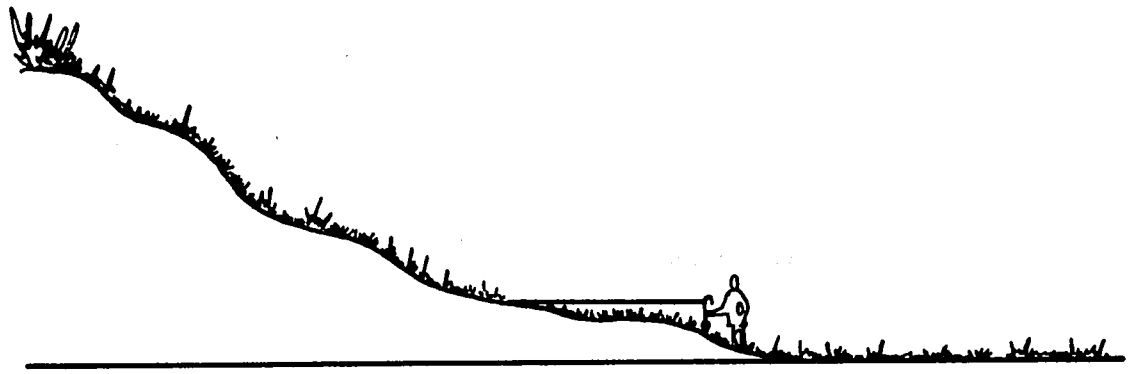


Fig. III-7 : Taping down hill

For taping uphill, the rear tapeperson holds his end of the tape high enough while the head tape-man holds his end of the tape close to ground. Necessary plumb-bobbing and marking are done as before and the measurement proceeds.

Thus the points to be carefully observed in taping can be summerised as follows :

(i) Always hold the tape horizontally.

(ii) Always hold the tape tight.

(iii) Always use the plumb-bob carefully for transferring the end point of the tape to the ground.

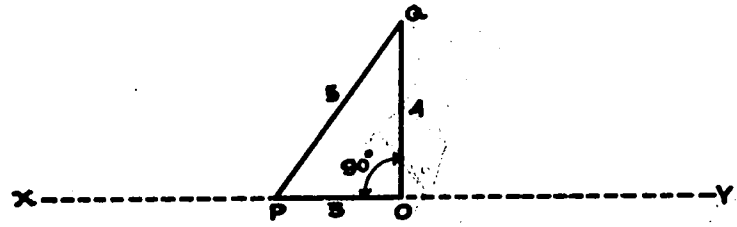
(iv) Always tape in a straight line.

B. **Angle Layout :**

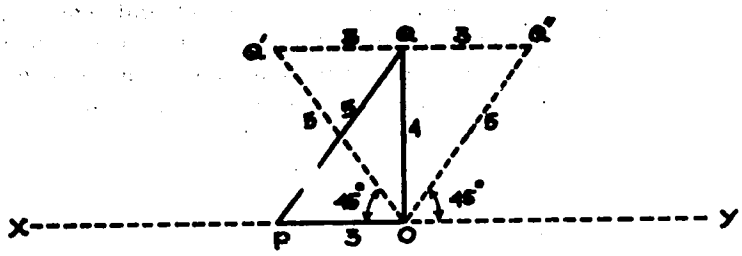
It is frequently required to layout angles (90° and 45°) using only a tape in connection with laying out of corners buildings, bridges, irrigation structures, roads etc. Two methods are used.

Method 1 (3:4:5 Triangle Method)

Let XY be a line and let O be the point on the line where a 90° angle is to be laid with the line XY.



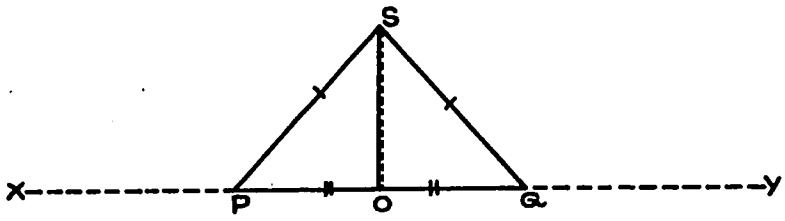
Lay down a triangle OPQ with a tape so that OP : OQ : PR = 3 : 4 : 5. The sides of the triangle may also be any common multiple of this ratio. The angle POQ will be 90°.



If we want to layout an angle of 45° at the point O, we can first set the triangle OPQ' as already stated and then can layout the triangles OQQ' or OQQ'' as desired by simple tape measures and thereby obtain POQ' or YOQ' as 45° as may be desired.

Method 2 (Intersecting Lines Method)

Let XY be a line and O be a point on the line where a 90° angle is to be laid with the line XY.



Measure equal distances OP and OQ on the two sides of the point O. Locate the points S such that PS and QS measure equal. Then POS or QOS will be 90°.

Once the 90° angle is established at the point O, 45° angles at the point O can be established as discussed in the method 1.

C. Levelling

String line levelling is done using a string level. The string is stretched and the level is held close to and parallel with the string. By adjustment of the level, the bubble in the level is brought to the centre and the corresponding alignment of the string gives a horizontal level.

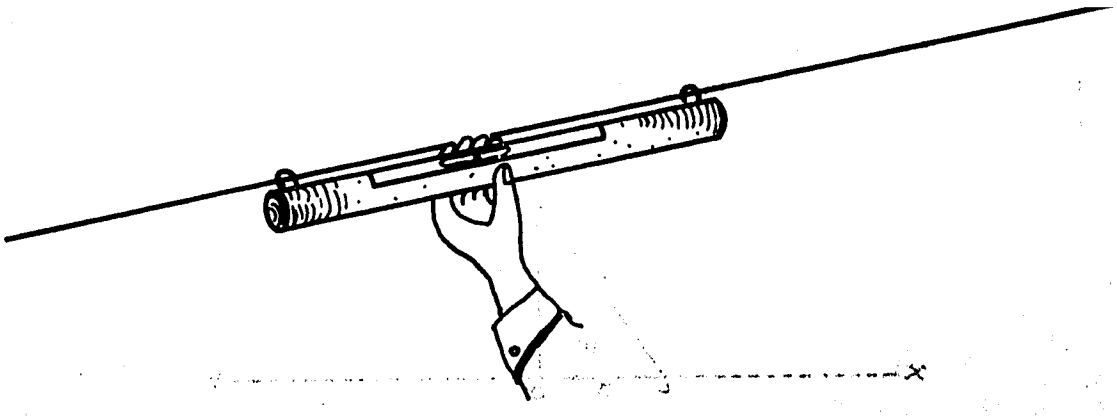


Fig III-8: Levelling with a string Level.

Hose levelling is done with a clear plastic hose full of water and two sticks on which to mark the water level heights. One end of the water filled hose is taken to one of the stakes while the other end is taken to the other stake. Since the water level in both ends of the hose will be level, there will be a level plane between the two marked stakes.

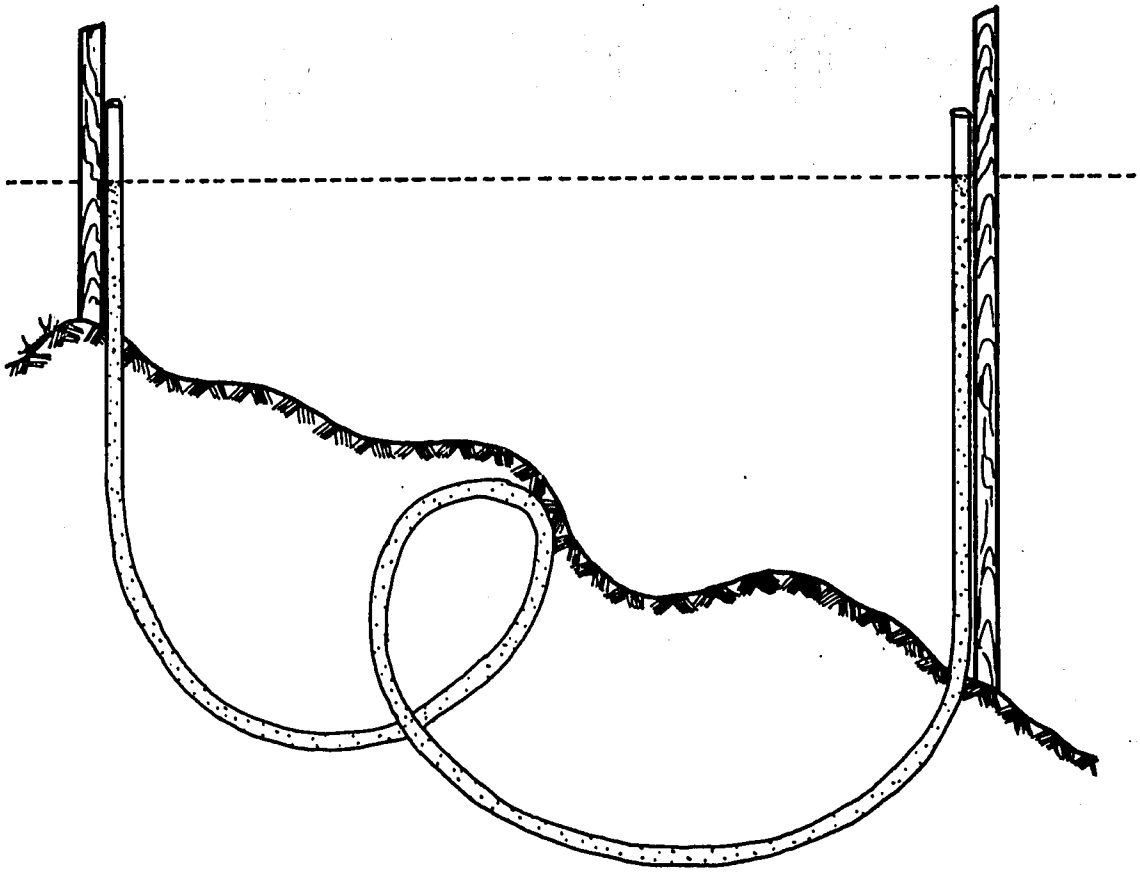


Fig. III-9 : Water Levelling

D, Site Layout Using the Method of Batter Boards :

Batter boards are used to preserve the lines of a proposed structure during excavation and construction. Right-angle batter boards are made by nailing two boards to three stakes to form the angle. Straight batter boards are made with one board and two stakes.

To transfer lines of a proposed structure to batter boards, hold two plumb-bobs over the nails in the two layout stakes marking the line of a proposed structure. Stretch a string along this line from the opposite batter boards and adjust it until it touches the two plumb bob lines. Place nails or make saw cut marks on the batter boards where the string crosses.

Batter boards are used only after the site layout has been done by the previously discussed methods, viz, taping, angle layout and levelling.

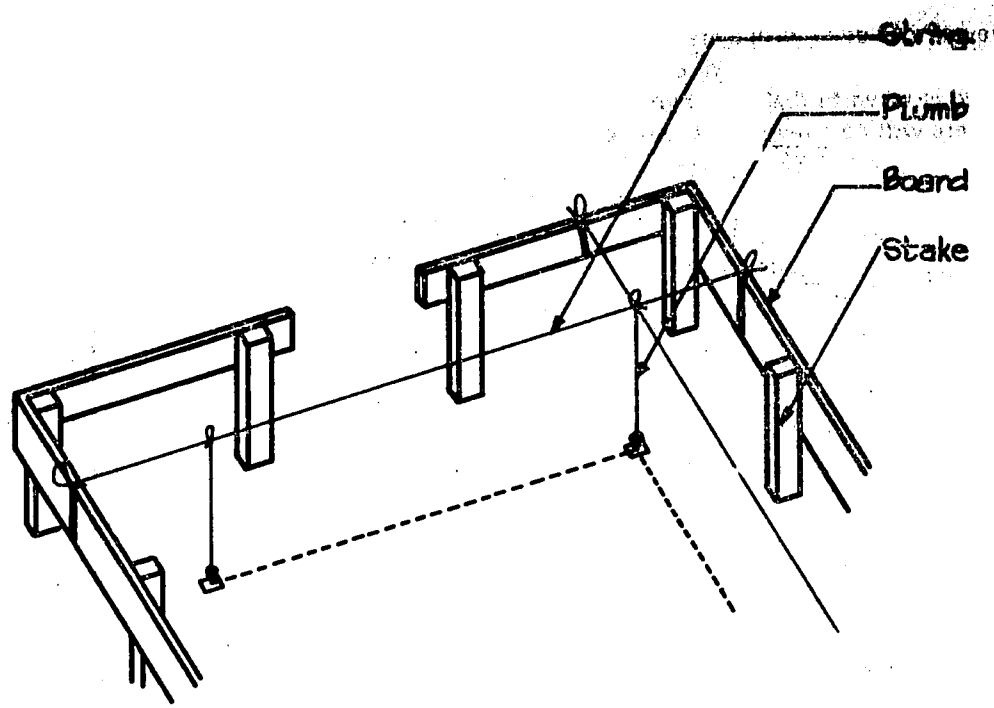


Fig. III-10 : Use of Batter Boards for Site Layout

4. Excavation for Foundation Structure and Shoring.

Before excavation for foundation is allowed to begin, laying out of the excavation lines by means of batter boards must be checked once again by the supervisor. Then the supervisor should setup an elevation stake near the edge of the excavation at a known height above the level of the footing grate. The contractor can use this stake for checking the elevation of the hole at any time during the digging.

It is very common for lobourers to take chances when they are doing excavation work. They do not worry about the sides of an excavation collapsing until they actually start to fall in. To take precaution against this danger, the sides of the excavation should be sloped back no less than a one-to-one slope. If wet sand is encountered, it will be necessary to build wooden shoring (Figure III-10) to keep the sand from falling in on the men who are doing the digging. The soil that is removed from the excavation should always be placed back from the edge at a distance equal to the depth of the excavation. People should not be allowed to stand near the excavation, for the weight of the people could cause the sides of the excavation to collapse. At night, it is wise to put up some kind of barrier or fence to prevent people or animals from falling into the excavation.

When the excavation reaches the approximate plan elevation of the bottom of footing, it should be made sure that the foundation bed is composed of a permanently stable material of considerable depth. If at all questionable, the foundation should be explored below grade by means of a soil auger or driving rod. For finishing the excavation, all loose or disturbed material below plan grade shall be removed and the hole should present a reasonably even approximately level surface.

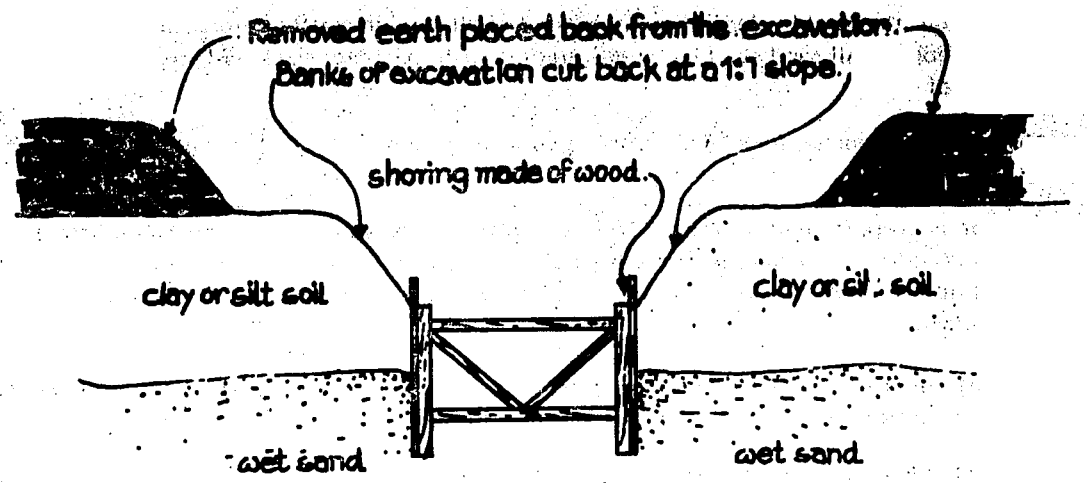


Fig. III-11 : Excavation and Shoring

5. Brick laying

Brick laying is the art of arranging bricks with mortar for construction of walls, abutment, piers and other engineering structures. Brick laying has been one of the oldest crafts in the history of human civilization and constitutes an important segment in almost any civil engineering construction in our country. The materials and workmanship required for a good quality brick-work are specified below :

(a) **Brick :**

All bricks used for construction shall be of first class quality. First class bricks have a uniform shape and sizes, measuring 9½"x4½"x2¾", and they are of uniform colour and degree of burn. They should ring clearly when struck against one another, and they should not absorb water of more than one sixth (1/6) of their dry weight.

All bricks shall be thoroughly cleaned of all foreign materials and well soacked in water before using. Those bricks with grease, grit, earth, fungus etc. will not bond well with the mortar, and the dry ones will absorb water too readily from the mortar thereby preventing the mortar from acquiring its proper strength.

(b) **Mortar :**

Mortar is a mixture of lime, sand and water, or lime, cement, sand and water, or cement, sand and water. Mortar provides an even bed for the brick, unites the brickwork into one unit, prevents the penetration weather and adds beauty to the structure. Mortar is also used to cover walls in the form plaster. All mortar shall normally contain a generous proportion of water satisfying the condition that the paste is still workable with a trowel. If the mortar becomes stiff before it is used, additional water shall be mixed to keep the mortar workable. **Water shall not be added to mortar after it is placed on the brickwork.** Sprinkling water on the newly-laid brick work washes away the cement in the mortar decreasing the strength of the structure. All mortar shall be used within thirty (30) minutes after mixing, since by then the motar begun to take its 'initial set' or hardening. Mortar which has taken its initial set shall not be used or remixed with fresh mortar and should be discarded.

All cement used shall be Portland cement. Any cement which has hardened should never be used All hard lumps and foreign matter in cement shall be screened out and discarded because these lumps make week spots in the mortar and hence in the structure itself.

All sand must be thoroughly cleaned and screened of all foreign matter before use (see Item No. 8 under this section). All sand shall be well graded with particle sizes ranging from fine to a maximum size of 3/32".

All water used for mortar, for soaking bricks or washing sand shall be clean and pure enough for drinking.

Lime morter is proportioned **one part lime to three parts sand.** Only hydrated lime should be used in the mortar. It hardens slowly and its strength increases with age. But it looses strength and deteriorates when in contact with water and therefore should not be used for outside structures.

Lime-cement mortar is proportioned **one part lime to one part cement to six parts sand.** It is easily worked with the trowel and is suitable for almost any use.

Cement mortar is proportioned **one part cement to three parts sand.** According to laboratory test this is the strongest mortar. However it is not easily workable with a trowel making it difficult for the bricklayer to construct good mortar joints. For this reason, a **small amount of lime** may be added (about ¼ of one part unit of the standard measurment).

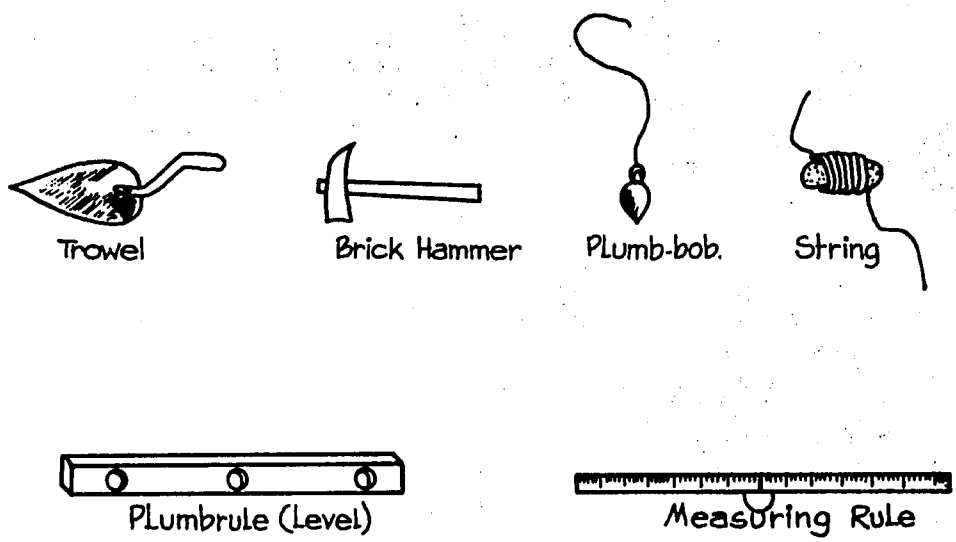


Fig. III-12 : Brick Laying Tools.

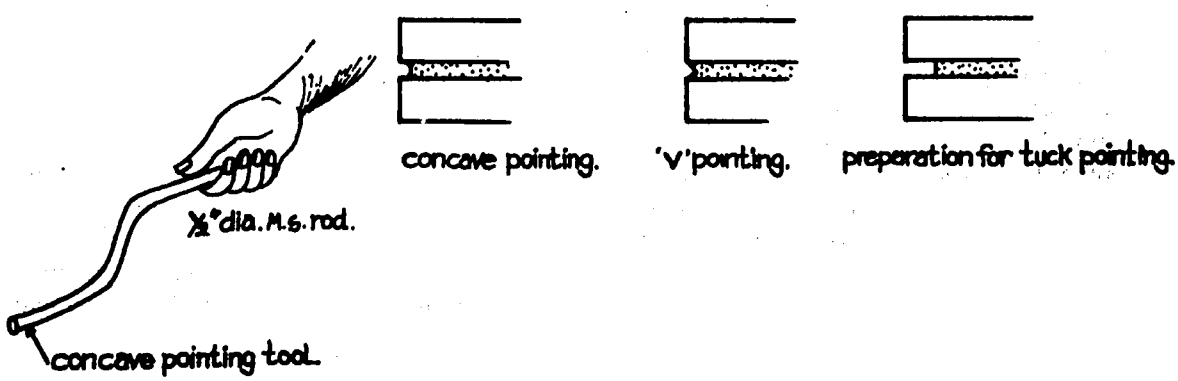


Fig. III-13 : Pointing.

To summarize, the points to be observed for good brick laying work are as follows :

(i) Always use first class bricks, 9½"x4½"x2¾" which are uniform in size, shape, degree of burn and produce, clear ringing sound when struck against one another.

(ii) Always use thorough and uniform mortar joints, ¼" to ⅜" thick.

(iii) Always use a strong mortar mix. A brickwall can be no stronger than the mortar joints which bond the brick together.

(iv) Always insists on first class workmanship. This means that the walls are plumb i. e. perfectly vertical, corners are square, lines are straight, dimensions are exactly as called for is the specifications and all joints are completely filled with mortar and well compacted and finished.

(v) After the brick work is completed, take out all face joints to a depth of about 1½ inches, dampen the joints and finish them with a 1 : 2 cement mortar using concave pointing.

6. Shuttering and Falseworks.

For concrete casting works where specific surface patterns and finishes are not desired, the shuttering boards need not be of first quality or finished timber but must be free of cracks and large holes through which moisture and concrete may runout.

All shuttering work must be strong enough and sufficiently braced to eliminate any sagging or bulging when the concrete is placed.

Shuttering should be used for all concrete walls over 1' in height. Boards should have straight edges and square ends to eliminate leakage. All shuttering works must have adequate bracing to insure against bulging or slipping. All shuttering work should be done to ensure easy and economical removal, since, if undamaged, the materials may be used again.

Shuttering for footing slabs may require boards at the edges only because the casting is done on the soil or on brick soling. Shuttering on the edges may be braced by wood, 2"x3" timber spaced approximately 2' apart or by earth fill ensuring straight lines and accurate measurements. When the slab is only 3" or 4" thick, bricks set on edge and supported by earth fill may be used. This will eliminate the cost of laying wood and sawing it to sizes.

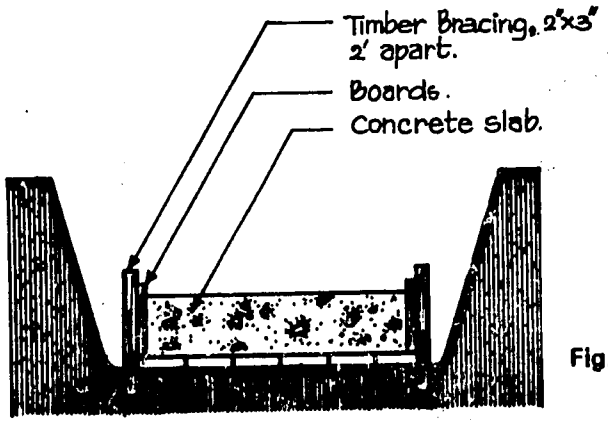


Fig. III-14 : Shuttering for Footing Slab—Wood Bracing

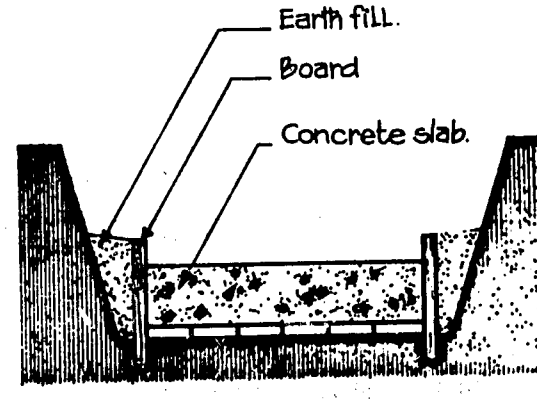


Fig. III-15 : Shuttering for Footing Slab—Earth Fill Bracing

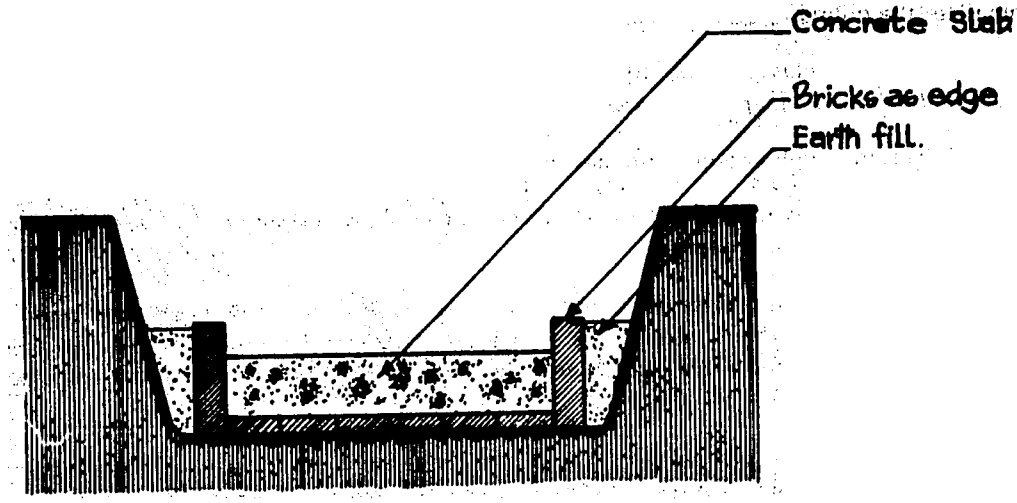


Fig. III-16 : Shuttering for Footing Slab—Using Bricks on Edge

Shuttering for Concrete Walls will require both horizontal and vertical braces of 2"x3" timbers spaced approximately 2' apart, the opposite horizontal braces being tied together by wire through the form work (Fig. III-17). Always use wooden spacers to ensure accurate wall width and remove them as the concrete placement progresses. **No wood or waste material should be left in the concrete.** To Keep the shuttering up right, lateral braces are also needed on

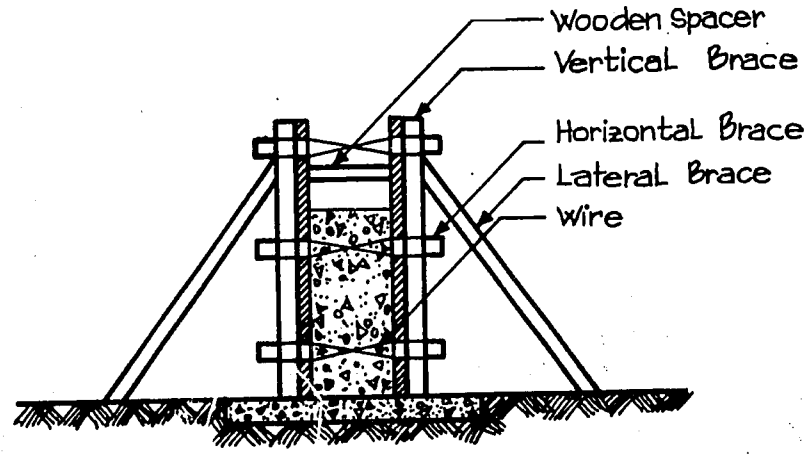


Fig. III-17 : Shuttering for Concrete Wall

Shuttering for Concrete Beams is similar to that for walls except that there is added support at the bottom in the form of upright supports of sawed timber, bamboo etc. spaced no more than 2' apart. The bottoms of the uprights must rest on a solid base of brick or planks.

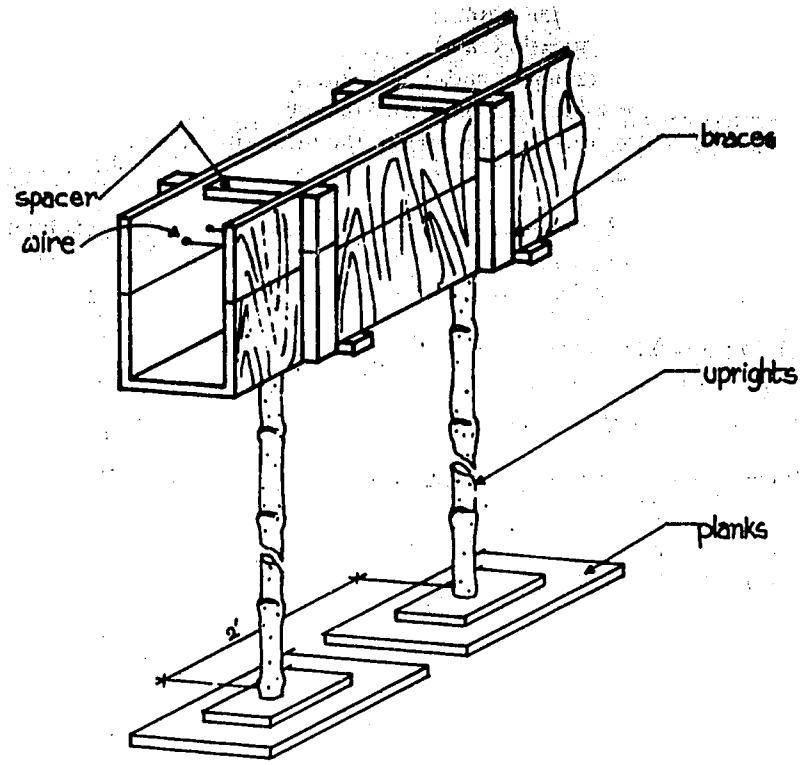


Fig. III—18 : Shuttering for Concrete Beams

Shuttering for Concrete Slabs : This requires boards on horizontal timbers supported by vertical supports of sawed timber, bamboo, etc. spaced approximately 2′ appart, with the edges formed by planks with braces. C. I. sheets may replace wood boards while the bracing remains the same.

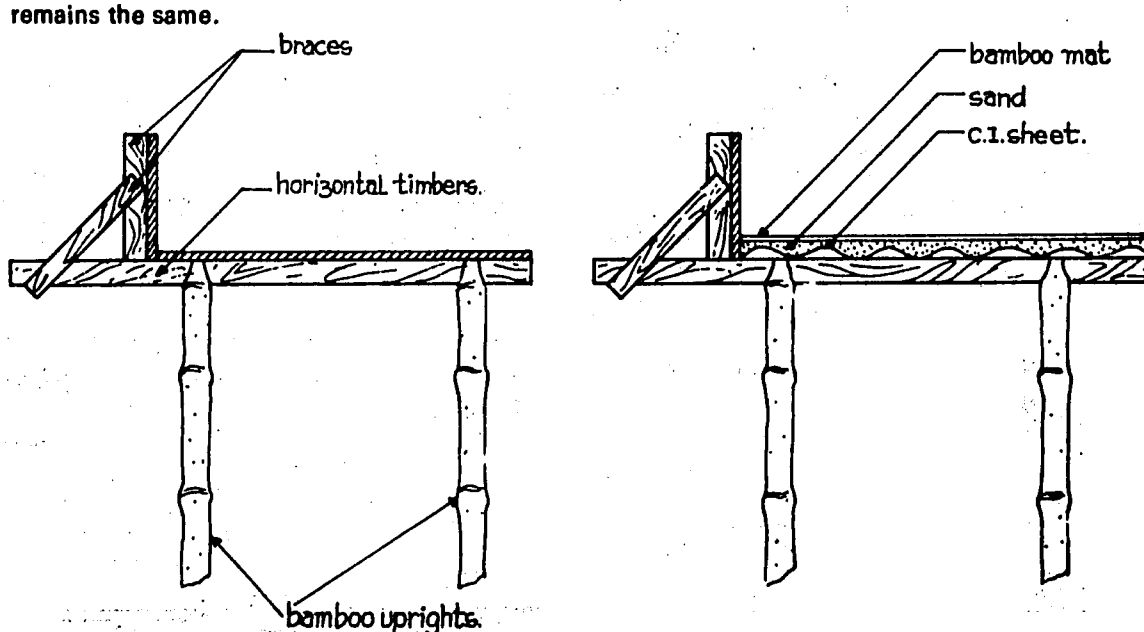


Fig. III-19 : Shuttering for Concrete Slabs

Fig. III-19 : Shuttering for Concrete Slabs

Shuttering removal demands proper care. Shuttering for all parts of a structure is not removed at the same time. The location and loading of a structure determines the removal time of shuttering. Generally column and beam sides may be removed after 3 days, the bottom shuttering may be removed in 7 days and resupported with bamboo or wood uprights for another 14 to 21 days. The full load for which the structure has been designed should not be permitted until after 28 days.

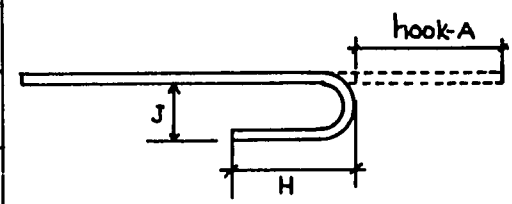
Shuttering should be removed carefully so that the edges or surfaces of the concrete are not damaged. Steel tools should not be placed against the concrete to pull the shuttering loose. Any neccessary wedging should be done with wooden wedges.

7. Bending, Joining and Placement of Reinforcement Steel :

Reinforcing bars are not to be heated for the purpose of bending since by so doing they are frequently burned and the steel is weakended.

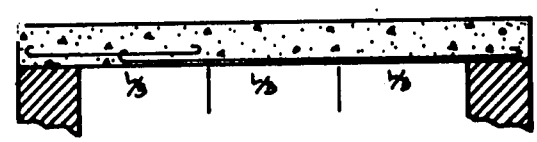
Bends in reinforcing bars should show no sign of fractures. Bending for hooks should follow standard specifications as per the table given below :

Rod Diameter (inches)	Hook A (inches)	Length J (inches)	Length H (inches)
1/4	4	2	3½
3/8	5	3	4
1/2	6	4	4½
5/8	7	5	5
3/4	8	6	6
7/8	10	7	7
1	13	10	9

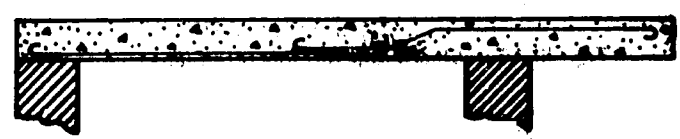


When rods are not of the proper length, joining or splicing must be done. There are several rules to follow when splicing rods as shown in the following diagrams.

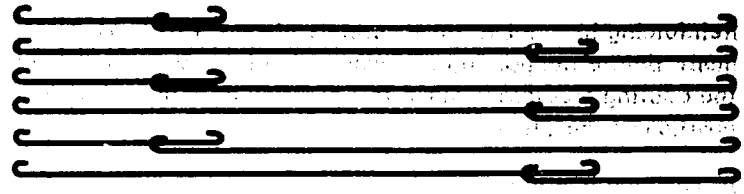
Rule 1 : Never splice in the middle third of the span.



Rule 2 : Never splice over supports



Rule 3 : Always splice in an alternate fashion.



Rule 4 : Minm. lengths of splices must be as per table VIII-19

Rule 5 : All ends must be hookd.

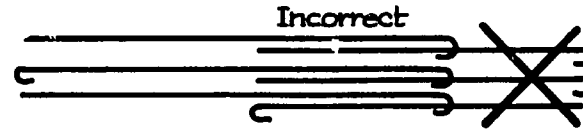
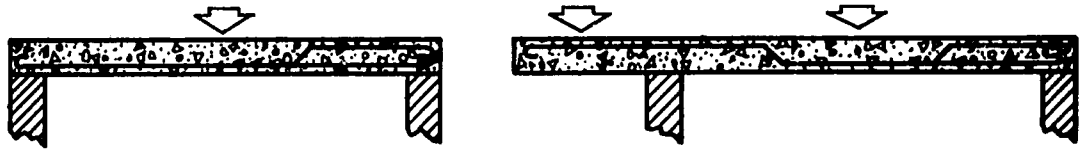


Fig. III-20 : Splicing Rules for M. S. (mildsteel) Rods.

Reinforcing steel must be placed as indicated in the structural drawings. The effectiveness of a bar usually depends on its position in the concrete and in some cases, unless steel is placed as shown on the structural drawings, it might just as well be omitted because it does not serve any useful purpose as illustrated below :



Correct Method of Placement of Reinforcement

Wrong Method of Placement of Reinforcement

Fig. III-21 : Correct and Incorrect Placement of Steel.

Reinforcing bars must be accurately placed, wired at intersections and secured against displacement before the pouring of concrete begins. Bars shall not be placed in the wet concrete as the pouring progresses since this practice does not allow the job supervisor to know the exact position of the steel.

A common method of holding reinforcement from contact with the forms is by means of mortar blocks. These blocks are cast of the same mixture of cement and sand the mixture of the concrete in which they will become an integral part. They are to be of such thickness that they will provid the proper bar clearace shown on the drawings. Where used to hold the vertical steel, each block should be cast with a double wire embedded in it, so that it can be tied in place when used. Blocks should be water cured for several days before use, otherwise they will not have sufficient strength to support the weight of the bars.

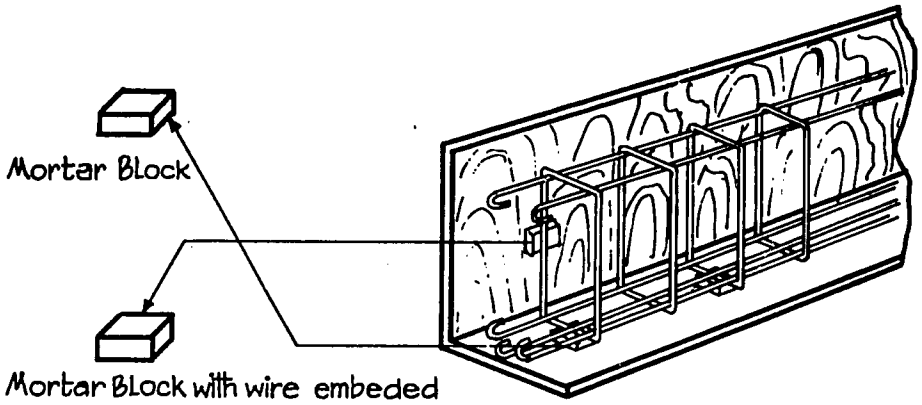
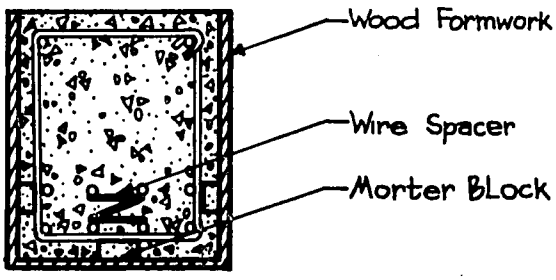


Figure III-22 : Placement of Reinforcement

Where two layers of steel are required at a given distance apart, it is customary to maintain this distance by means of "spacer" bars. "spacer" bars are short pieces of small sized steel, bent into a "Z" or into some other convenient shape of the proper dimensions. The layers of steel are wired to the legs of the "Z". The spreaders are spaced according to the stiffness of the layers.



In summary, the following rules may be enumerated for reinforcement work in concrete :

(i) Never substitute for the proper sizes of rods required for the job.

(ii) All rods must be cleaned and free from rust, oil, grease, mud or any other foreign matter.

(iii) All ends must be hooked when using smooth rod.

(iv) Rods must be straight and/or cranked as specified in the drawings.

(v) Splices in rods must be made with an overlap of a minimum of 30 rod diameters.

(vi) Rods must be securely tied in position with tying wire before pouring concrete. Never place rods while pouring concrete.

(vii) Rods must be placed so that it is completely surrounded by concrete. Concrete should be placed and vibrated in such a manner until it completely surrounded the reinforcment.

(viii) Rods must be well supported in the form so that the pouring will not bond them out of position.

8. Concrete Mixing, Placing, Finishing and Curing :

Concrete Mixing is preceeded by screening of the sand and washing of the khoa. The most common sand used, especially in the rural areas, is a fine sand. Although it is not the most suitable, it is often used due to its ready availability and economy. Before using the sand, it must be screened (Fig. III-23) to eliminate mud lumps and other foreign matter by using a wiremesh of maximum 3/16" size.

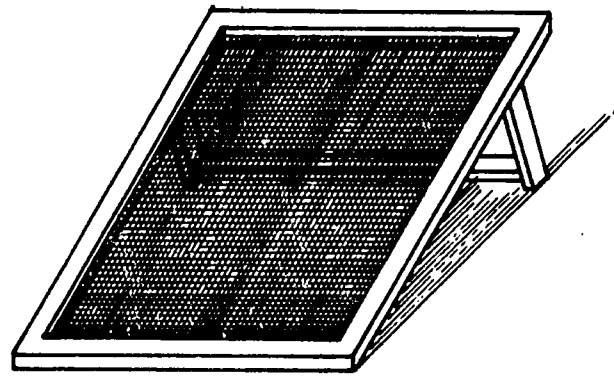


Fig. III-23 : Typical Screen for Sand.

Silt Test. If there is a heavy concentration of silt, dust or dirt in the sand, it can not be used unless these are removed by washing. An easy method to use on the site to check for clean sand is the silt test (Fig. III-24). The test can be made as follows :

Take a simple jar. Fill it to a depth of 2" with a sample of the dry sand to be tested. Add water until the jar is about 3/4th full. Shake vigorously for about a minute, the last few shakes being merely horizontal movements of the container to level off the sand. Allow the jar to stand for an hour, during which time any silt, dust or dirt will be deposited in a layer above the sand. If this layer is more than $\frac{1}{8}$" thick, there is too much concentration of silt, dust and dirt for use in concrete work, and you should not use the sand.

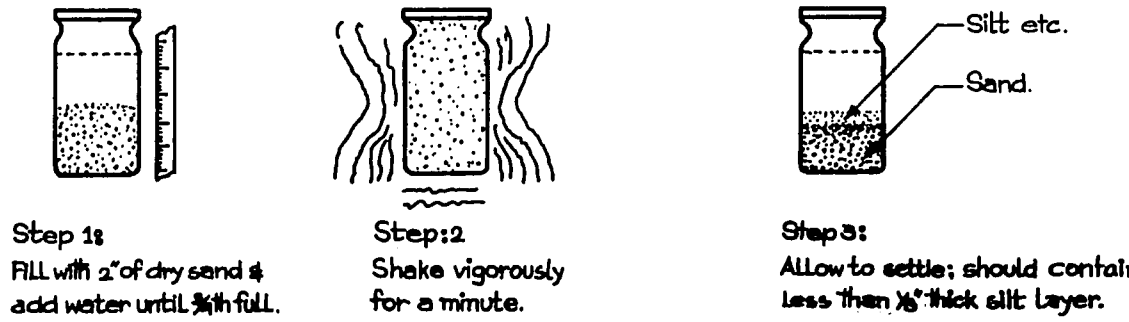


Fig. III-24 : Testing for Clean Sand by Silt Method.

For washing sand and khoa, two types of troughs may be used (Fig. III-25). Sand may be placed in the closed trough and water poured over it. On stirring the silt particles will come to be suspended in the water and may be drained out. Khoa may be placed in the open trough and water poured over it. Water will wash out the impurities through the sloping end of the trough while the cleaned khoa may be collected from the other end.

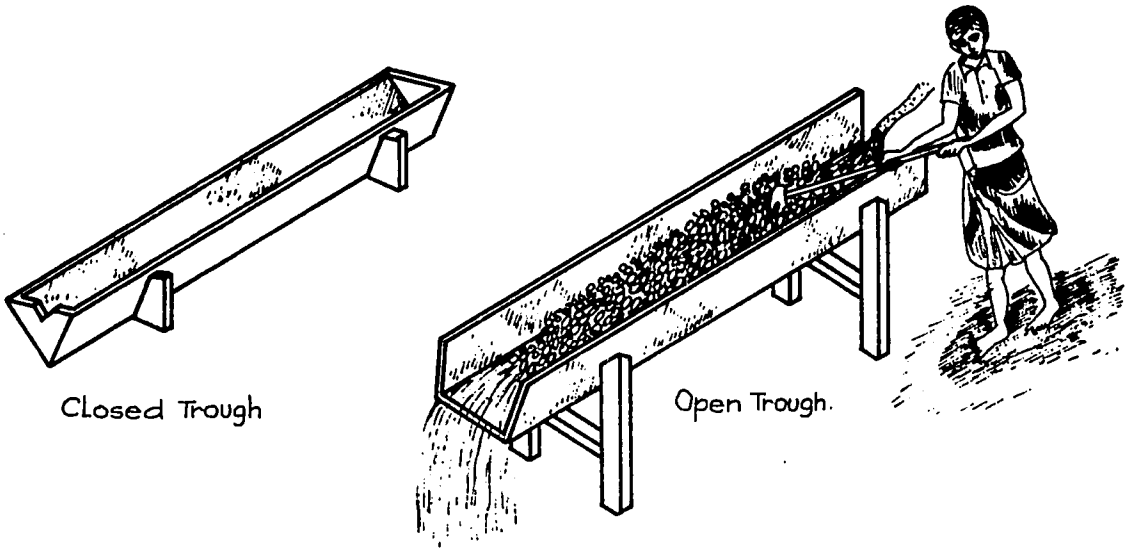


Fig. III-25 : Washing Aggregate

Large quantities of concrete mixing should always be done in concrete mixers. For small batches, hand mixing is usually adopted. The simple tools required for mixing and placing concrete are shown in the fig. III-26.

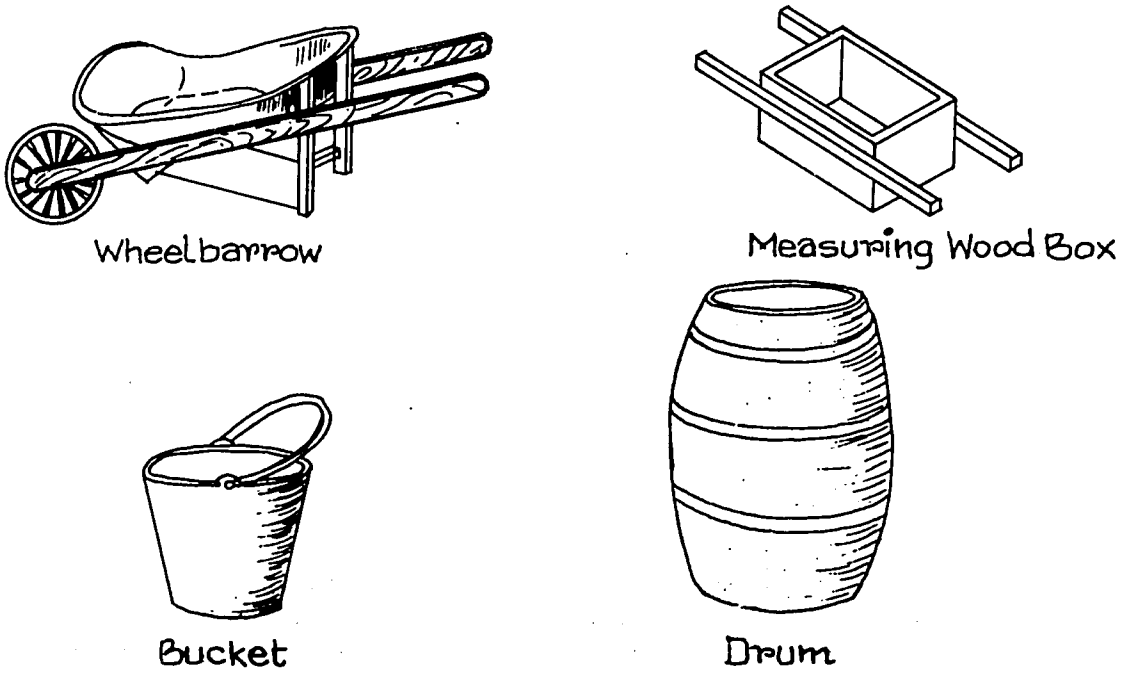


Fig. III-26 : Simple Tools for Making and placing Concrete

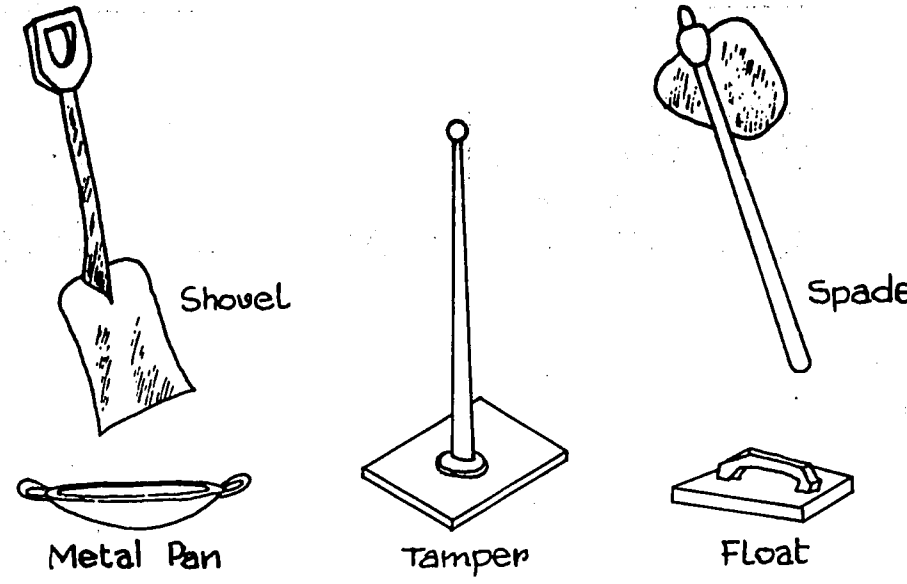


Fig. III-26 : Simple Tools for Making and placing Concrete

In the hand mixing method (Fig. III-27.) concrete is mixed on a watertight pad with a flat smooth surface. It can be made of concrete, bricks or metal sheeting. The most common pad is made of bricks with the joints filled with mortar. Care must be taken so that not too much water seriously decrease the strength of the concrete. A rule, generally used when adding water is the following : If a man walks on a mix and sinks down to his ankles then there is too much water in the mix ; if he sinks 1" or 2", then the right amount of water is present. The measuring of materials may be done by the wood box method (Fig. III-27)

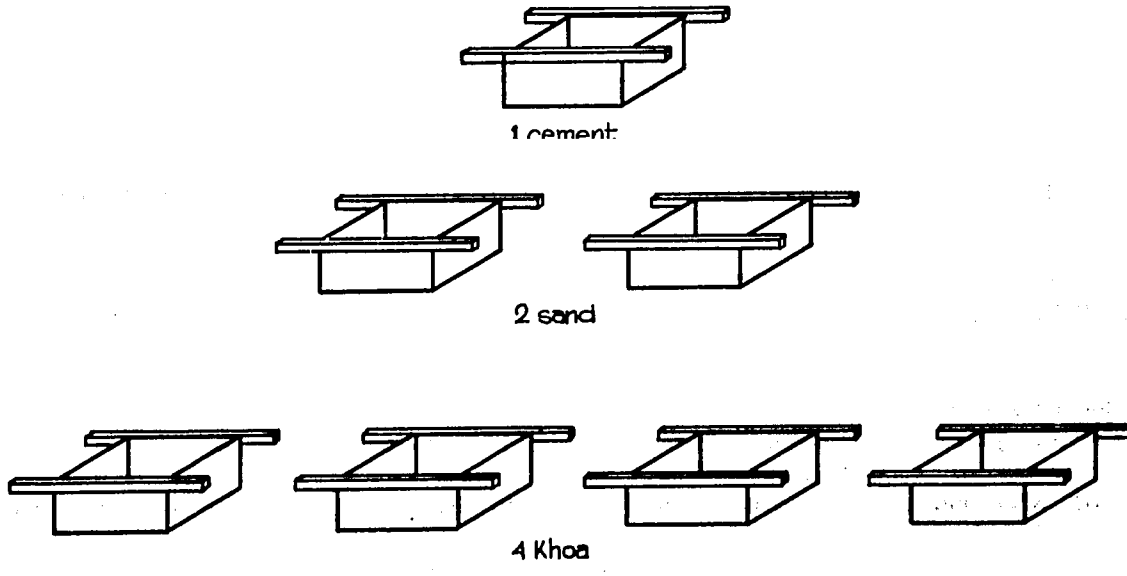


Fig. III-27 : Wood Box Method for Measuring Materials.

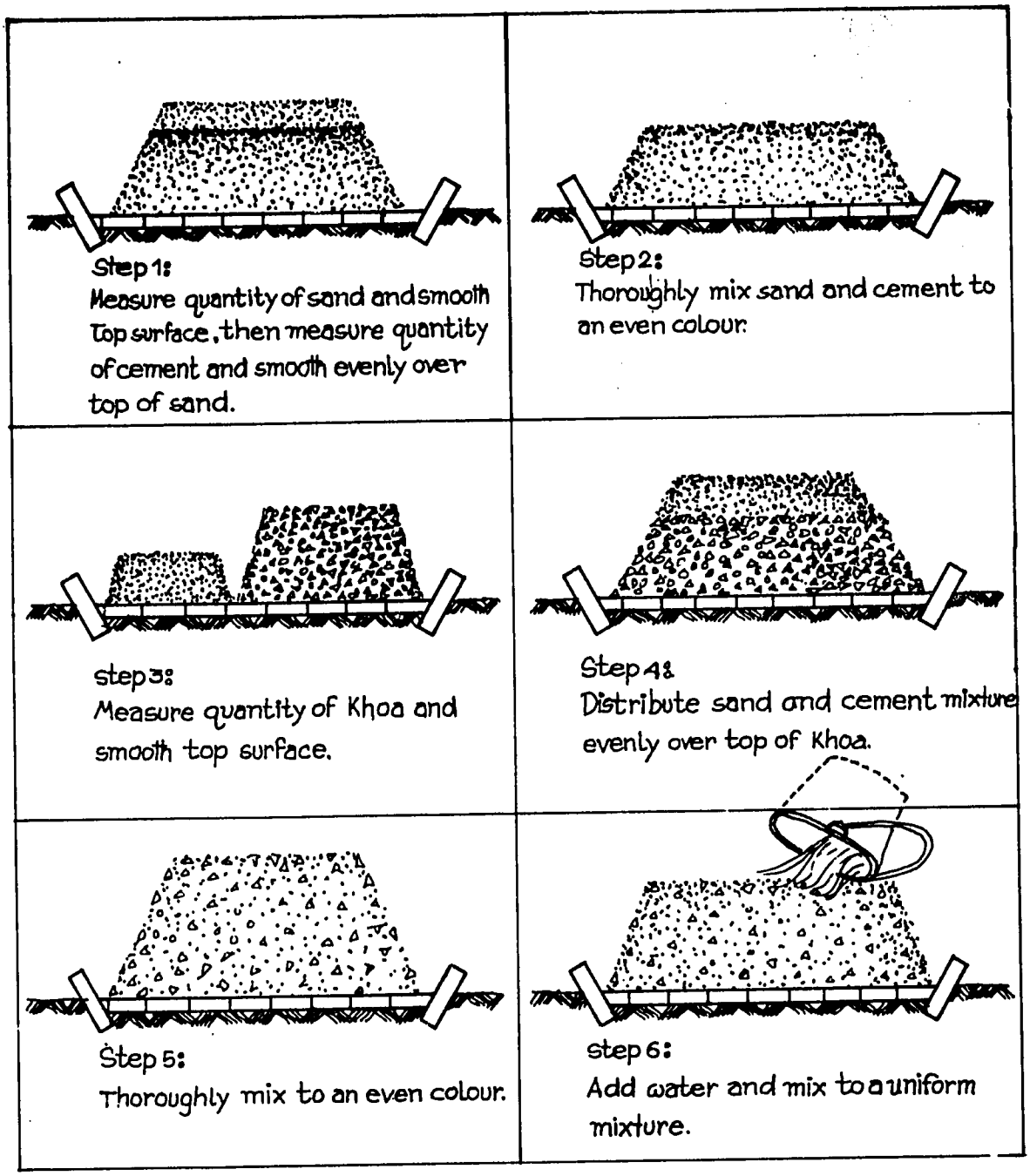


Fig. III-28 : Procedure for Hand Mixing Concrete

Machine mixing of concrete is done in a standard concrete mixture where the concrete is mixed in a revolving drum. The procedure for machine mixing is as follows :

(i) Khoa and sand are measured and dumped into the turning drum and allowed to mix for a few seconds.

(ii) Measured quantities of cement and water are then added and everything is allowed to mix for about 60-90 seconds.

(iii) The mixture is then poured out into wheel barrows or on a pad from which it is carried to the work place in metal pans.

Concrete Placing : Must be done immediately after it is produced. It should be placed and compacted in its final position before setting has commenced and should not be subsequently disturbed. If, at any time, it is considered necessary to add extra water to obtain the requisite workability, it may be taken to mean that the cement has set.

Placing the concrete should be done in one continuous operation as far as possible to avoid the necessity of cold joints in the concrete.Concrete should be deposited and never thrown or dumped from a height, to prevent the segregation of the aggregates.

The concrete, after being deposited in the form-work, should be rodded so that it is forced round the corners and edges to enable the spaces between the rainforcing bars to be completely filled. While depositing the concrete, water is likely to collect at the top which seriously interferes with the hardening of concrete by slowing down the process of hardening. To avoid this stiffer mixtures should be used and the concrete deposited in shallow layers, about 6" thick. Rodding in concrete is normally done 25 times per square foot. Too much rodding, however, will cause segregation of concrete.

Concreting should be carried-out continuously without pause upto the construction joints, the position and arrangements of which should be pre-determined. Constructon joints are so positioned that the strangth of the member is not affected, and the most suitable place is normally away from the middle-third of the span and close to the support but never over it.

Slump Test : No definite measure of consistency and workability of concrete has yet been devised but the slump test affords a useful indication of both these properties. Equiqment for a slump test consists of a slump cone and a measuring cane as shown below :

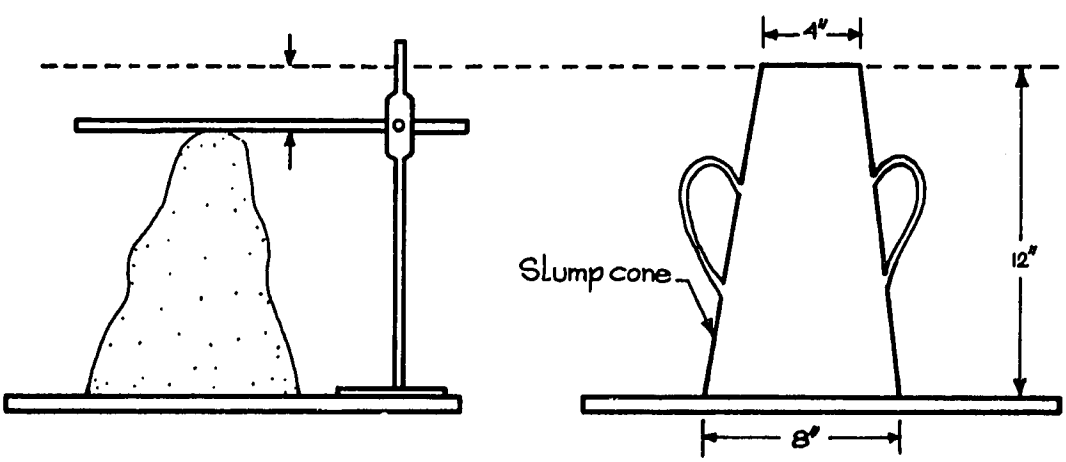


Fig. III—29 : Slump Test.

The detailed procedure for the test is as follows :

The mould should be placed on a smooth, flat, non-absorbent surface and the operator shall hold the mould firmly in place while it is being filled. The mould shall be filled about one-fourth of its height with the concrete which shall then be puddled using 25 strokes of a 5/8" rod, 2' long and bullet pointed at the lower end. The filling shall be completed in successive layers similar to the first and the top struck off so that the mould is exactly filled. The mould shall then be removed by raising it vertically immediately after filling. The moulded concrete shall then be allowed to subside and the height of the specimen measured, after it has come to rest.

The following values of slump are generally adopted :

Allowable Slump, Inches.	Degree of workability	Suitable works
0—1	Very low	Precast and vibrated concrete works in roads and piles.
1—2	Low	Road works ; mass concrete in foundation ; lightly reinforced sections.
2—4	Medium	Slabs ; Normal reinforced concrete ; Heavily reinforced sections.
4	High	Unacceptable.

The following is a list to check before starting to place concrete :

(i) Is a sufficient quantity of concrete materials available on the job site to finish the work ?
(ii) Is the weather satisfactory or rain is expected ?
(iii) Will the placement go on into the night ; if so, is sufficient lighting available ?
(iv) Are the M.S. rods in place. cleaned, and secured in final position ?
(v) Is the shuttering clean, wetted, tight and adequately supported ?
(vi) Is the earth on which concrete is to be placed damp so that the ground will not soak water from the concrete.
(vii) Is the earth properly prepared and of the correct elevation ?
(viii) Is sufficient manpower available to handle the rate of concrete mixing.
(ix) Is curing material on the site ?

As the concrete placing is progressing, the supervisor must keep these items in mind:

(i) Never use concrete that has been mixed and left standing for more than 10 minutes.
(ii) Never add water to concrete after it has been mixed.
(iii) Never allow earth, grass or other foreign material to fall into the concrete. For example, do not allow walking on concrete with mud in shoes or feet.
(iv) Never place the concrete on muddy earth.
(v) Never drop concrete from a height of more than 3'.

When placing concrete on old concrete, special care and special methods must be adopted to produce a good bond. The steps are illustrated in the Fig. III—30.

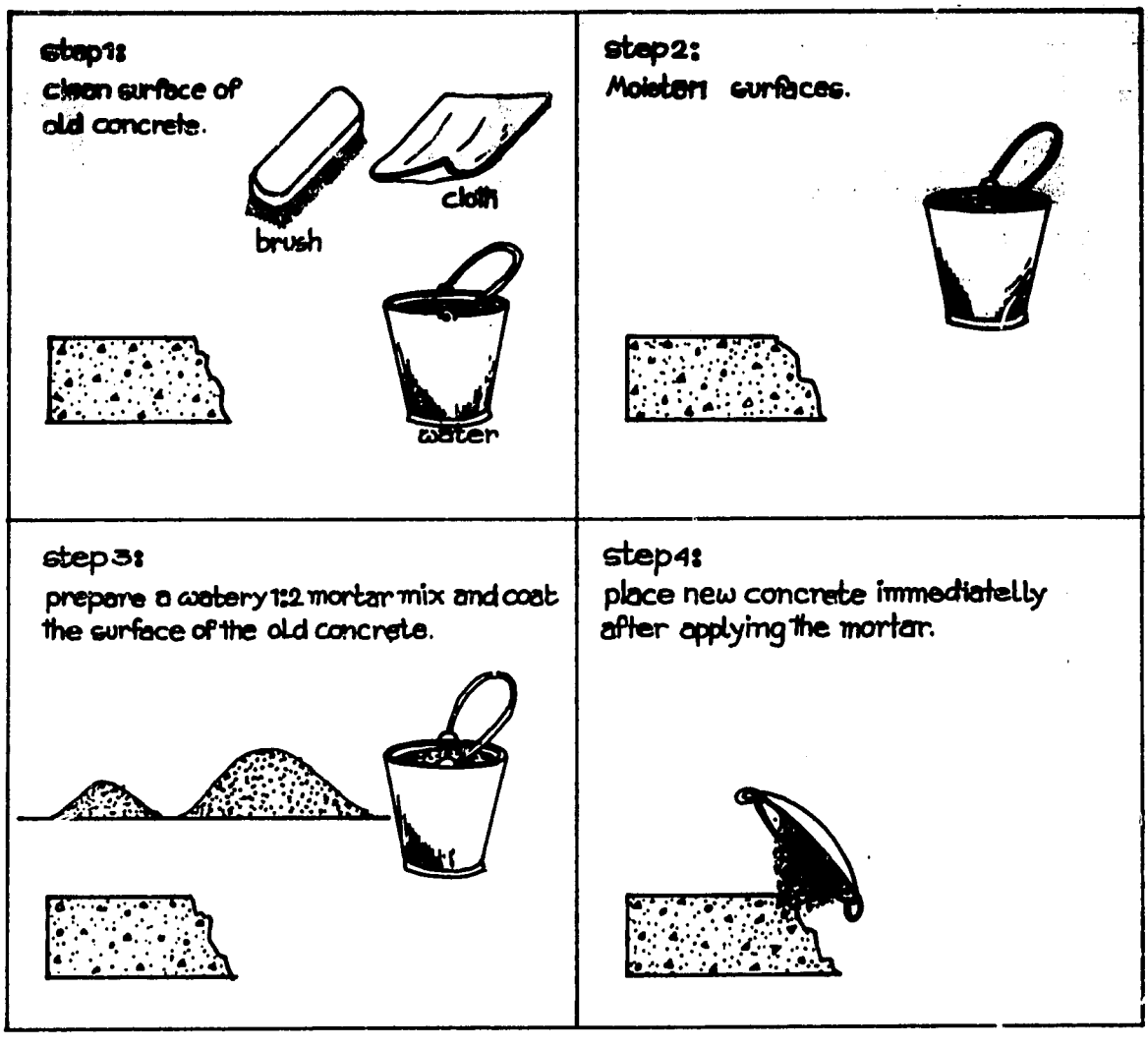


Fig. III—30 : Placing New Concrete on Old Concrete.

Placing concrete in water :- should be avoided if at all possible. Too much water in the concrete decreases the strength and can cause a failure if precautions are not taken. Often, under some conditions, water continues to seep in to the area where concrete is to be placed, and connot be removed. If this condition arises, the following placing method is advisable (Fig. III-31.) avoiding the following :

(i) Never spread a layer throughout the water.

(ii) Never rod the concrete.

(iii) Never allow water to cover the top of the concrete.

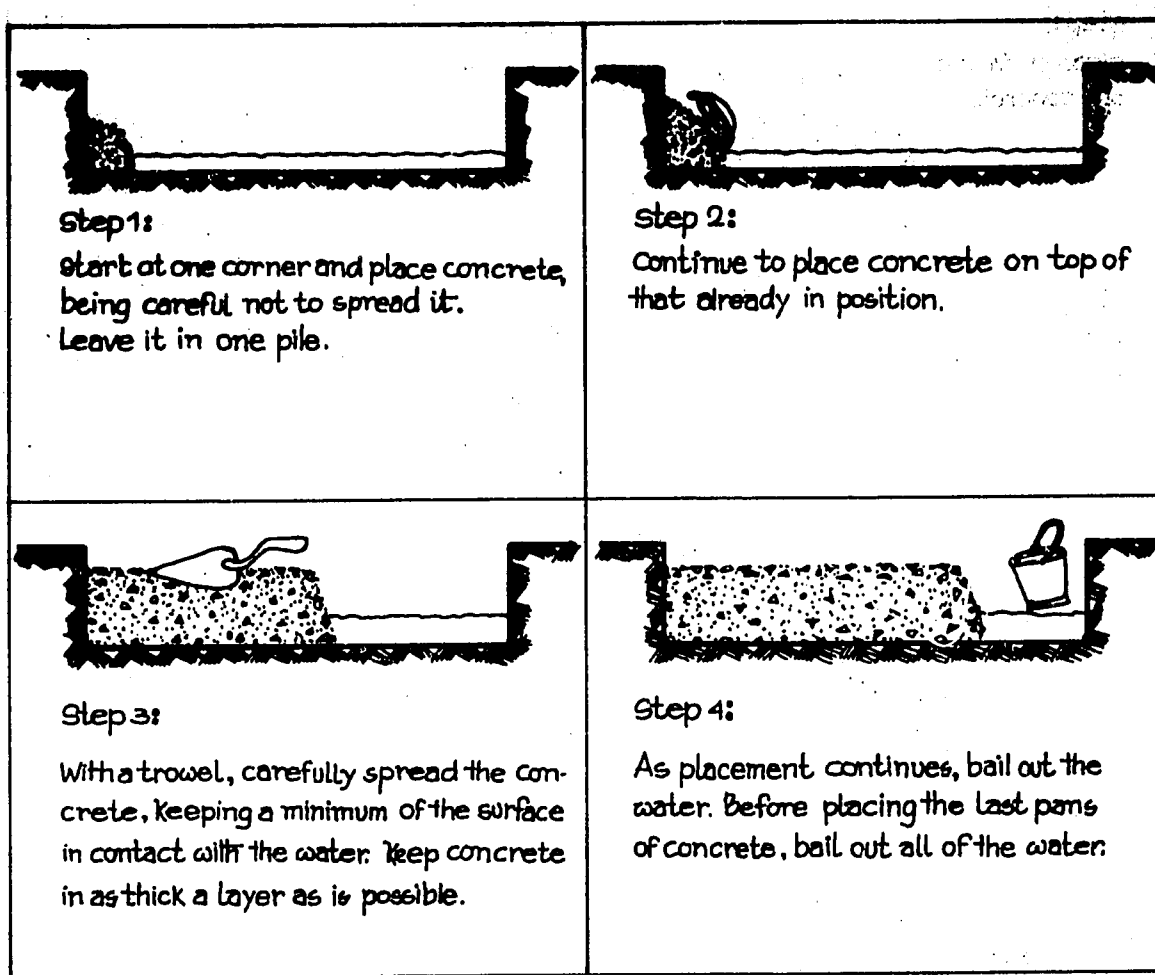
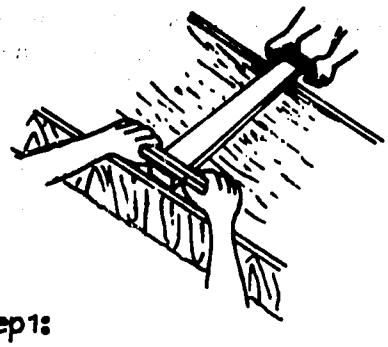
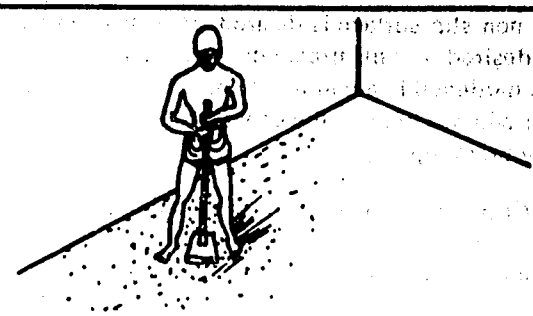


Fig. III-31 : Steps for Placing Concrete in Water.



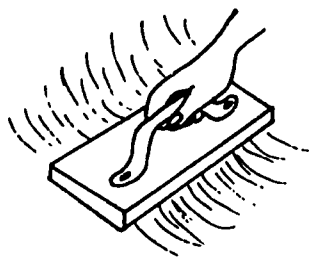
step 1:

The concrete is leveled to a proper grade by moving a straight edge of wood, 2"x3" in cross section, back and forth with a saw-like motion, or up and down across the top of the shuttering.



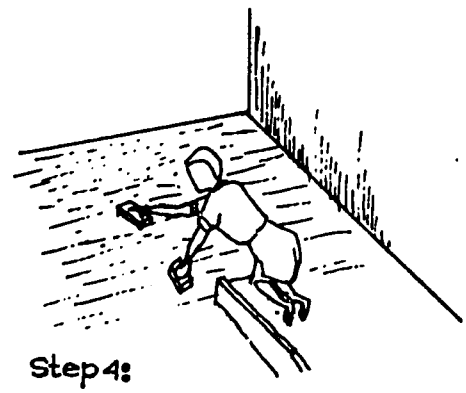
Step 2:

After the concrete has been leveled, it is tamped with a flat surface tamp to embed the large Khoa chips just beneath the surface, remove lumps and voids and to bring mortar to the surface for other finishing operations.



Step 3:

Some time after tamping when all the water has left the surface and the concrete has started to set, it is smoothed with a float to level, and the high spots are leveled and the holes are filled.



Step 4:

For finishing floors, a steel trowel should be used after floating to produce a hard, smooth surface.

Fig. III-32 : Steps for Finishing Concrete Work.

If a non-slip-surface is desired, steel trowelling is unnecessary after floating. If further roughering is desired, a stiff broom or wire brush may be used. Finishing the surfaces after the concrete has hardened is a bad practice. The mortar mix used for this purpose will not be strong enough and will not bind to the concrete sufficiently. Also after some time, this type of fininished surface may break up.

Curing concrete is one of the most important construction operations, but often one of the most neglected. Concrete properly mixed, placed and finished will lack strength if proper curing operations are not followed.

Concrete, after placing, should be protected during the first stages of hardening, from the harmful effects of sun shine, drying winds, excessive cold and also from running waters or shocks. Curing can be accomplished by any of the methods illustrated in the figure. III—33. The minimum time for curing is seven (7) days. The surfaces being cured must be kept moist during the entire period.

For curing vertical surfaces, two layers of burlap (gunny sacking or woven jute 'chat'), kept moist all through the curing period may be used.

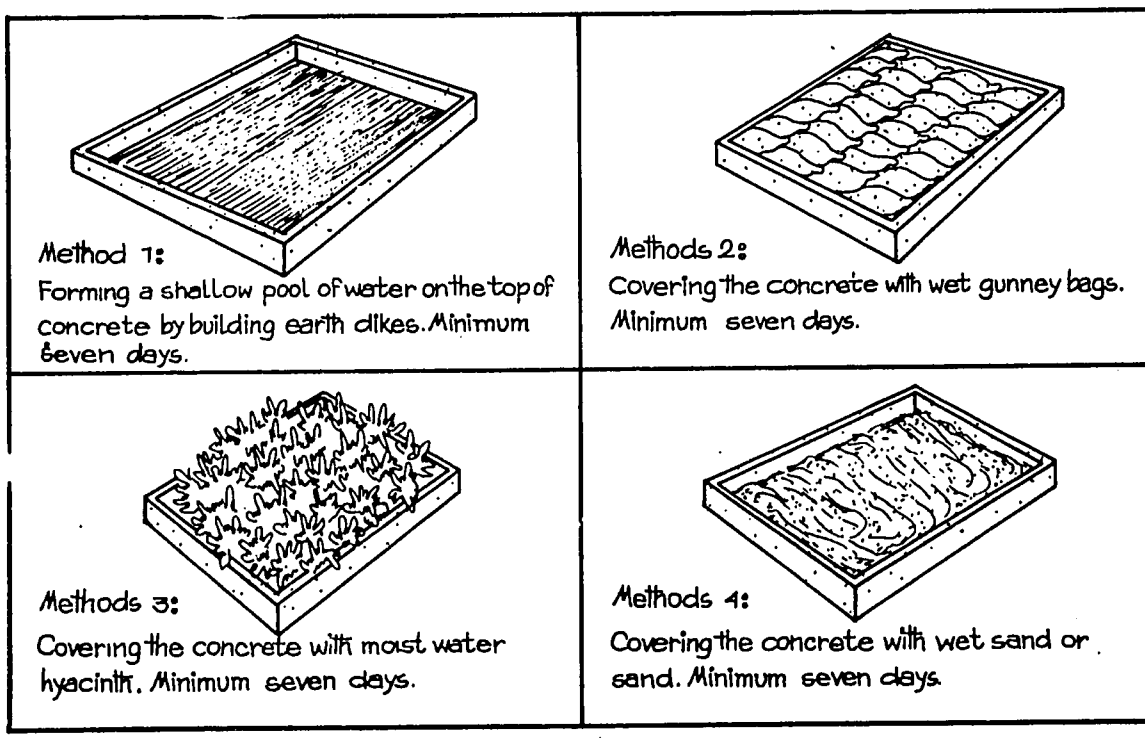


Fig. III-33 : Methods of Curing Concrete

9. Finishing Earthwork and Dress ng and Pitching the Sides.

For finishing, the eathwork should be evenly compacted using hand tampers or a roller. The earth should be slightly damp which permits the best and easiest compaction. If the soils is too dry, water should be added to obtain the above quality and if too wet, it should be allowed to dry in the sun. The earth should be spread evenly in 6" layers should be compacted to 4"

The sides of the earthwork should be protected from damage due to weather action or other sources by turfing or pitching with stones (see Section VII). If turfing is to be done, the outer layer of soil should consist of good soil and sand to promote the growth of grass.

SECTION IV

ASSESSMENT OF THE GIVEN FIELD CONDITIONS AND REQUIREMENTS AND SYNTHESIS OF THE FIELD DATA LEADING TO THE SELECTION OF AN APPROPRIATE DESIGN EXAMPLE.

1. Preliminary Investigation

Preliminary investigation involves the necessary project studies which will permit a sound analysis and conclusions with respect to the specific socio-economic justifications. These are primarily :

(a) Studies ensuring that the services proposed to be performed through the project is justifiable and the project is responsive to an urgent social and/or economic need.

(b) Studies ensuring that the project as proposed will adequately serve the intended purpose.

The studies are to be done through reconnaissance work involving observations and enquiries concerning the problems and needs of the communities, the physical factors involved namely geography of the terrain, the catchment area, its general slope, average and the lowest contours, performance of similar structures in the surrounding localities, availability and accessibility of construction materials and skills, the existing systems of transportation in the area and the present and future transportation requirements.

If the preliminary investigation shows that the project is justifiable and viable then detailed studies should be undertaken for the collection and assessment of all the relevant data, leading to the preparation of a programme for the project.

2. The detailed Study

The detailed study will concern the following :

(a) Establishing the location and alignment of the proposed structure.
(b) Field investigations of the soil conditions and strengths and recording of the information.
(c) Site surveying, measurements and recording of information.
(d) Synthesis of the field data leading to the selection of an appropriate design example Manual.

Establishing the location and alignment :

Step 1 : Procure a topographic map of the area showing the important featuree such as river-course, roads, agricultural land, swamps and important landmarks. If no such map is available, procure atleast the thana or 'mouza' map of the locality and mark the project site on it.

Step 2 : In the light of the locational considerations explained in the Section II of the Manual select a suitable location and alignment for the structure.

Step 3 : With spot measurements of distances and levels by taping and levelling as explained in Selection III of the manual, prepare a sketch map of the site as shown.

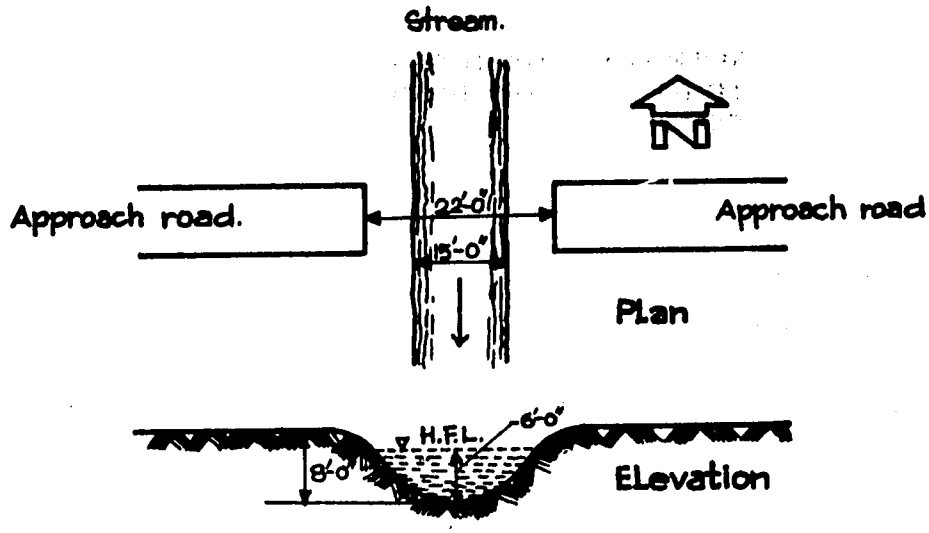


Fig. IV-1 : Sketch Map for Culvert or Bridge site

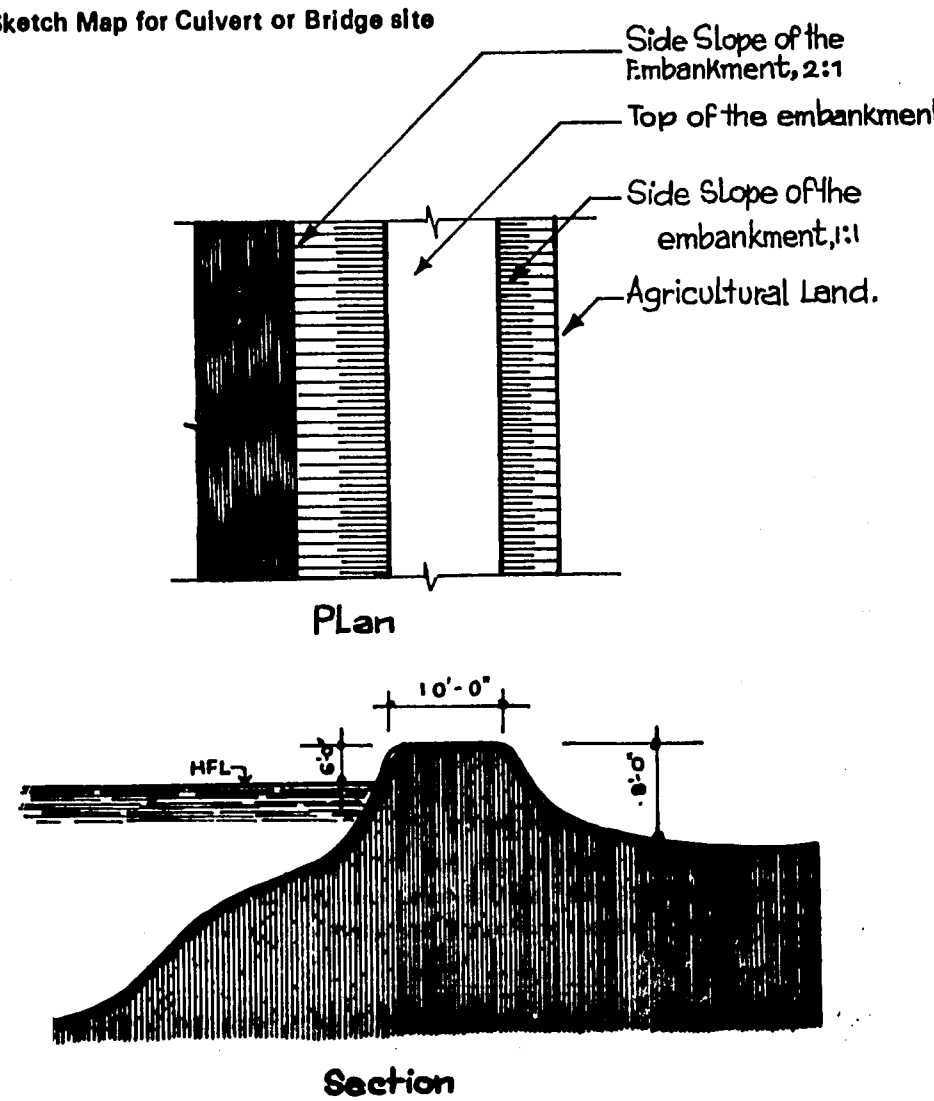


Fig. IV-2 : Sketch Map for Sluice way

Field Investigation of Soil Condition

Step 1 : Undertake surface exploration as explained in Section III of the manual and identify the soil types along the proposed alignment of the structure, particularly at the likely locations of the foundations for the structure.

Step 2 : From the visual detection of fault zones or geologic irregularities as well as from an estimation of the probable locations for foundations, mark on the sketch map the locations as L_1, L_2, L_3, and L_4 so on.

At the marked locations,

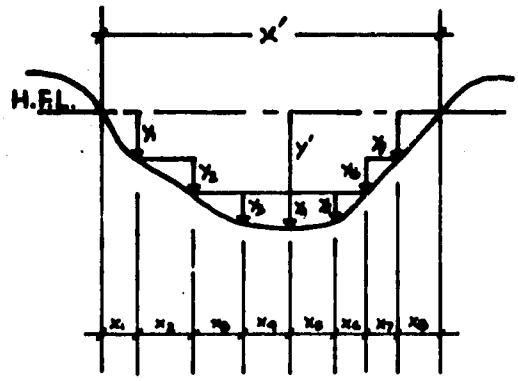
Step 3 : Undertake systematic sub-surface explorations as explained in Section III of the manual :

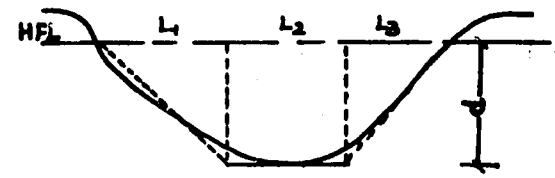
Step 4 : Record the results of the field investigation of soil conditions in a tabular form as shown below :

Locations	Depth in fest	Type of soil : Sand/Silt/Clay/gra organic.	Nature Compact Dry/wet Coarse	General assesment from Table III—2
L_1	0 5 10 15 20			
L_2	0 5 10 15 20			
L_3	0 5 10 15 20			
L_4	0 5 10 15 20			

Site Surveying and Measurement :

Step 1 : If the project is a culvert or a bridage,measure the channel section along the alignment by taping and levelling as explained on page 36 in Section III of the Manual and draw the section with measurements of distances and level as shown.





$$\text{Area } A = d\left(L_2 + \frac{L_1 + L_3}{2}\right)$$

Determine the area 'A' of the waterway at HFL by assuming an approximate trapezoidal section as shown in the figure above. Find highest flood discharge 'Q' by

$$Q = A \times 4 \text{ (for culverts)}$$

and $$Q = A \times 8 \text{ (for bridges)}$$

4 and 8 being the assumed peak velocities of flow in feet/sec. during flooding.

If the project is a sluiceway, estimate the area of the corresponding basin in acres with the help of the topo sheet and/or field observations and determine the peak runoff in cusec using the formula :

$$Q = C.i.A.$$

where Q = the peak Runoff volume of water in cusec.
i = rainfall intensity in inches per hour

(These intensities are not available for want of autographic rain gauges. At any rate, in the construction of various hydrological and hydraulic works, allowance should be made for intensities greater than 5 to 6 inches per hour)

A = estimated basin area in acres.
C = a runoff coefficient, 0.463 for the flat plains of Bangladesh.

Step 2 : If the project is a culvert or a bridge, determine the required size of the culvert or bridge opening for the waterway using the simplified formula or the practical rules discussed in the Section II of the Manual.

If the project is a sluiceway, determine the required size for each vent by dividing the value of 'Q' from the step 1 by the numbers of vents anticipated (usually 4-5) and then dividing this figure with 4, the assumed peak mean velocity through the vents. For example, if Q is equal 500 cusec and if 5 vents are anticipated, then

$\frac{500}{5 \times 4}$ = 25sq. ft. is the area of cross section of each vent.

3. Synthesis of the field data :

Case 1 : When the project is a culvert.

Step 1 : To select a suitable type of culvert, compare the estimated highest flood discharge 'Q' (cusec) with the table below :

Estimated highest flood discharge past the section of the stream	Recommended Type of culvert
1. Less than 30 cusec.	1. R. C. pipe culvert.
2. Between 30 and 150 cusec.	2. R. C. box culvert.
3. Between 150 and 300 cusec.	3. Open foundation culvert.

Step 2 : Having selected the type, compare the rest of the relevant field data with the probable combinations as tabulated below and arrive at an exact or close match leading to the selection of an appropriate design example from the Manual.

Type of culvert	Channel with at HFL	Maxm. channel depth a HFL	Approach roadway width	Soil condition for foundation	Reqd. area of opening for the waterway	Corresponding Design Example in the Manual
Brick Arch Culvert	3'-0" 5'-0" 8'-0"	5'-6" 5'-6" 7'-6"	12'-0" 12'-0" 12'-0"	Satisfactory Satisfactory Satisfactory	10 sq. ft. 20 sq. ft. 45 sq. ft.	C1 C2 C3
R. C. Pipe Culvert	5'-0" 5'-0"	3'-0" 3'-0"	24'-0" 24'-0"	Satisfactory Not so Satisfactory	8 sq. ft. 8 sq. ft.	C4 C5
R. C. Box Culvert	8'-0" 8'-0" 12'-0" 12'-0" 12'-0"	5'-0" 5'-0" 5'-0" 5'-0" 7'-0"	20'-0" 20'-0" 20'-0" 20'-0" 20'-0"	Satisfactory Not so Satisfactory Satisfactory Not so Satisfactory Satisfacrory	15 sq. ff. 15 sq. ft. 35 sq. ft. 35 sq. ft. 55 sq. ft.	C6 C7 C8 C9 C10
Open Foundation Culvert	15'-0" 15'-0"	7'-0" 7'-0"	20'-0" 20'-0"	Satisfactory Not so Satisfactory	120 sq. ft. 120 sq. ft.	C11 C12

Case II : When the project is a bridge.

Step 1 : To select a suitable type of bridge, compare the estimated highest flood discharge 'Q' (cusec) with the table below :

Estimated highest flood discharge past the section of the stream.	Recommended Type of bridge
1. Between 300 and 750 cusec.	1. R. C. slab bridge
2. Between 750 and 1700 cusec.	2. R. C. T-beam bridge.

Step 2 : Having selected the type, compare the rest of the relevant field data with probable combination as tabulated below and arrive at an exact or close match leading to the selection of an appropriate design example from the Manual.

Type of bridge	Channel width at HFL	Maxm. channel depth at HFL	Approach roadway width	Soil condition	Reqd. area of opening for waterway	Corresponding Design Example
R.C. Slab bridge	20'-0" 20'-0"	7'-6" 7'-6"	20'-0" 20'-0"	Satisfacy. Not so Satisfacy.	150 sq. ft. 150 sq. ft.	B1 B2
R.C. T-beam bridge	20'-0" 20'-0,,	7'-6" 7'-·6"	12'-0" 12'-0"	Satisfacy. Not so Satisfacy.	200 sq. ft. 200 sq. ft.	B3 B4
	20'-0" 20'-0"	7'-6" 7'-6"	20'-0" 20'-0"	Satisfacy. Not so Satisfacy.	200 sq. ft. 200 sq. ft.	B5 B6
	25'-0" 25'-0"	8'-0" 8'-0"	20'-0" 20'-0"	Satisfacy. Not so Satisfacy.	300 sq. ft. 300 sq. ft.	B7 B8
	30'-0" 30'-0"	8'-0" 8'-0"	20'-0" 20'-0"	Satisfacy. Not so Satisfacy.	400 sq. ft. 400 sq. ft.	B9 B10
	35'-0" 35'-0"	8'-0" 8'-0"	20'-0" 20'-0"	Satisfacy. Not so Satisfacy.	550 sq. ft. 550 sq. ft.	B11 B12
	40.0" 40-0"	10'-0" 10'-0"	20'-0" 20'-0"	Satisfacy. Not so Satisfacy.	700 sq. ft. 700 sq. ft.	B13 B14

Case III :-When the project is a sluice way.

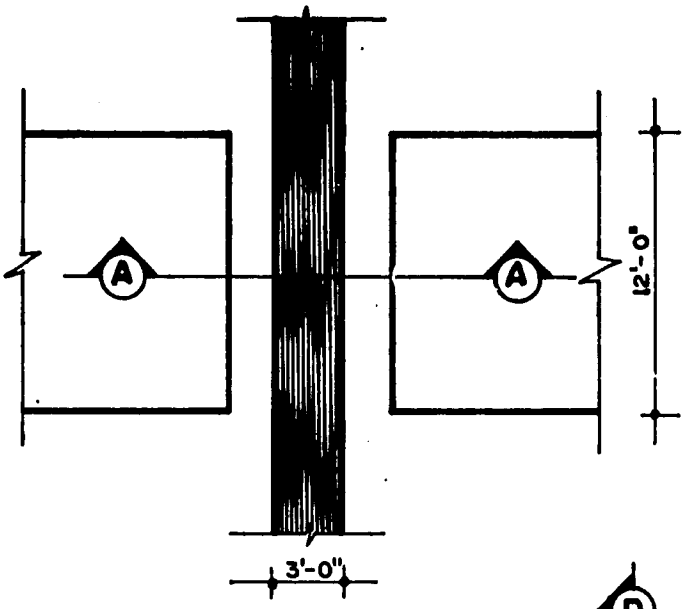
Step 1 : To select a suitable type of sluice, compare the estimated peak flow rate 'Q' (cusec) with the table below :

Estimated peak flow trhough each sluiceway	Recommended type for the sluiceway
1. Upto 30 cusec	1. R. C. Pipe vents
2. Between 30 and 60 cusec	2. R. C. box culvert type
3. Between 60 and 150 cusec	3. Open channel type

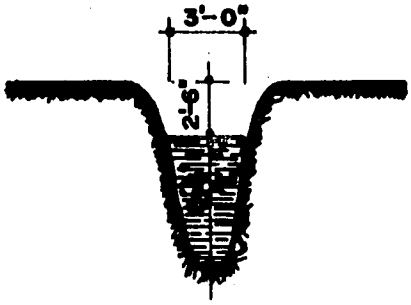
Note: For a total flow much higher than 30 cusec, upto 4 or 5 R. C. pipe vents can be used in parallel, the required number of vents being obtained by divididg the given peak flow by 30 and rounding off the resulting figure appropiately.

Step 2 : Having selected the type of the sluice, compare the rest of the relevant field data with the probable combinations tabulated below and arrive at an exact or close match leading to the selection of an appropriate design example from the Manual.

Type of Sluice	Span	Length	Height	Soil condition for foundation	Correspond design example in the Manual
R.C. Pipe Type	3'-0"	10'-0"	—	Satisfactory	S 1
R.C. box culvert type	4'-0"	10'-0"	—	Satisfactory	S 2
	5'-0"	10'-0"	8'-0"	Satisfactory	S 3
	5'-0"	10'-0"	9'-6"	Satisfactory	S 4
Multiple vent R.C. Pipe Type	3'-0"	10'-0"	—	Satisfactory	S 5



PLAN.
SCALE-1/8"=1'-0"



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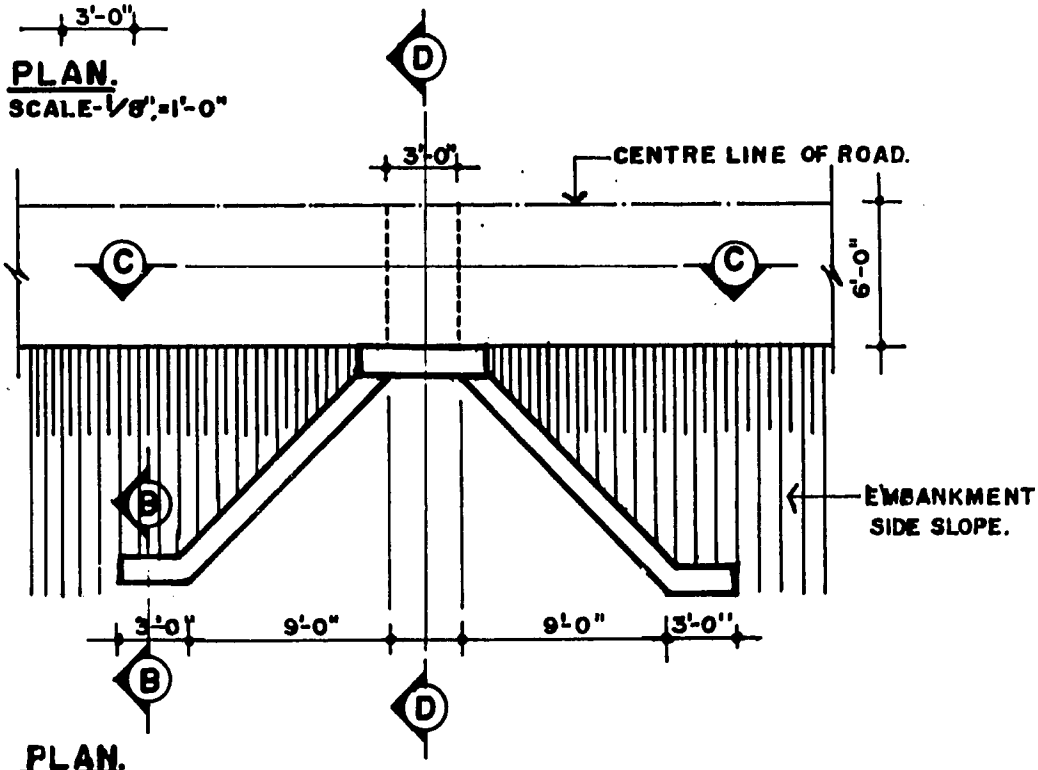
SCALE- 1/8"=1'-0"



PLAN.
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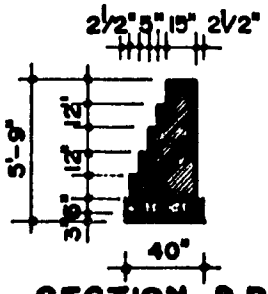
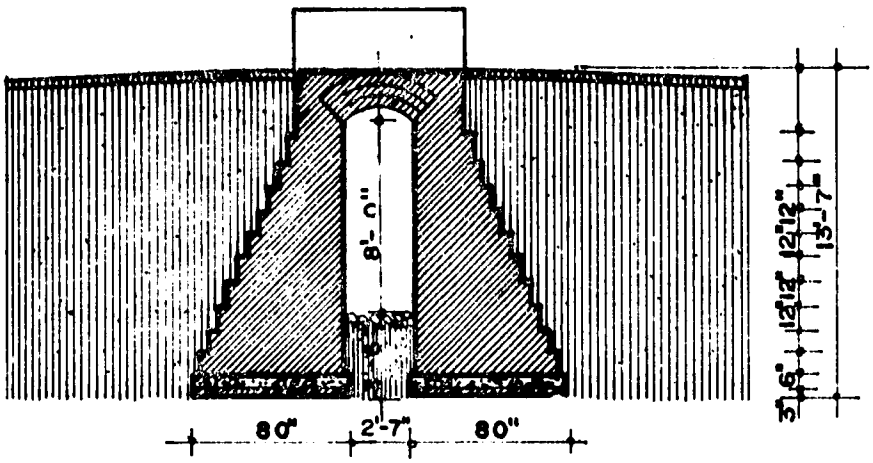
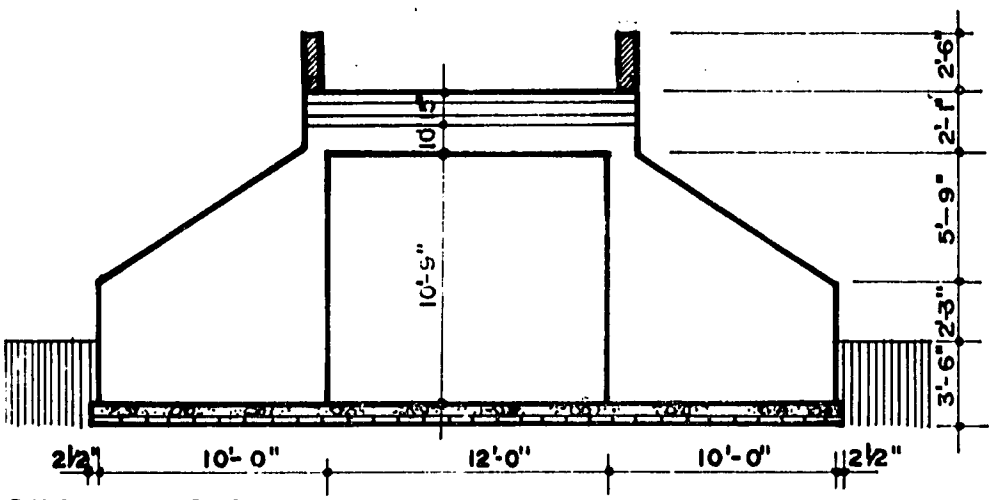


SECTION_B.B.
SCALE-1/8"=1'-0"

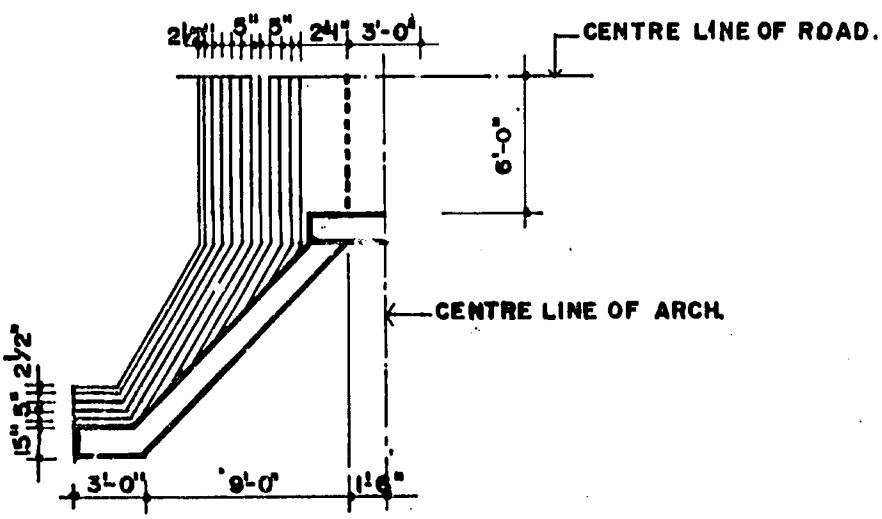
DESIGN EXAMPLE C-1



SECTION-C.C.
SCALE - 1/8" = 1'-0"



SECTION-D.D
SCALE - 1/8" = 1'-0"



PLAN
SCALE - 1/8" = 1'-0"

DESIGN EXAMPLE C - I

SPECIFICATIONS.

BRICK ARCH CULVERT

SPAN_ 3'-0"

ROAD WIDTH_ 12'-0"

SOIL CONDITION_ SATISFACTORY.

CHANNEL DEPTH_ 8'-0"

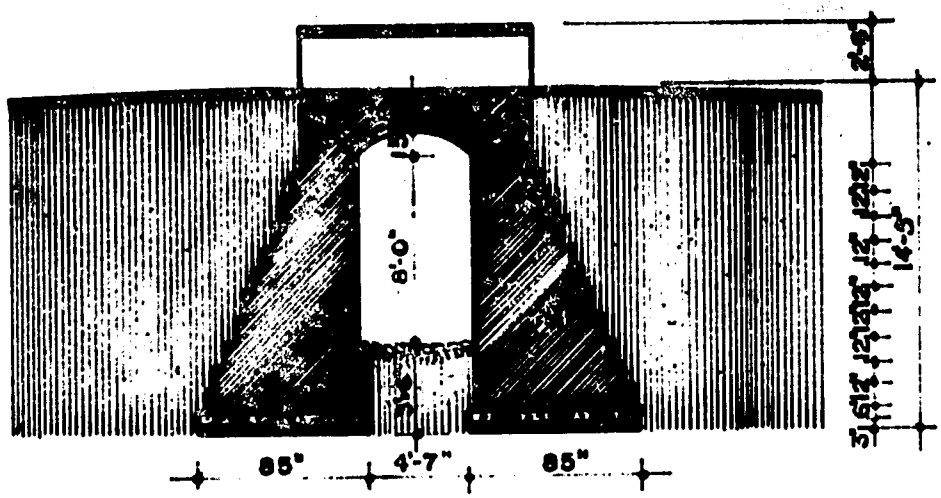
- 1ST. CLASS BRICKS.
- 1:4 MORTAR MIX FOR BRICKWORK.
- 1:3:6 MIX. FOR CEMENT CONCRETE.
- 1:2 MORTAR MIX. FOR POINTING.
- PROVIDE 5"X3" WEEPHOLES EVERY 5'-0" HORIZONTALLY AND VERTICALLY.

MATERIALS.

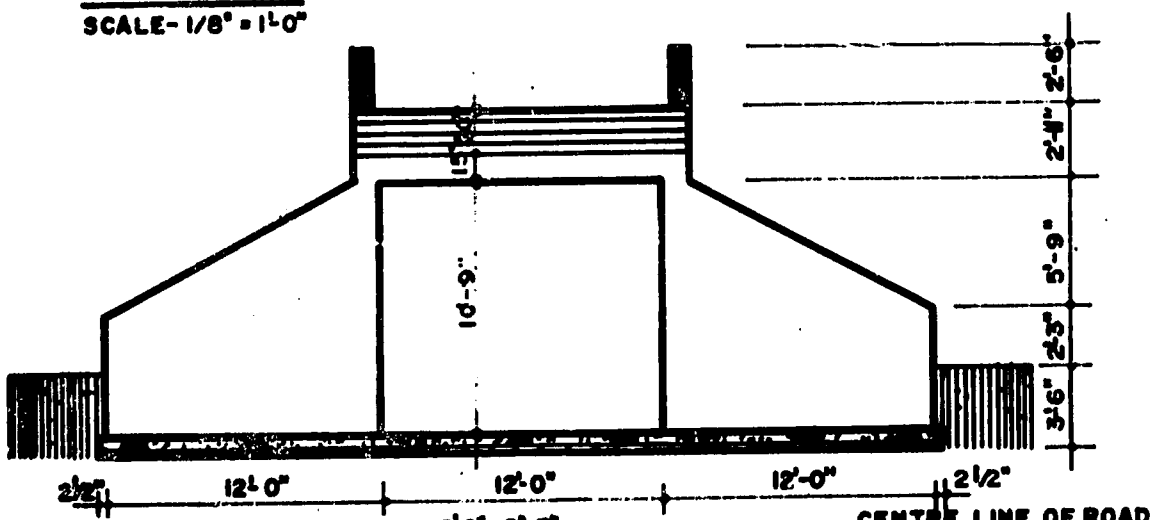
BRICK SOLING	CEMENT CONCRETE	BRICK ARCH MASONRY	BRICK WORK IN ABUTMENT	BRICK WORK IN WINGWALL	BRICK WORK IN RAILING	FLUSH POINTING
490 sft.	243 cft.	96 cft.	1440 cft.	840 cft.	48 cft.	770 sft.

NO OF BRICKS	SAND	CEMENT	KHOA
32385 Nos.	842 cft.	180 Bags.	220 cft.

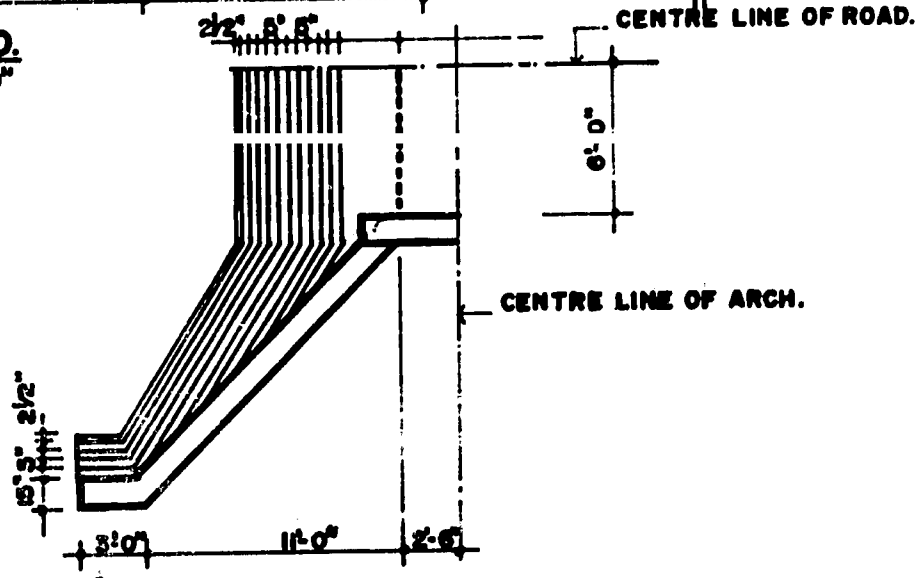
DESIGN EXAMPLE |C- 2|



SECTION_C.C.
SCALE- 1/8" = 1'-0"

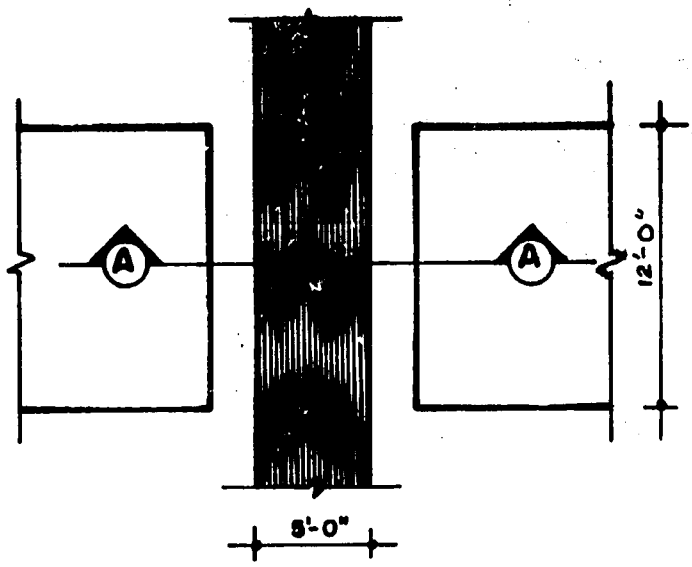


SECTION_D.D.
SCALE-1/8"= 1'-0"

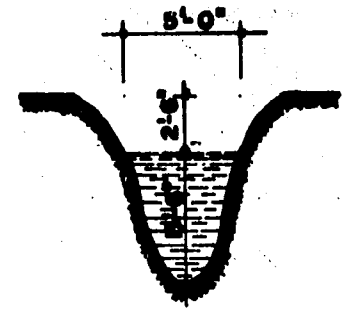


PLAN
SCALE-1/8"= 1'-0"

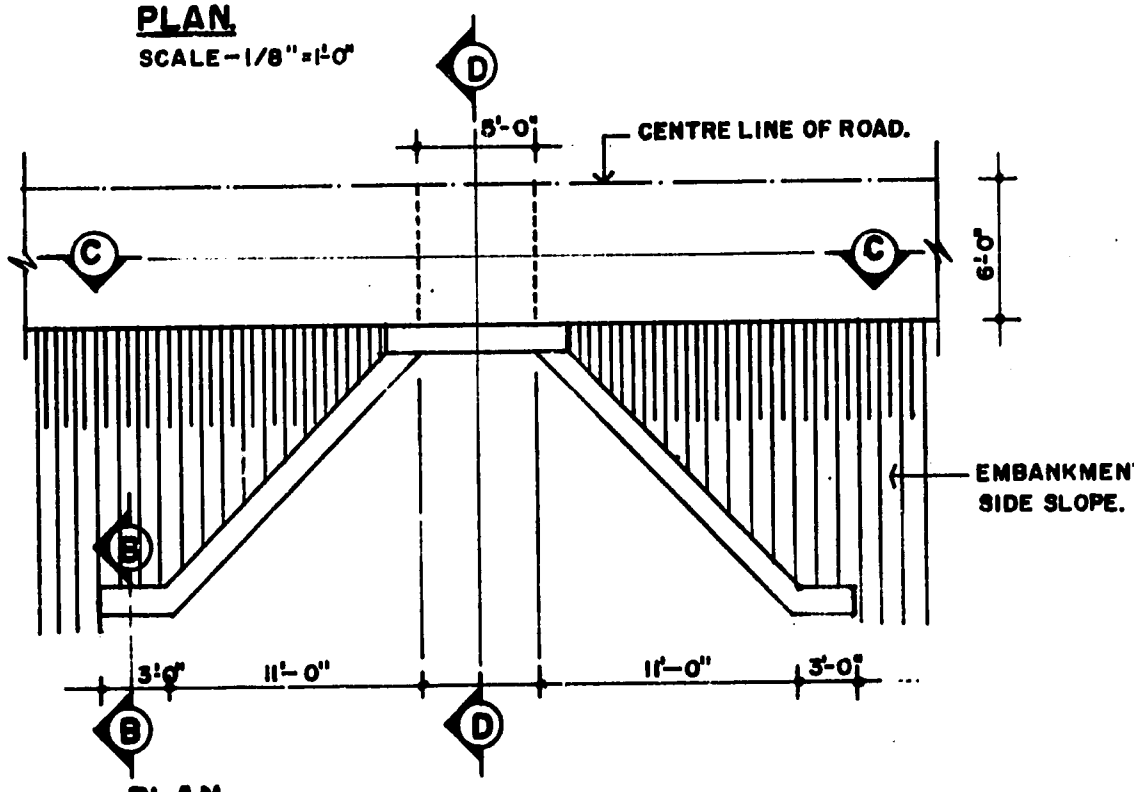
DESIGN EXAMPLE C-2



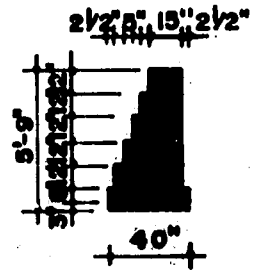
PLAN
SCALE-1/8"=1'-0"



SECTION A.A
SCALE-1/8"=1'-0"



PLAN
SCALE-1/8"=1'-0"



SECTION B.B
SCALE-1/8"=1'-0"

DESIGN EXAMPLE C-2

SPECIFICATIONS.

BRICK ARCH CULVERT

SPAN — 5'-0"

ROAD WIDTH — 12'-0"

SOIL CONDITION — SATISFACTORY.

CHANNEL DEPTH — 8'-0"

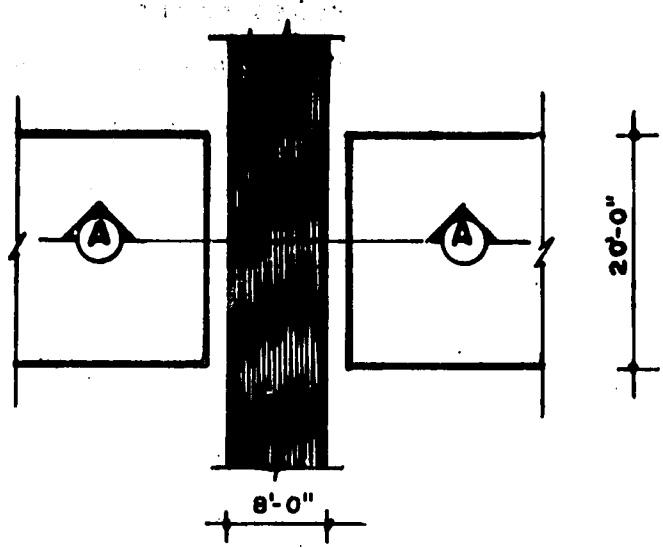
- 1ST. CLASS BRICKS
- 1:4 MORTAR MIX FOR BRICKWORK
- 1:3:6 MIX FOR CEMENT CONCRETE
- 1:2 MORTAR MIX FOR POINTING.
- PROVIDE 5"X3" WEEP HOLES EVERY 5'-0" HORIZONTALLY AND VERTICALLY.

MATERIALS.

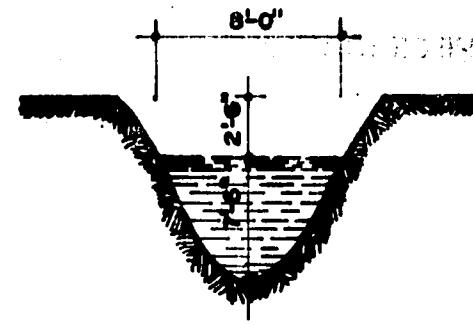
BRICK SOLING	CEMENT CONCRETE	BRICK ARCH MASONRY	BRICK WORK IN ABUTMENT	BRICK WORK IN WINGWALL	BRICK WORK IN RAILING	FLUSH POINTING
568 sft.	284 cft.	205 cft.	1654 cft.	1590 cft.	63 cft.	910 sft.

NO OF BRICKS.	SAND	CEMENT.	KHOA.
46024 Nos.	1300 cft.	259 Bags.	256 cft.

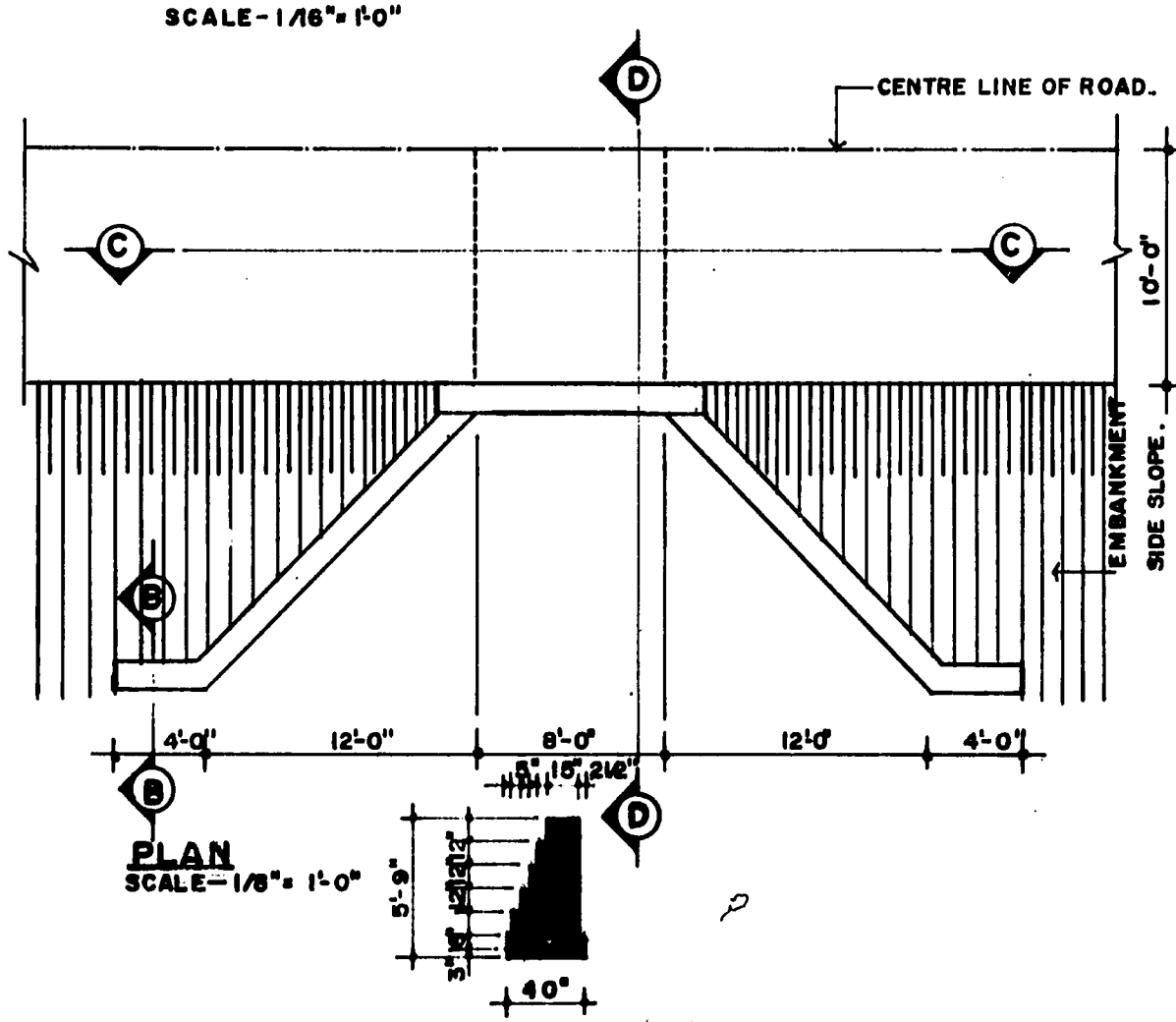
DESIGN EXAMPLE C-3



PLAN
SCALE-1/16"= 1'-0"



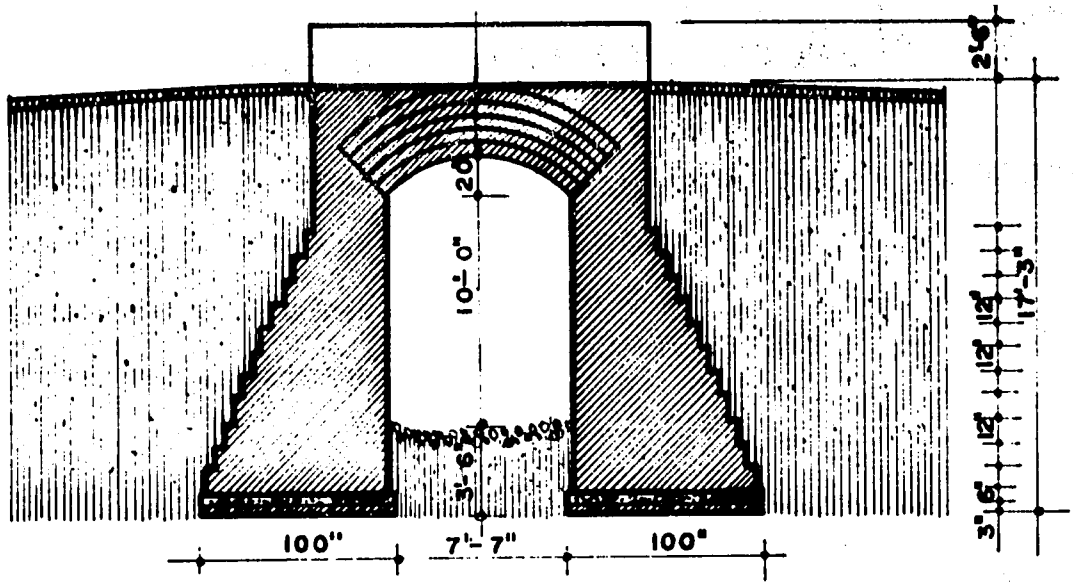
SECTION-A.A.
SCALE-1/8"= 1'-0"



PLAN
SCALE-1/8"= 1'-0"

SECTION-B.B.
SCALE-1/8"=1'-0"

DESIGN EXAMPLE C-3



SECTION-C.C.
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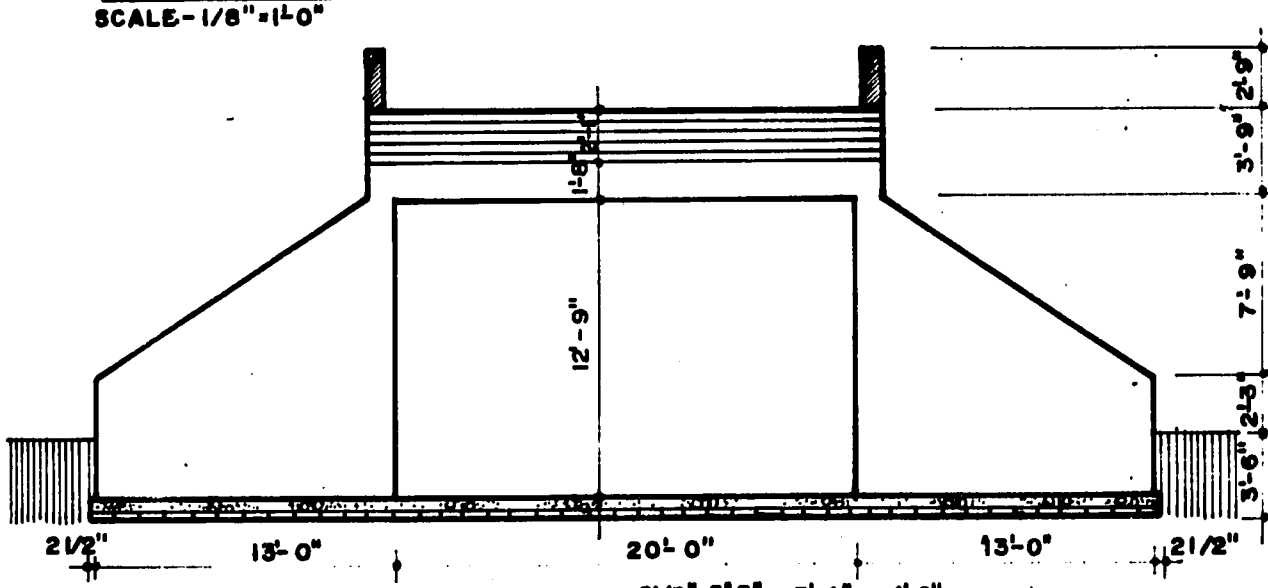
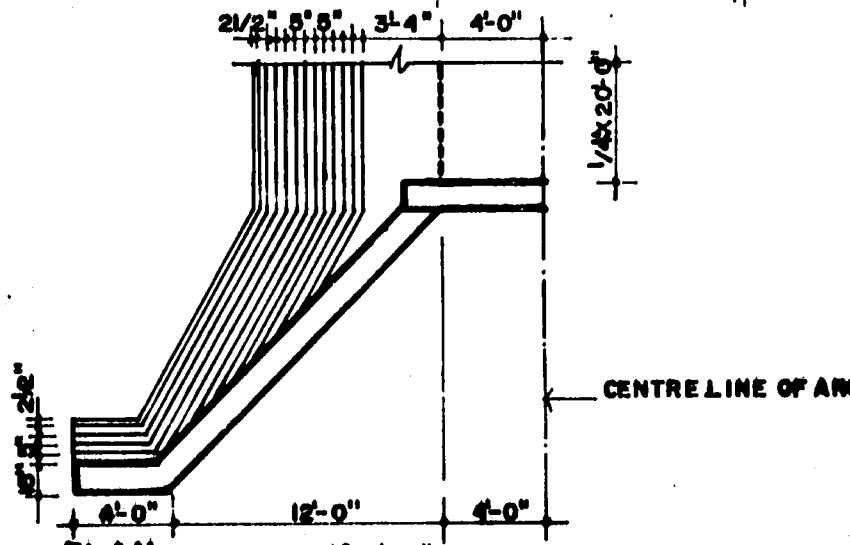


SECTION-D.D
SCALE-1/8"=1'-0"



PLAN. SCALE-1/8"=1'-0"

DESIGN EXAMPLE C-3

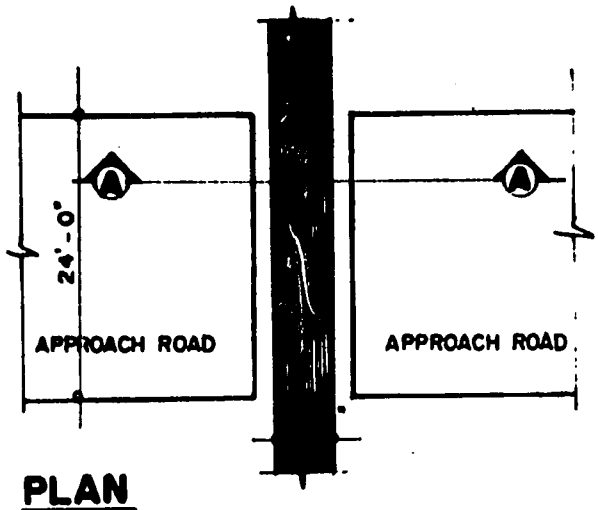
SPECIFICATIONS.	BRICK ARCH CULVERT. SPAN_ 8'-0" ROAD WIDTH_ 12'-0" SOIL CONDITION_ SATISFACTORY CHANNEL DEPTH_ 10'-0" ● 1ST CLASS BRICKS. ● 1:4 MORTAR MIX FOR BRICKWORK. ● 1:3:6 MIX FOR CEMENT CONCRETE. ● 1:2 MORTAR MIX FOR POINTING. ● PROVIDE 5"X3" WEEPHOLES EVERY 5'-0" HORIZONTALLY AND VERTICALLY.

MATERIALS

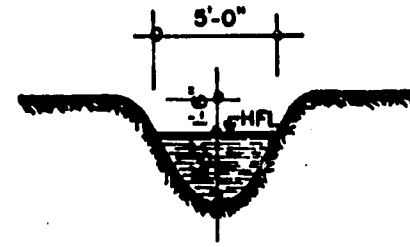
BRICK SOLING	CEMENT CONCRETE	BRICK ARCH MASONRY	BRICK WORK IN ABUTMENT	BRICK WORK IN WINGWALL	BRICK WORK IN RAILING	FLUSH POINTING
692 sft.	346 cft.	362 cft.	2126 cft.	1962 cft.	92 cft.	1250 sft.

NO OF BRICKS	SAND	CEMENT	KHOA.
60,324	1530 cft.	323 Bags	312 cft.

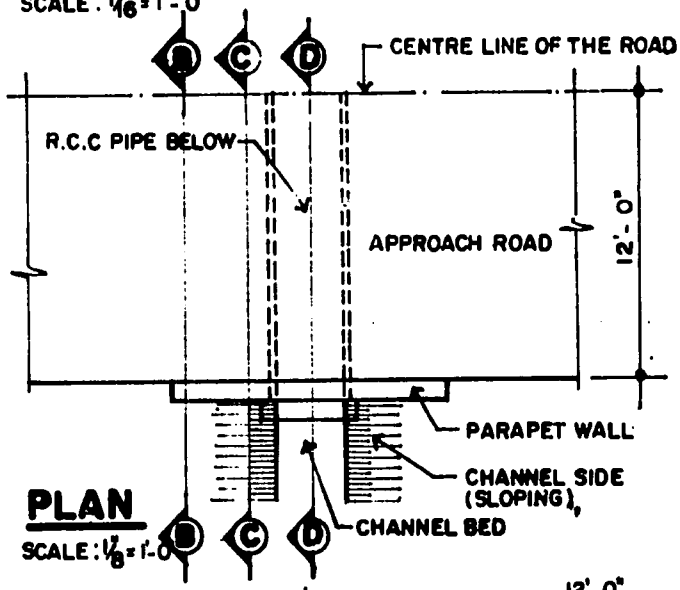
DESIGN EXAMPLE C - 4 R. C. Pipe Culverts



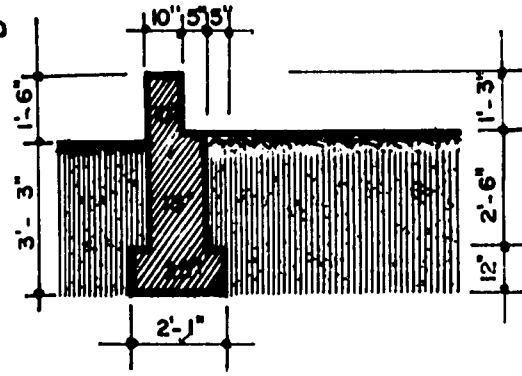
PLAN
SCALE : 1/16" = 1'-0"



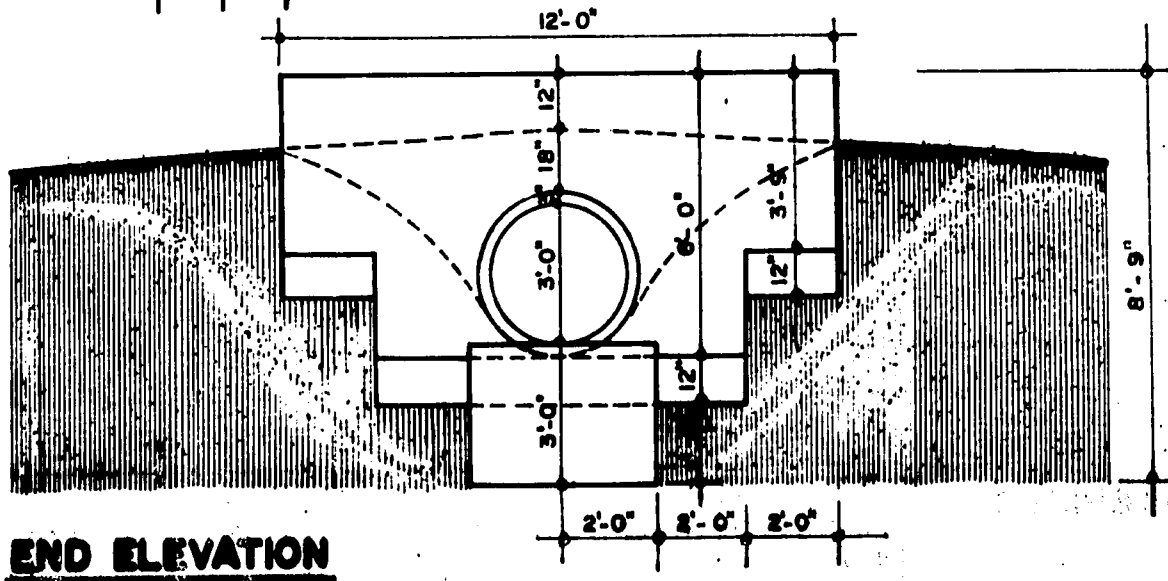
SECTION A-A
SCALE : 1/8" = 1'-0"



PLAN
SCALE : 1/8" = 1'-0"

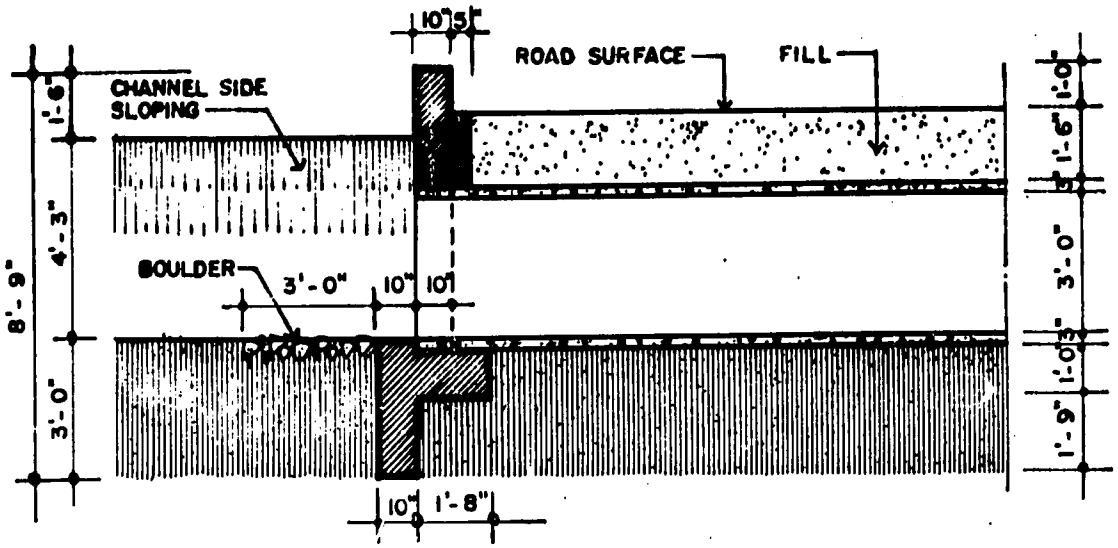


SECTION B-B
SCALE : 1/4" = 1'-0"



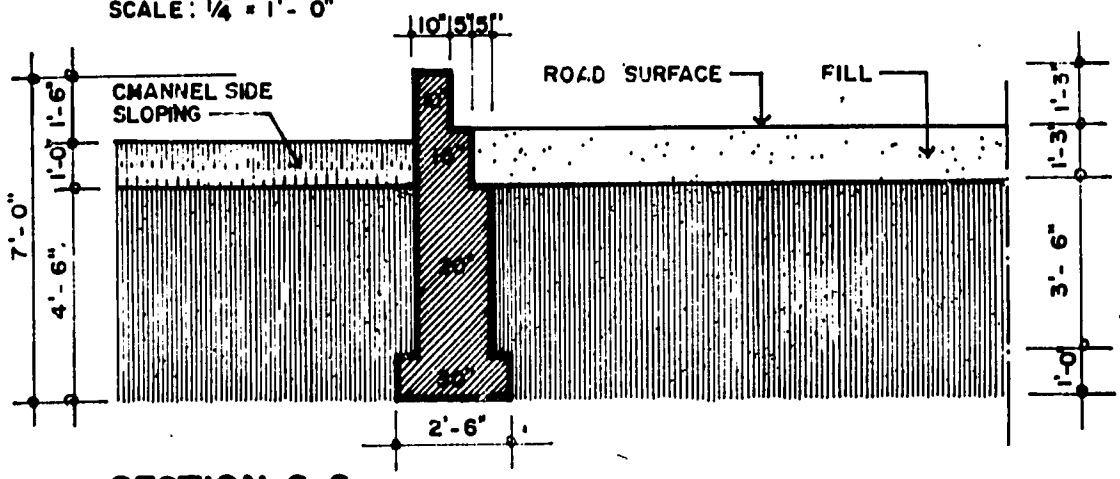
END ELEVATION
SCALE : 1/4" = 1'-0"

DESIGN EXAMPLE C - 4



SECTION D-D

SCALE : 1/4" = 1'- 0"



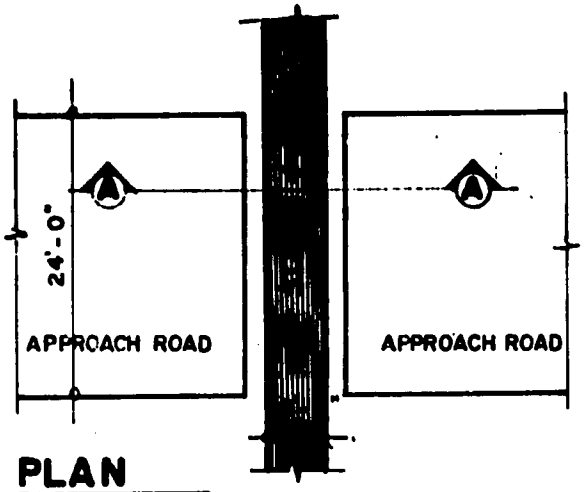
SECTION C-C

SCALE : 1/4" = 1'- 0"

SPECIFICATIONS	● STANDARD BELL AND SPIGOT JOINTS FOR R.C.C. PIPE SECTIONS ● IST. CLASS BRICKS ● 1 : 4 MORTAR MIX FOR BRICK WORK ● 1 : 3 MORTAR MIX FOR PLASTERING ALL EXPOSED BRICK WORK.

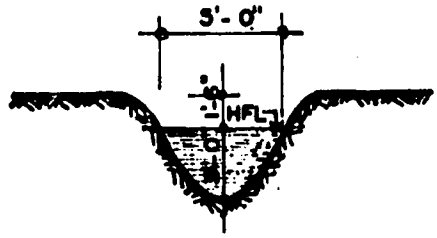
	R.C.C. PIPE	BRICKWORK	BRICKS	CEMENT	SAND	BOULDER	
MATERIALS	3'-0" DIA 6 PIECES EACH 4'-0" LONG	262 CFT.	3020 CFT.	18 BAGS	85 CFT.	50 CFT.	

DESIGN EXAMPLE C-5



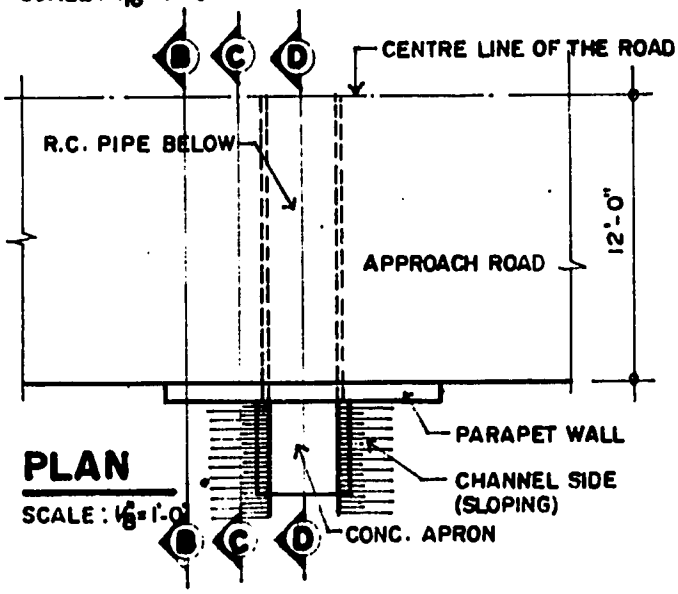
PLAN

SCALE : 1/16" = 1'-0"



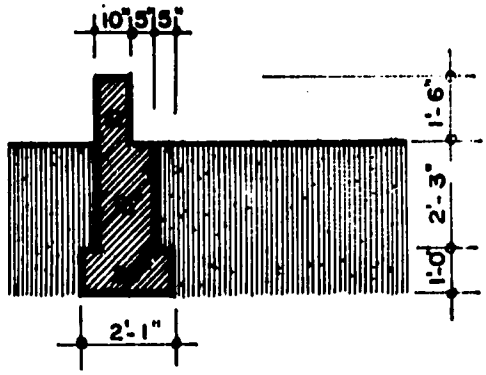
SECTION A-A

SCALE : 1/8" = 1'-0"



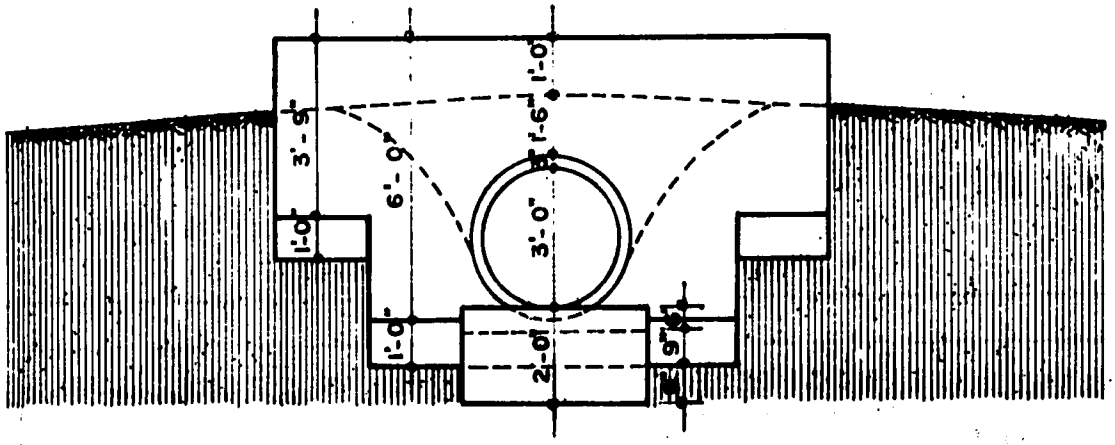
PLAN

SCALE : 1/8" = 1'-0"



SECTION B-B

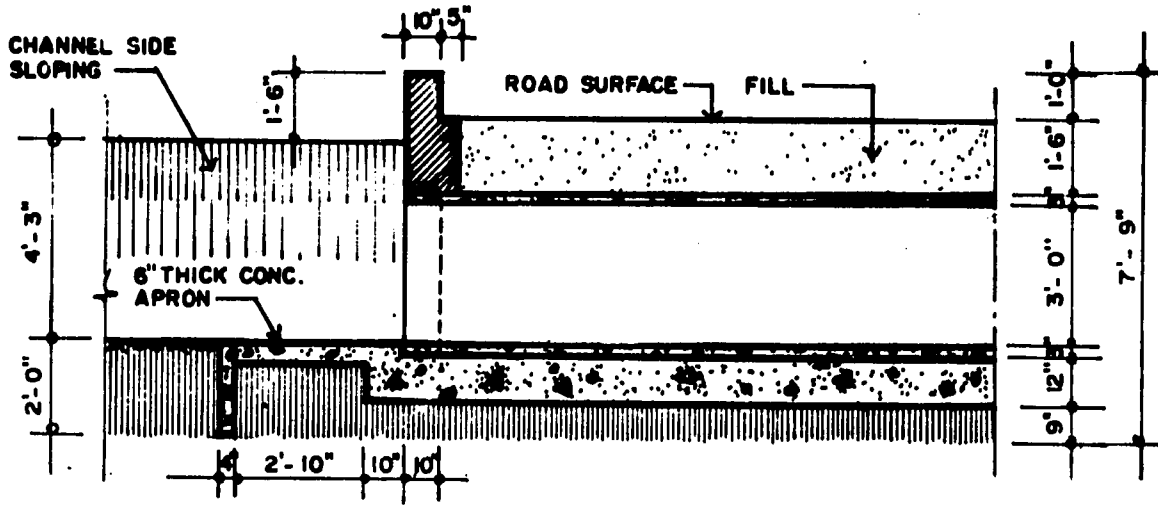
SCALE : 1/4" = 1'-0"



END ELEVATION

SCALE : 1/4" = 1'-0"

DESIGN EXAMPLE C-5



SECTION D-D

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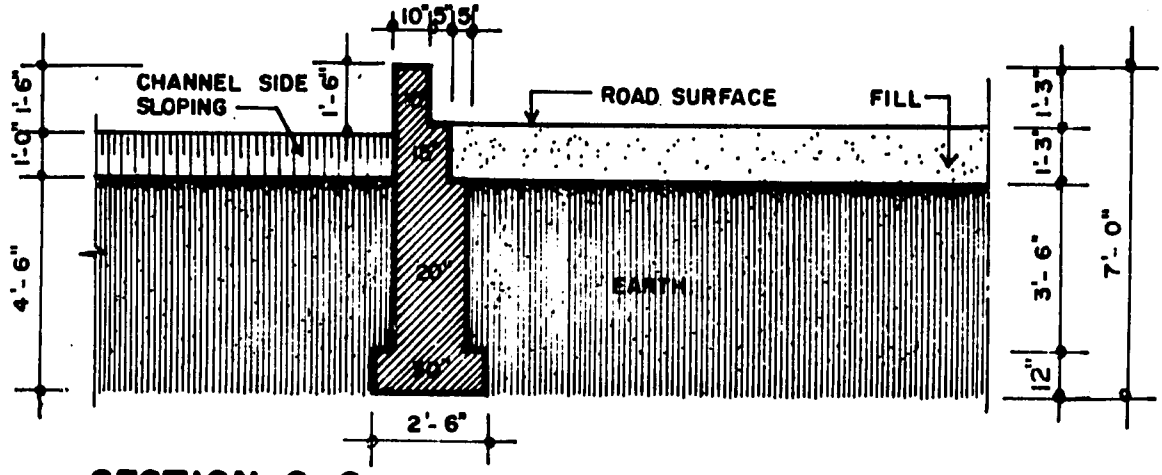


SECTION C-C

SCALE: 1/4" = 1'-0"

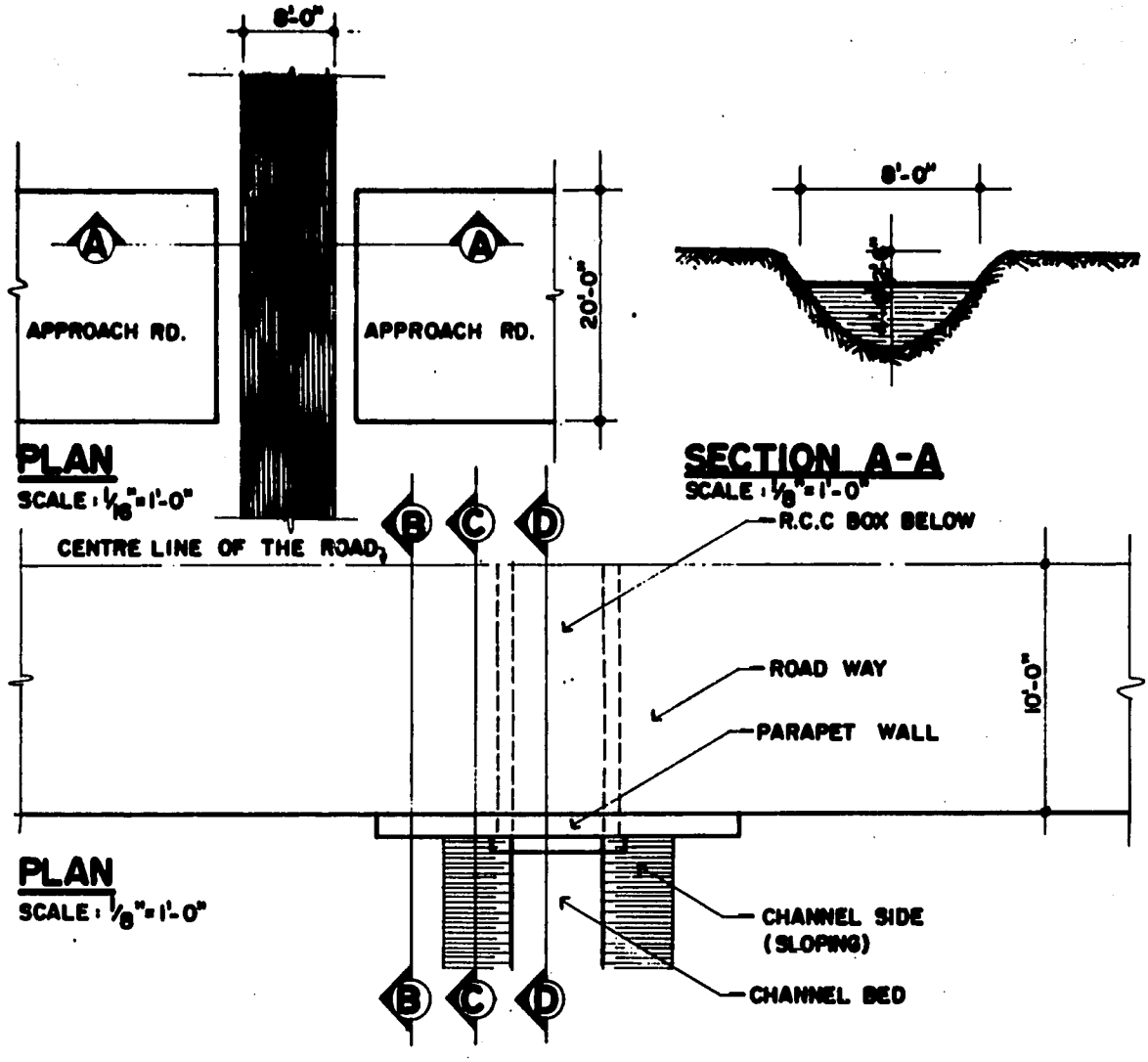
SPECIFICATIONS

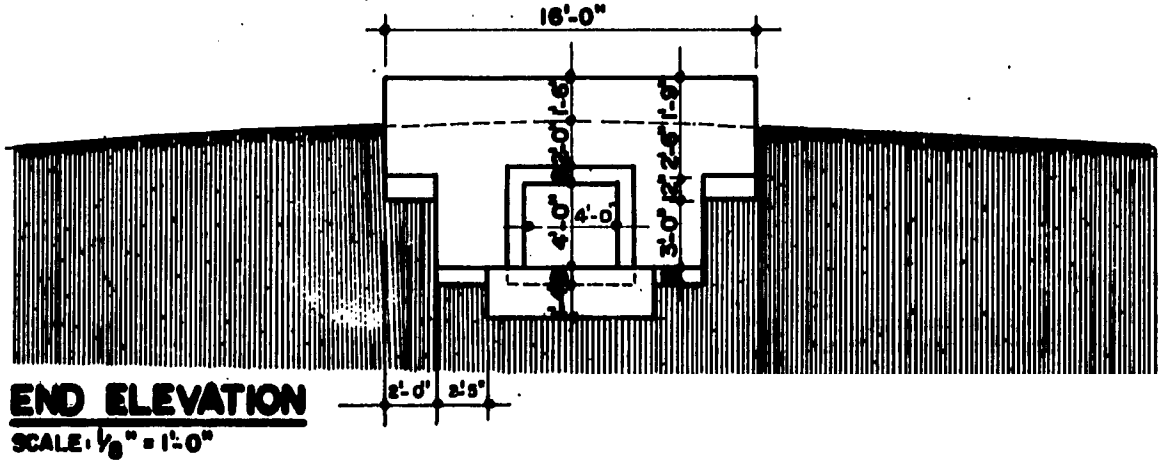
- STANDARD BELL AND SPIGOT JOINTS FOR R.C.C. PIPE SECTIONS
- IST. CLASS BRICKS
- 1:4 MORTAR MIX FOR BRICK WORK
- 1:3 MORTAR MIX FOR PLASTERING ALL EXPOSED BRICK WORK.
- 1:3:6 CONCRETE MIX.

MATERIALS

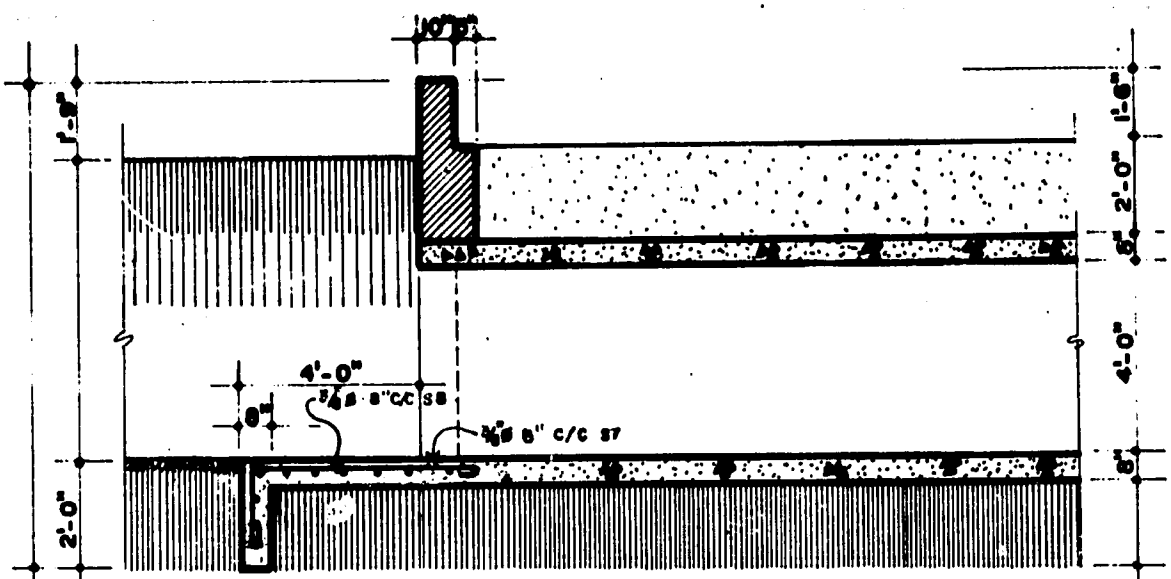
R.C.C. PIPE	BRICK WORK	CONC.WRK	BRICKS	CEMENT	SAND	KHOA
3'-0" DIA 6 PIECES EACH 4'-0" LONG	228 CFT.	126 CFT.	2630 NOS	32 BAGS	135 CFT.	117 CFT.

DESIGN EXAMPLE C-6 R. C. Box Culverts



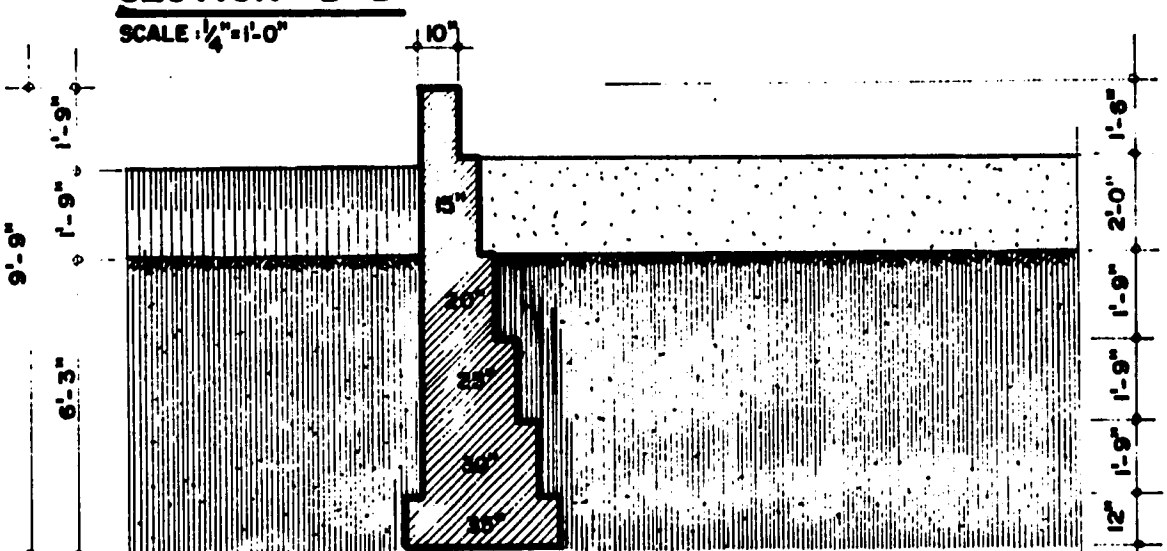


DESIGN EXAMPLE C-6



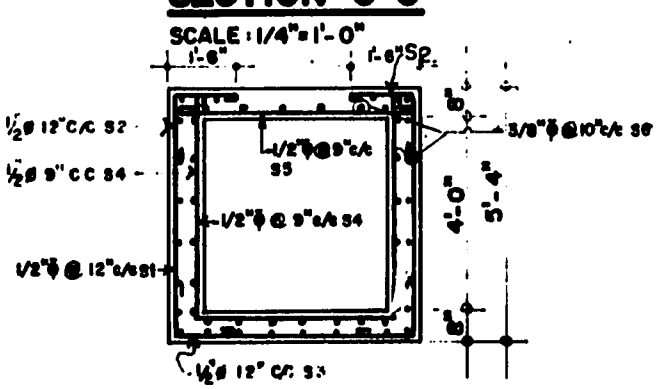
SECTION D-D

SCALE : 1/4" = 1'-0"



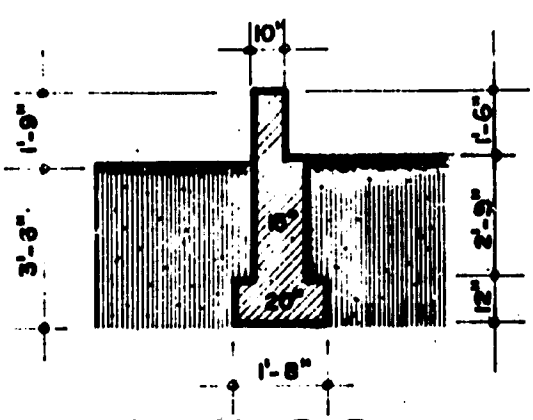
SECTION C-C

SCALE : 1/4" = 1'-0"



SECTION E-E

SCALE : 1/4" = 1'-0"



SECTION B-B

SCALE : 1/4" = 1'-0"

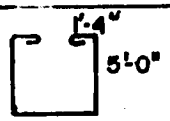
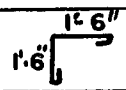
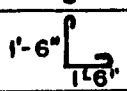
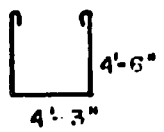
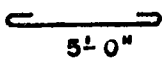
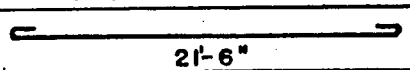
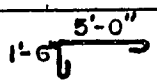
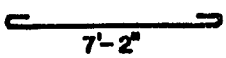
DESIGN EXAMPLE C-6

SPECIFICATIONS	CHANNEL WIDTH - 8'-0" CHANNEL DEPTH - 5'-0" ROADWAY WIDTH - 20'-0" AREA FOR THE WATERWAY - 25 sq.ft. ● IST. CLASS BRICKS. ● 1:4 MORTAR MIX. FOR BRICKWORK. ● 1:3 MORTAR MIX. FOR PLASTERING ALL EXPOSED BRICKWORK. ● 1:1½:3 MIX FOR REINFORCED CONCRETE WORK. ● 1:3:6 FOR CEMENT CONCRETE WORK.

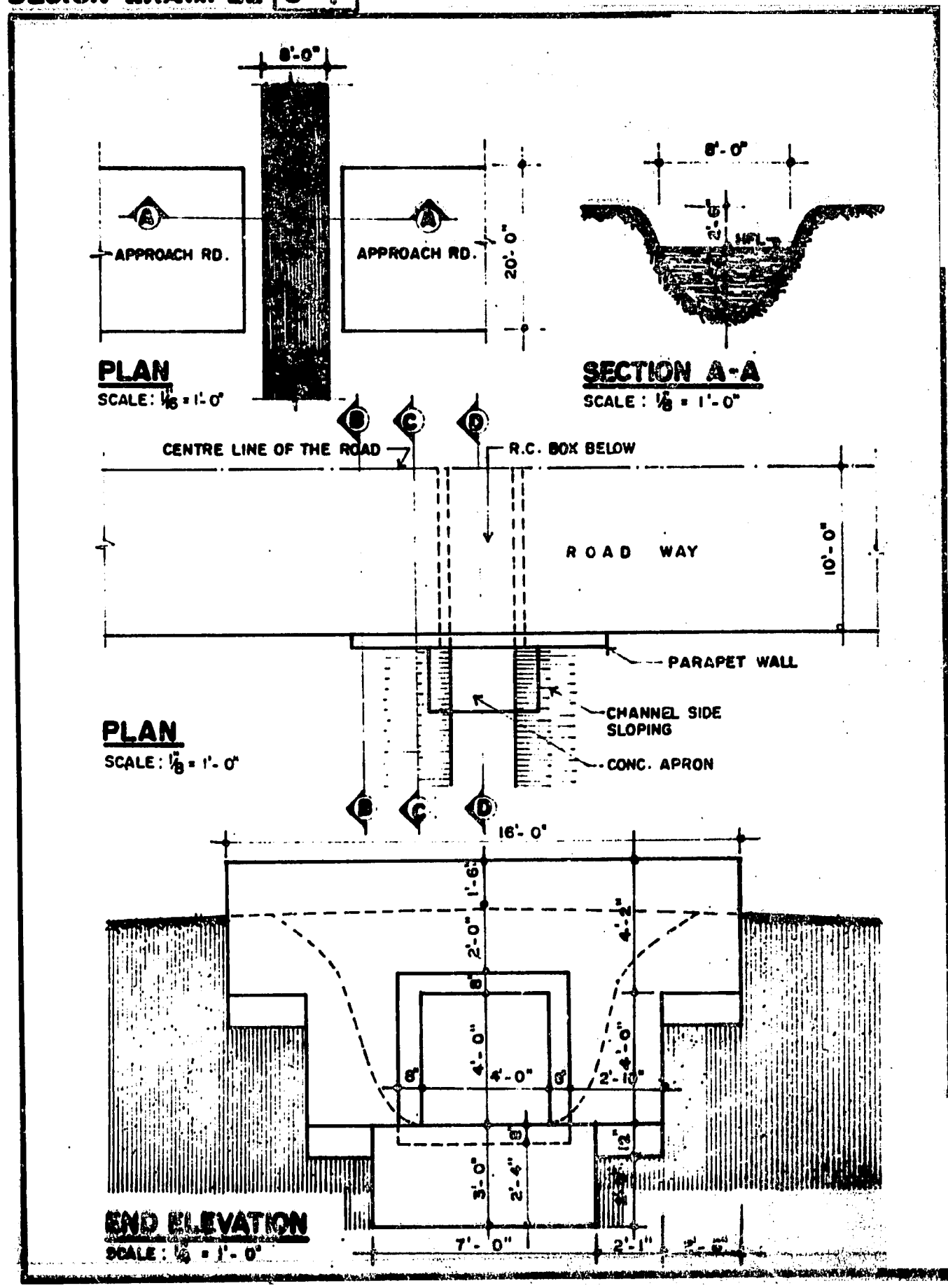
MATERIALS.

BRICK WORK.	CEMENT CONCRET.	BRICKS	CEMENT.	SAND.	KHOA.	M.S. RODS.
338 cft.	R.C.C. 314 cft.	3900 Nos	93 Bags	262 cft.	298 cft.	3/8" ø 483 # 1/2" ø 793 #

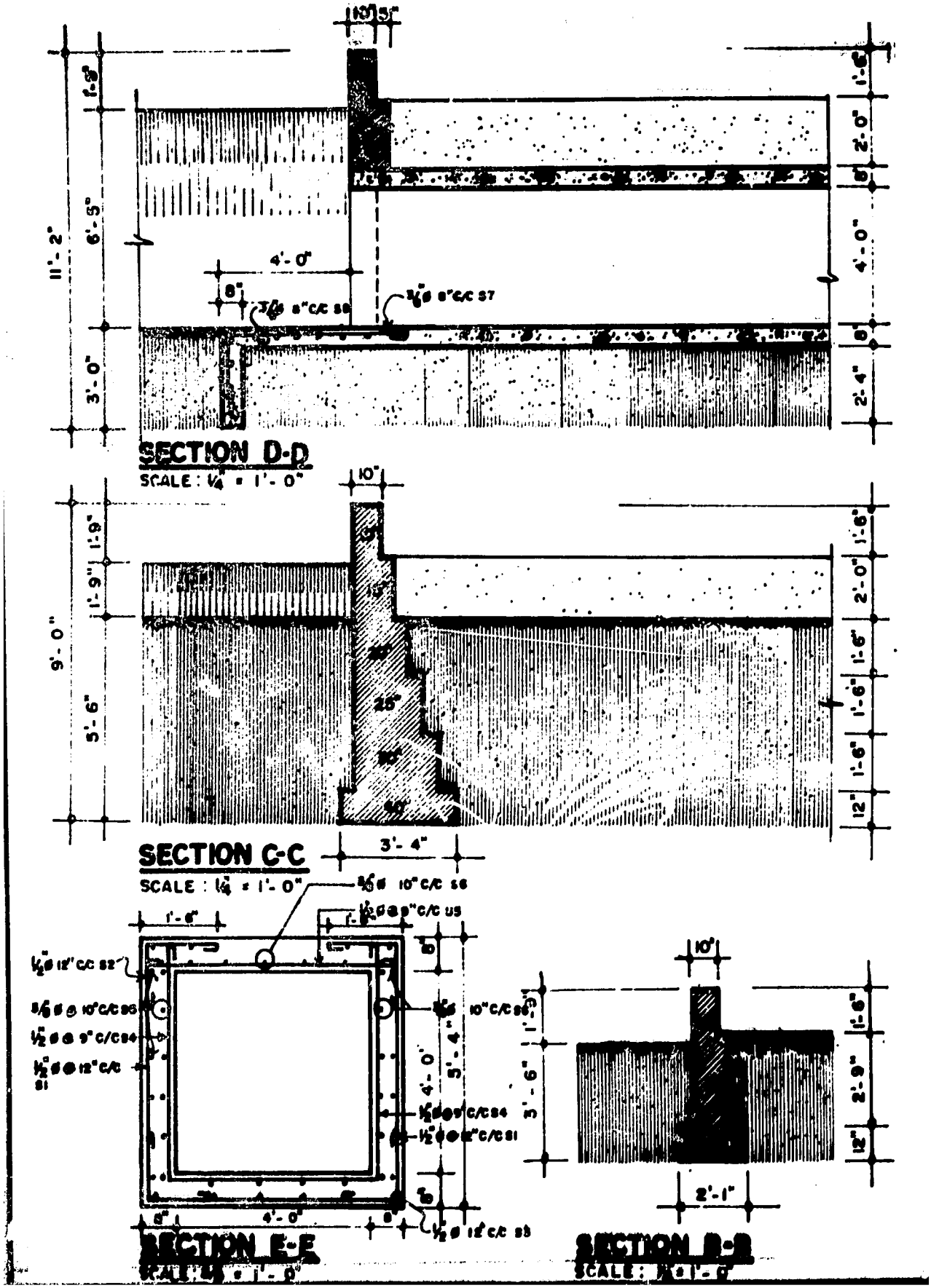
ROD BENDING SCHEDULE.

MARK	DIA	NOS.	LENGTH.	FINAL SHAPE.
S_1	1/2" ø	23	18'-8"	
S_2	1/2" ø	23	3'-8"	
S_3	1/2" ø	23	3'-8"	
S_4	1/2" ø	30	13'-11"	
S_5	1/2" ø	30	5'-8"	
S_6	3/8" ø	45	22'-0"	
S_7	3/8" ø	11X2	8'-0"	
S_8	3/8" ø	9X2	7'-8"	

DESIGN EXAMPLE C-7



DESIGN EXAMPLE C-7



DESIGN EXAMPLE C-7

SPECIFICATIONS

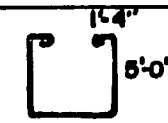
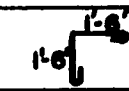
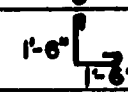
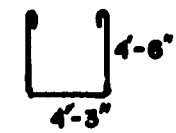
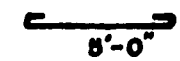
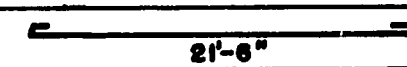
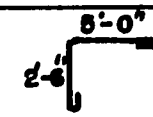
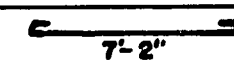
CHANNEL WIDTH - 8'-0"
CHANNEL DEPTH - 5'-0"
ROADWAY WIDTH - 20'-0"
SOIL CONDITION - NOT SO SATISFACTORY.
AREA FOR THE WATERWAY - 25 sq.ft.

- 1ST CLASS BRICKS.
- 1:4 MORTAR MIX FOR BRICKWORK.
- 1:3 MORTAR MIX FOR PLASTERING ALL EXPOSED BRICKWORK.
- 1:1½:3 MIX FOR REINFORCED CONCRETE WORK.
- 1:3:6 FOR CEMENT CONCRETE WORK

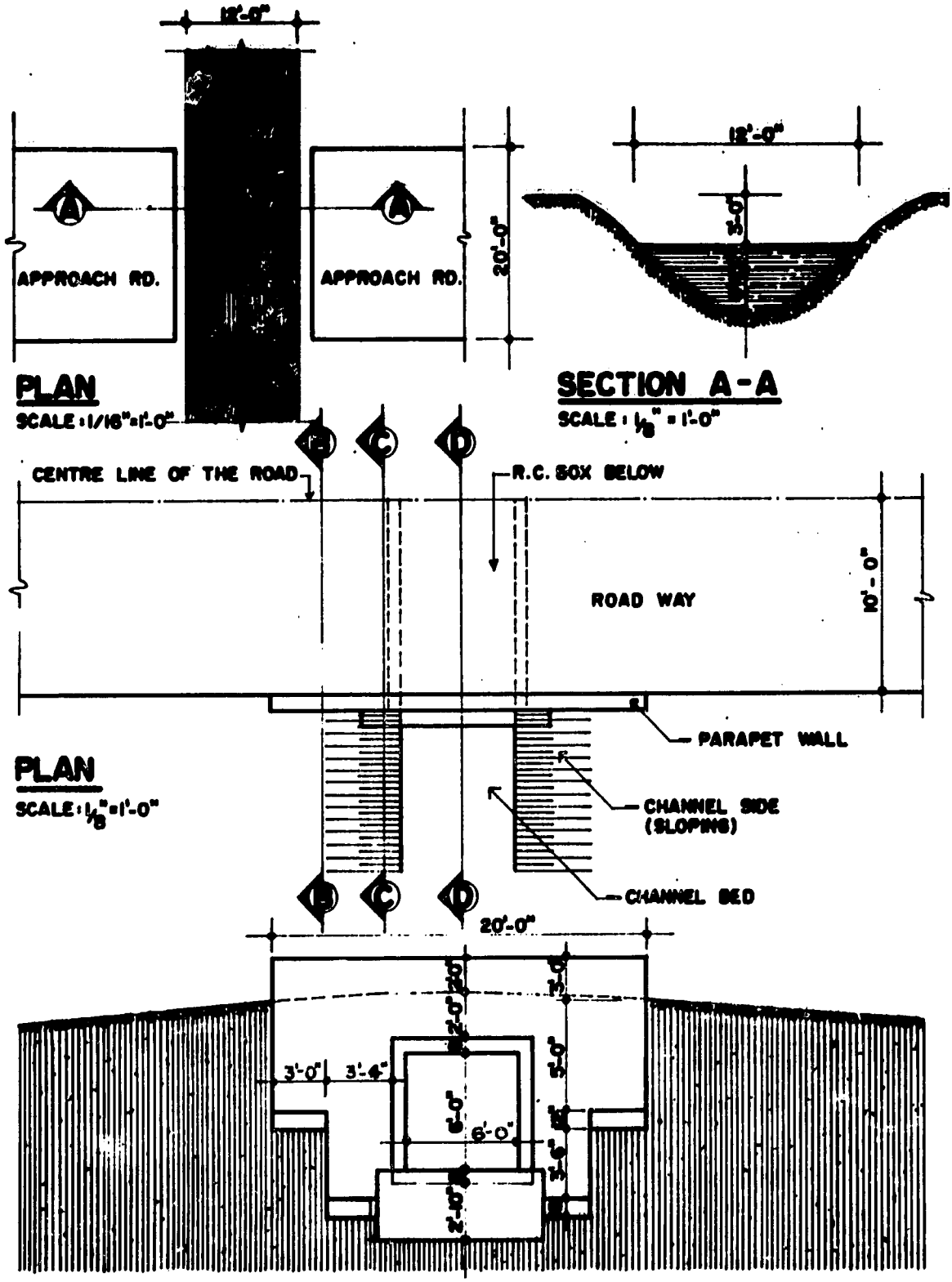
MATERIALS.

BRICK WORK.	C.CEMENT. CONCRETE	BRICKS	CEMENT	SAND	KHOA	M.S RODS.
306 cft.	C.C.324 cft.	3550 Nos	93 Bags	256 cft.	305 cft.	3/8" ϕ 504 # 1/2" ϕ 793 #

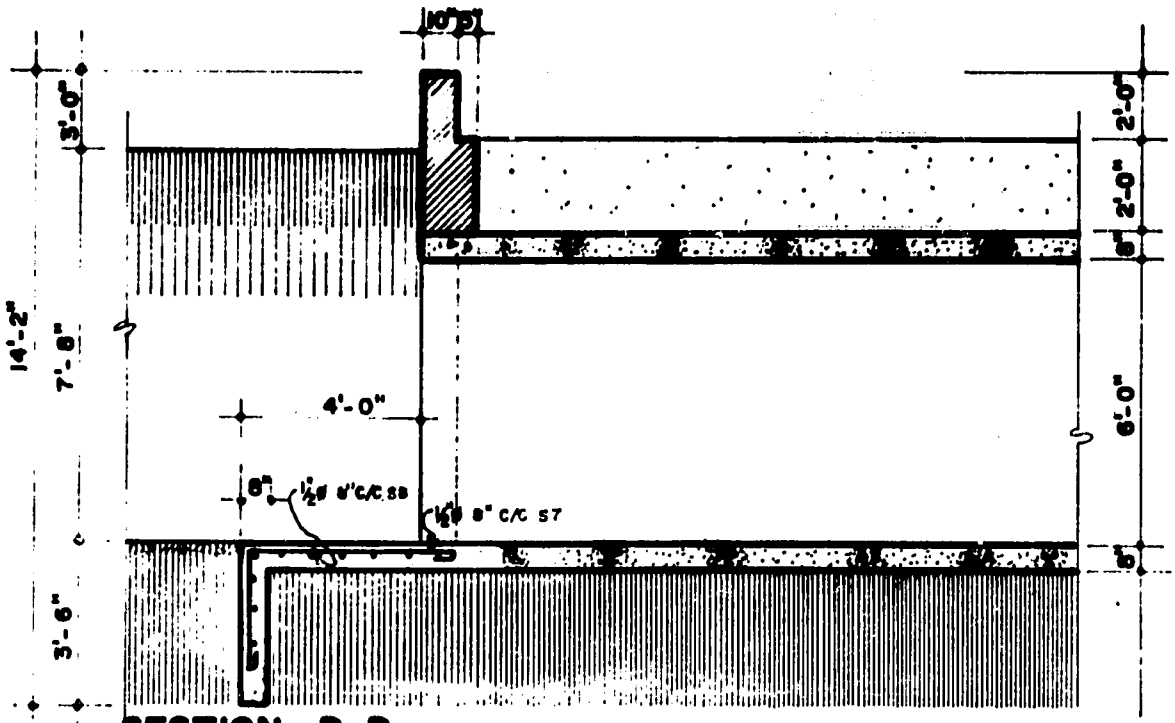
ROD BENDING SCHEDULE.

MARK	DIA.	NOS.	LENGTH	FINAL SHAPE.
S_1.	1/2" ϕ	23	18'-6"	
S_2	1/2" ϕ	23X2	3'-8"	
S_3	1/2" ϕ	23X2	3'-8"	
S_4	1/2" ϕ	30	13'-11"	
S_5	1/2" ϕ	30	5'-8"	
S_6	3/8" ϕ	45	22'-0"	
S_7.	3/8" ϕ	11X2	8'-0"	
S_8.	3/8" ϕ	11X2	7'-8"	

DESIGN EXAMPLE C-8

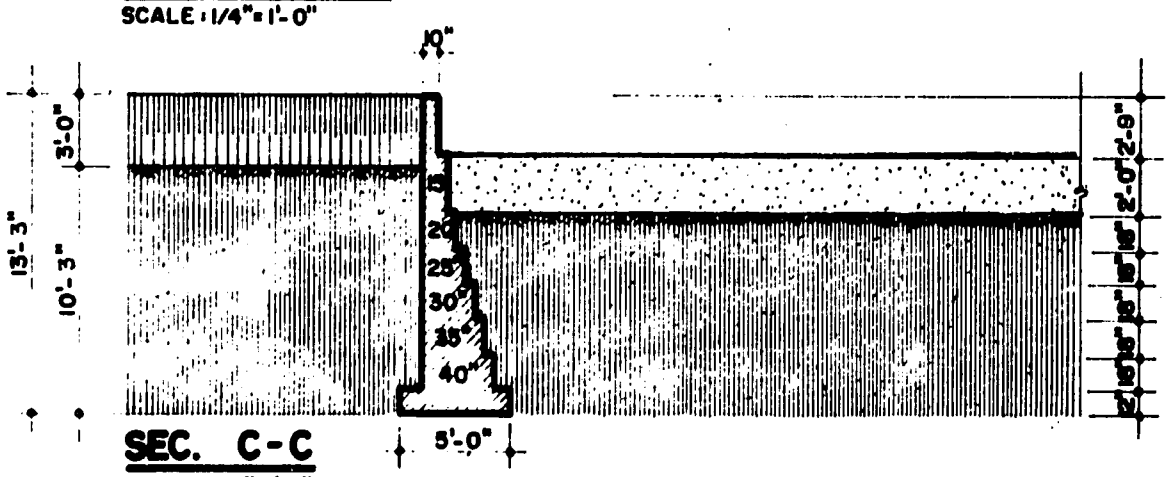


DESIGN EXAMPLE C-8



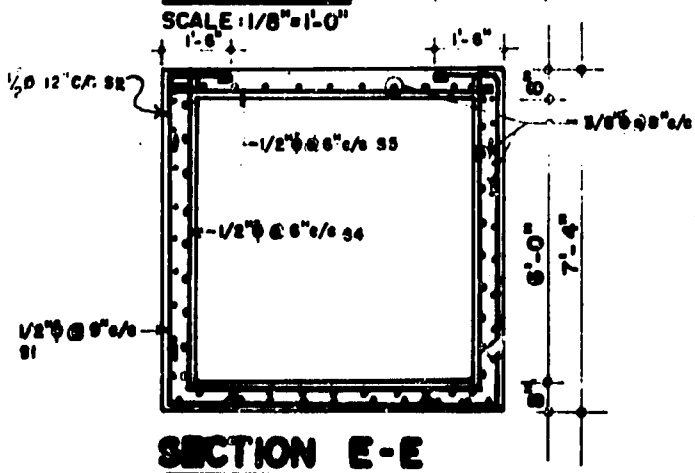
SECTION D-D

SCALE : 1/4" = 1'-0"



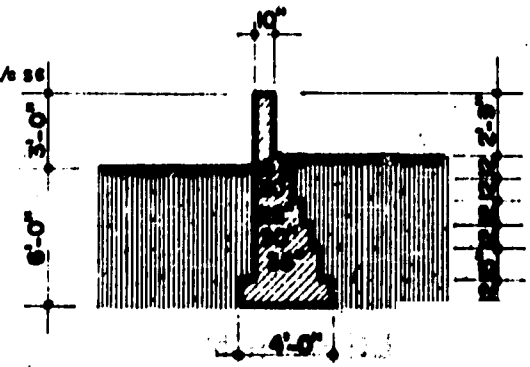
SEC. C-C

SCALE : 1/8" = 1'-0"



SECTION E-E

SCALE : 1/4" = 1'-0"



SECTION B-B

SCALE : 1/8" = 1'-0"

DESIGN EXAMPLE C - 8

SPECIFCATIONS.

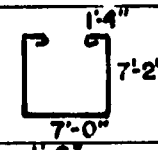
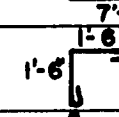
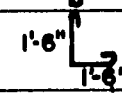
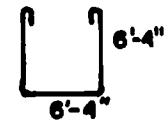
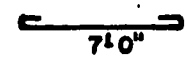
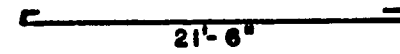
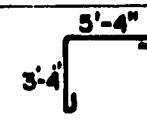
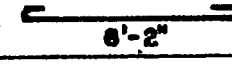
CHANNEL WIDTH - 12'-0"
CHANNEL DEPTH - 6'-0"
ROADWAY WIDTH - 20'-0"
SOIL CONDITION - SATISFACTORY.
AREA OF THE WATERWAY - 36'-0"

- IST CLASS BRICKS.
- 1:4 MORTAR MIX FOR BRICKWORK.
- 1:3 MORTAR MIX. FOR PLASTERING ALL EXPOSED BRICKWORK.
- 1:1½:3 MIX FOR REINFORCED CONCRETE WORK.
- 1:3:6 MIX FOR CEMENT CONCRETE WORK.

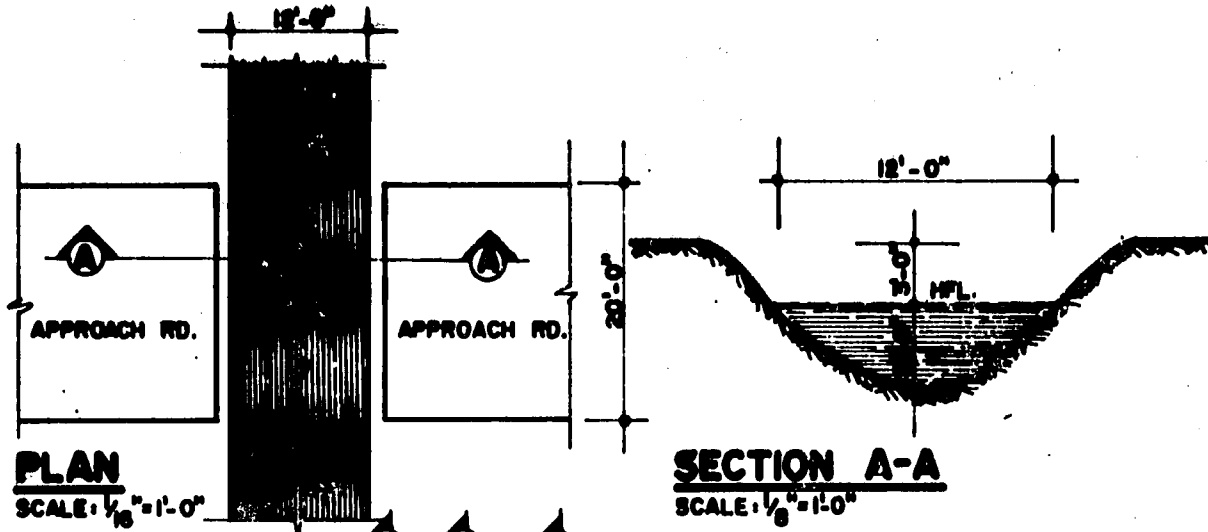
MATERIALS.

BRICK WORK.	CEMENT CONCRETE.	BRICKS	CEMENT.	SAND	KHOA	STONE CHIPS.	M.S. RODS.
619 cft.	R.C.C. 476 cft.	7130 Nos.	14 Bags	435 cft.	450 cft.		3/8" ø 637 # 1/2" ø 1275 #

ROD BENDING SCHEDULE.

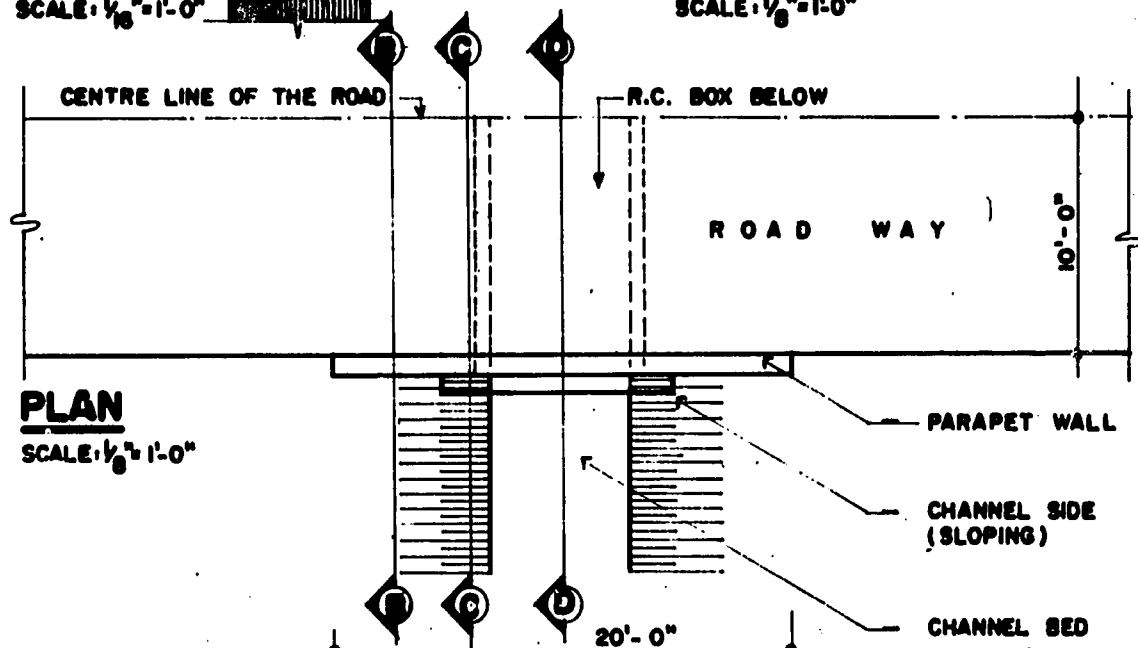
MARK	DIA.	NOS.	LENGTH.	FINAL SHAPE.
S_1	1/2" ø	23	24'-8"	
S_2	1/2" ø	23X2	3'-8"	
S_3	1/2" ø	23X2	3'-8"	
S_4	1/2" ø	34.	19'-8"	
S_5	1/2" ø	44	7'-8"	
S_6	3/8" ø	65	22'-0"	
S_7	3/8" ø	16	8'-10"	
S_8	3/8" ø	14	8'-8"	

DESIGN EXAMPLE C-9

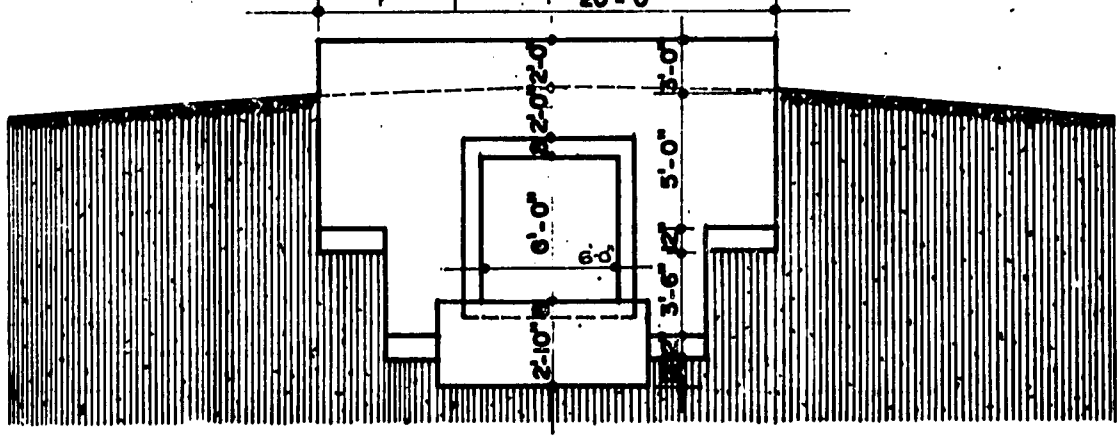


PLAN
SCALE: 1/16" = 1'-0"

SECTION A-A
SCALE: 1/8" = 1'-0"

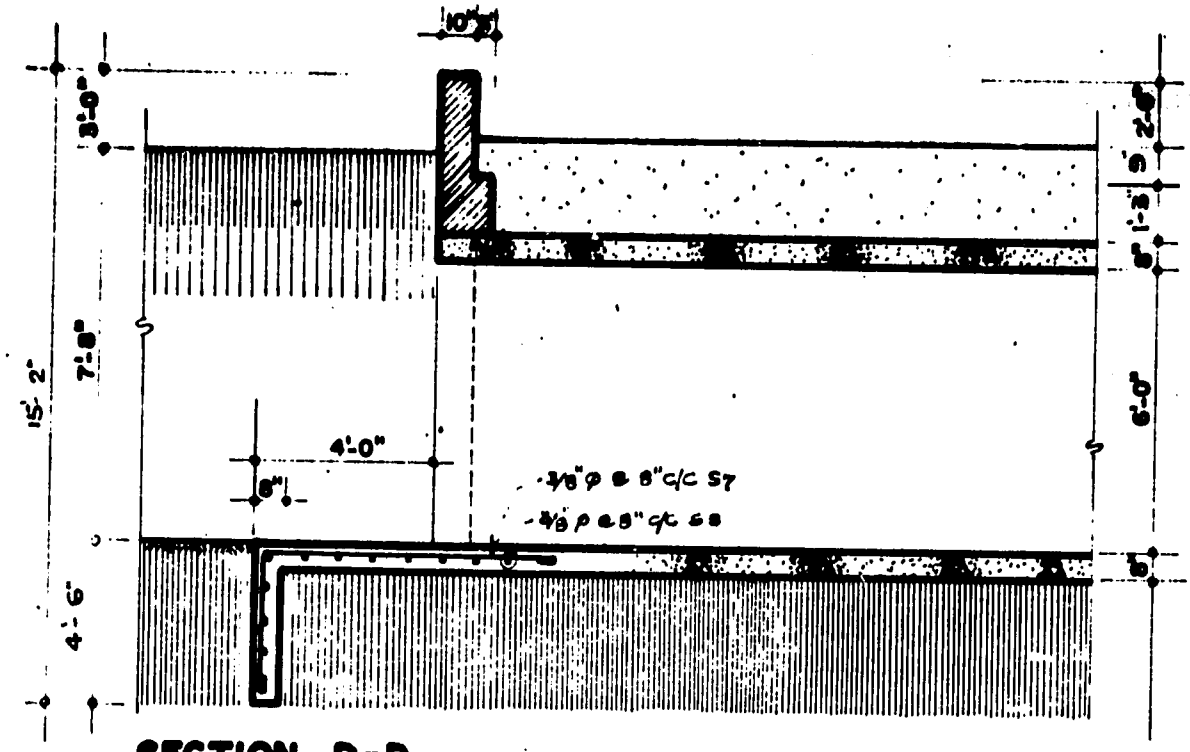


PLAN
SCALE: 1/8" = 1'-0"

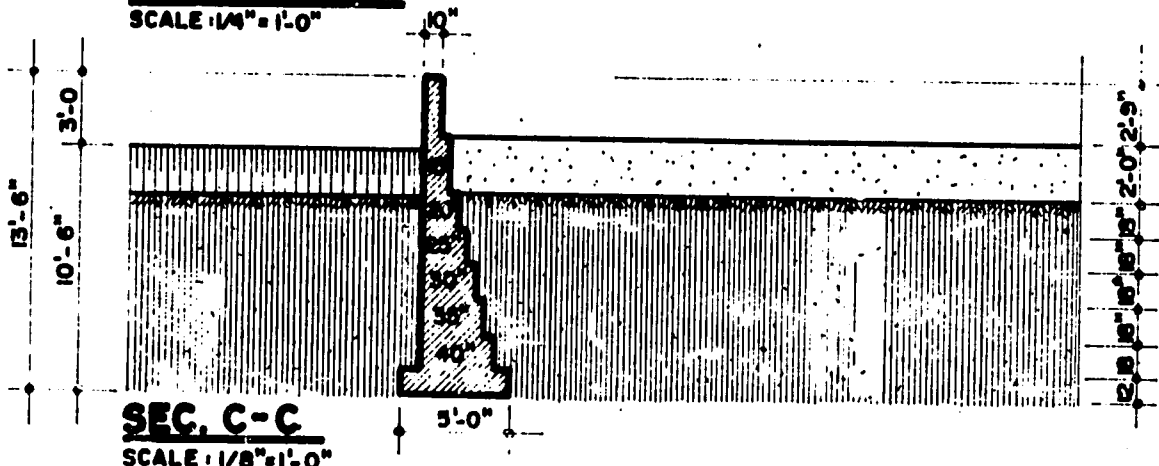


END ELEVATION
SCALE: 1/4" = 1'-0"

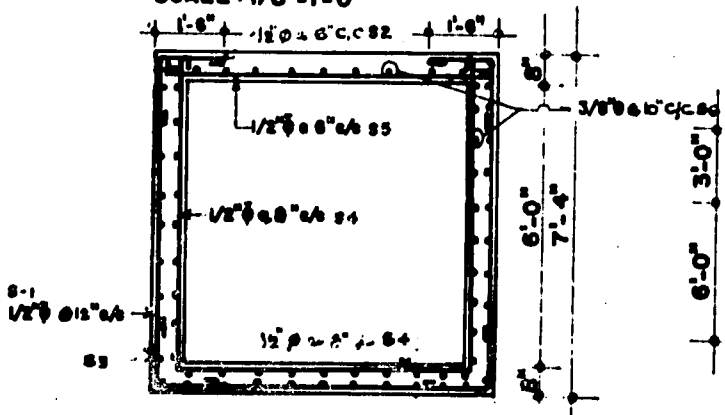
DESIGN EXAMPLE C-9



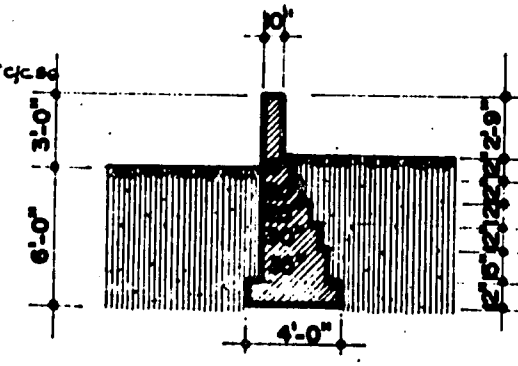
SECTION D-D
SCALE : 1/4" = 1'-0"



SEC. C-C
SCALE : 1/8" = 1'-0"



SECTION E-E
SCALE : 1/4" = 1'-0"



SECTION B-B
SCALE : 1/8" = 1'-0"

DESIGN EXAMPLE C- 9

SPECIFICATIONS.

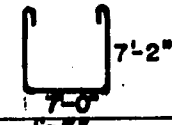
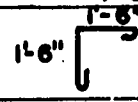
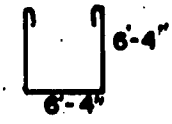
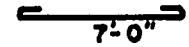
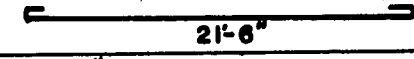
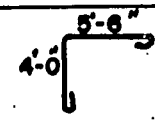
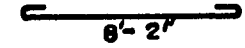
CHANNEL WIDTH-12'-0"
CHANNEL DEPTH-6'-0"
ROADWAY WIDTH-20'-0"
SOIL CONDITION-NOT SO SATISFACTORY
AREA OF THE WATERAY-36'-0"

- 1ST CLASS BRICKS.
- 1:4 MORTAR MIX FOR BRICKWORK.
- 1:3 MORTAR MIX FOR PLASTERING ALL EXPOSED BRICKWORK.
- 1:1½:3 MIX FOR REINFORCE CONCRETE WORK.
- 1:3:6 MIX FOR CEMENT CONCRETE WORK.

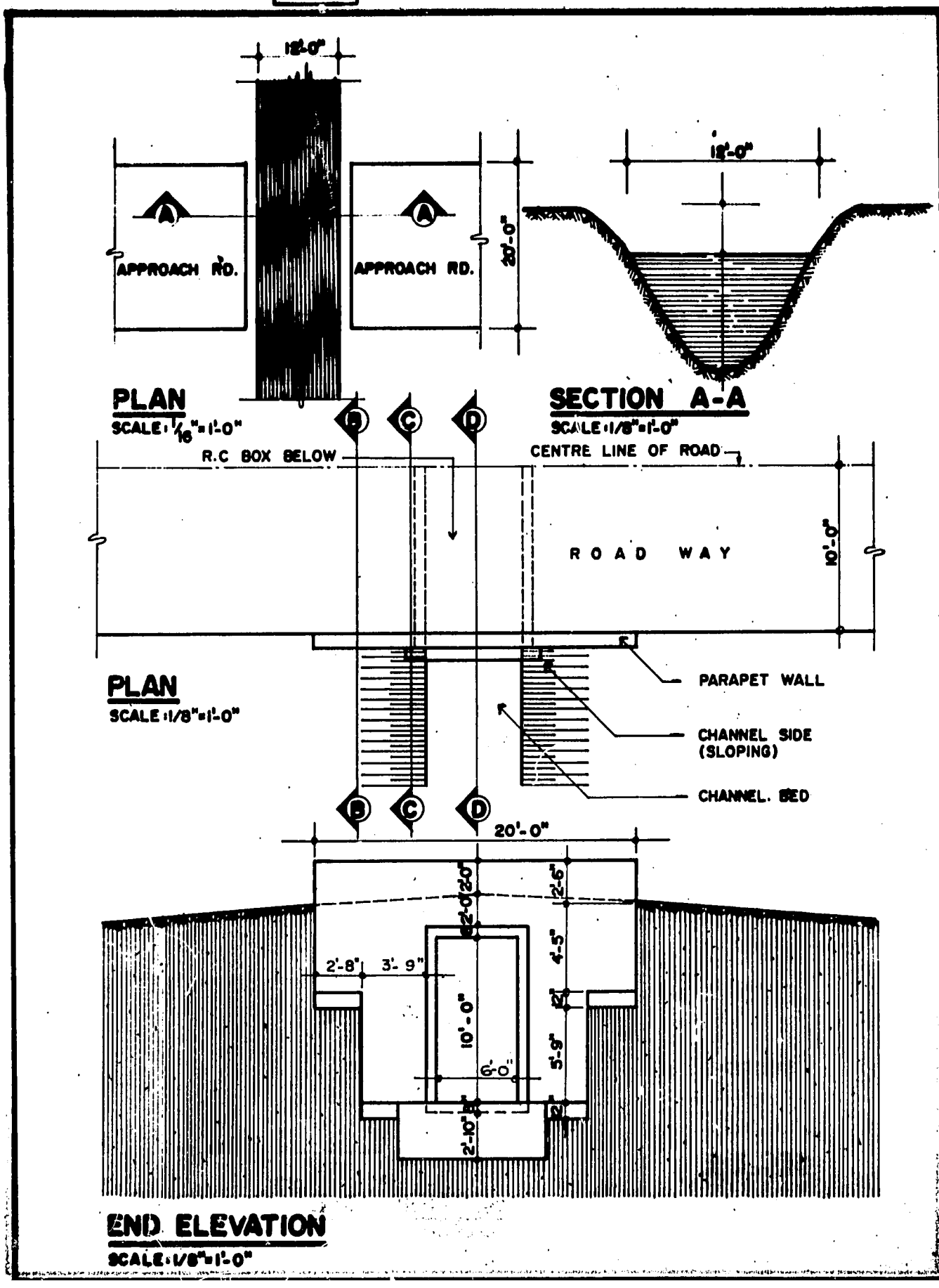
MATERIALS.

BRICK WORK.	CEMENT CONCRETE.	BRICKS	CEMENT.	SAND	KHOA	STONE CHIPS.	M.S. RODS.
619 cft.	R.C.C 489 cft.	7130 Nos	151 Bags.	441 cft.	461 cft.		3/8" ϕ 730 # 1/2" ϕ 1275 #

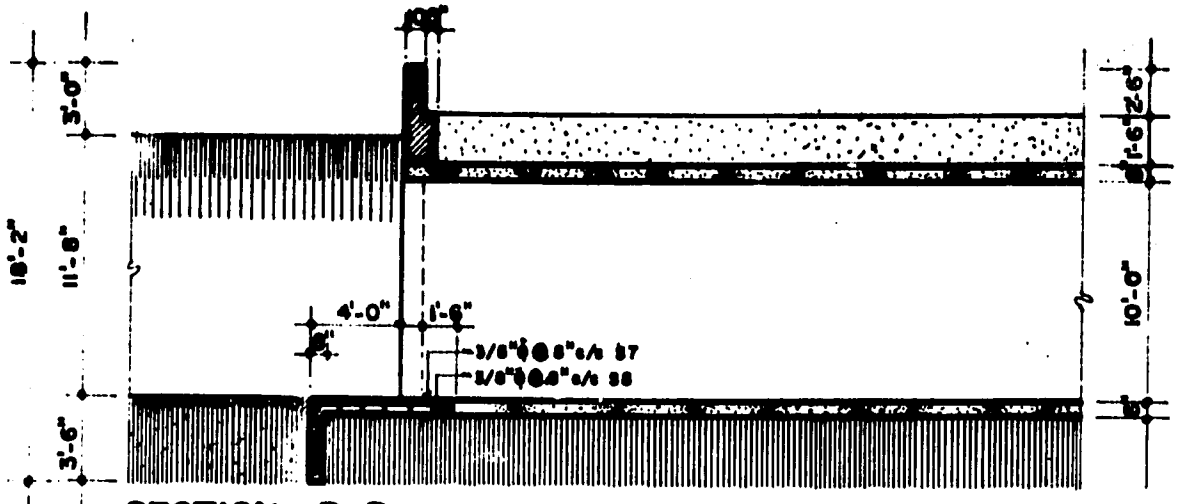
ROD BENDIND SCHEDULE.

MARK.	DIA	NOS.	LENGTH	FINAL SHAPE.
S_1	1/2" ϕ	23	24'-8"	
S_2	1/2" ϕ	23X2	3'-8"	
S_3	1/2" ϕ	23X2	3'-8"	
S4	1/2" ϕ	34.	19'-8"	
S_5	1/2" ϕ	44	7'8"	
S_6	3/8" -ϕ	65	22'-0"	
S_7	3/8" ϕ	2X15	10'-0"	
S8	3/8" ϕ	2X12	8'-8"	

DESIGN EXAMPLE C-10

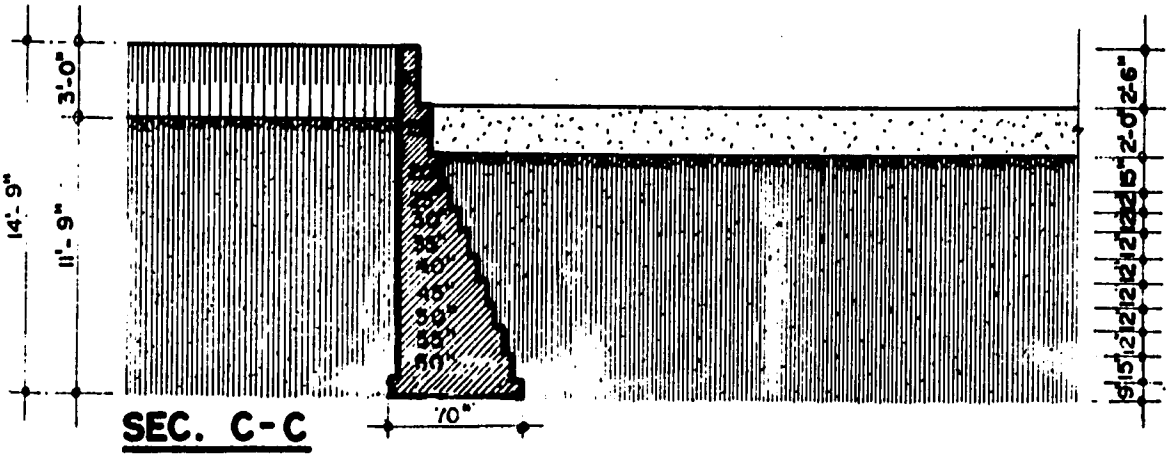


DESIGN EXAMPLE C-10



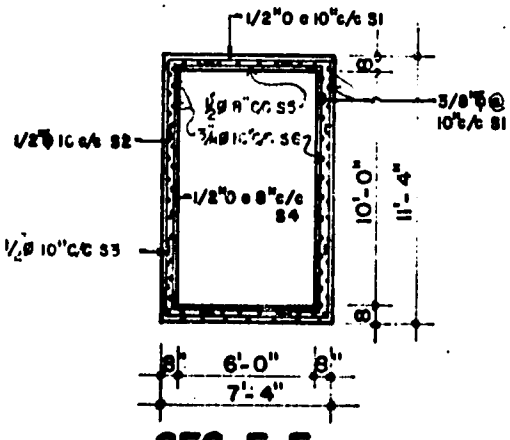
SECTION D-D

SCALE : 1/8" = 1'-0"



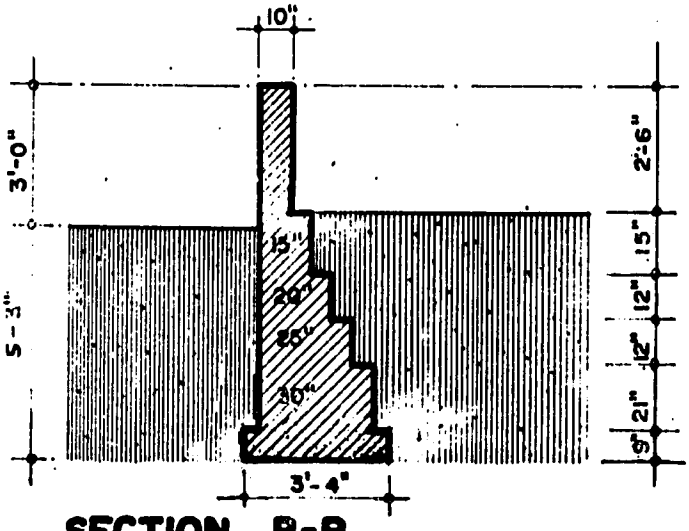
SEC. C-C

SCALE : 1/8" = 1'-0"



SEC. E-E

SCALE : 1/8" = 1'-0"



SECTION B-B

SCALE : 1/4" = 1'-0"

DESIGN EXAMPLE C-10

SPECIFICATIONS.

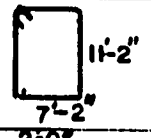
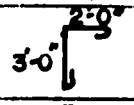
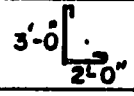
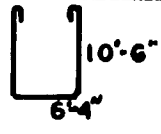
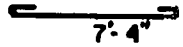
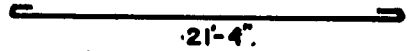
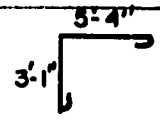
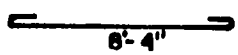
CHANNEL WIDTH- 12'-0"
CHANNEL DEPTH- 8'-0"
ROADWAY WIDTH -20'-0"
SOIL CONDITION-SATISFACTORY.
AREA OF WATERWAY-60 sq.ft.

- 1ST CLASS BRICKS.
- 1:4 MORTAR MIX FOR BRICKWORK.
- 1:3 MORTAR MIX FOR PLASTERING ALL EXPOSED BRICKWORK.
- 1:1½:3 MIX.FOR REINFORCED CONCRETE WORK.
- 1:3:6 MIX FOR CEMENT CONCRETE WORK.

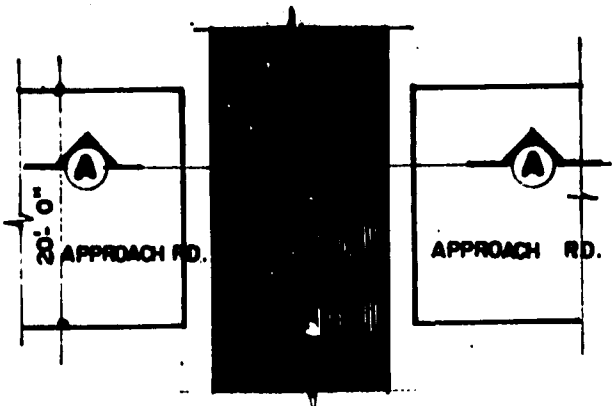
MATERIALS.

BRICK WORK.	CEMENT CONCRETE.	BRICKS	CEMENT	SAND	KHOA	STONE CHIPS.	M.S. RODS.
710 cft.	R.C.C 505cft.	8180 Nos	170 Bags	520 cft.	561 cft.		3/8" ø 871 # 1/2" ø 1898 #

ROD BENDING SCHEDULE.

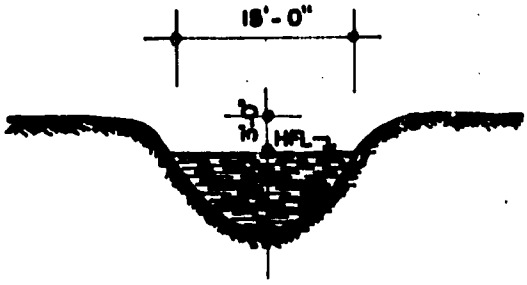
MARK.	DIA	NOS	LENGTH.	FINAL SHAPE.
S_1	1/2" ø	27	37'-4"	
S_2	1/2" ø	2X27	5'-8"	
S_3	1/2" ø	2X27	5'-8"	
S_4	1/2" ø	34	28'-0"	
S_5	1/2" ø	34	8'-0"	
S_6	3/8" ø	84	21'-10"	
S_7	3/8" ø	2X15	8'-11"	
S_8	3/8" ø	2X12	8'-10"	

DESIGN EXAMPLE C-11 Open Foundation Culverts



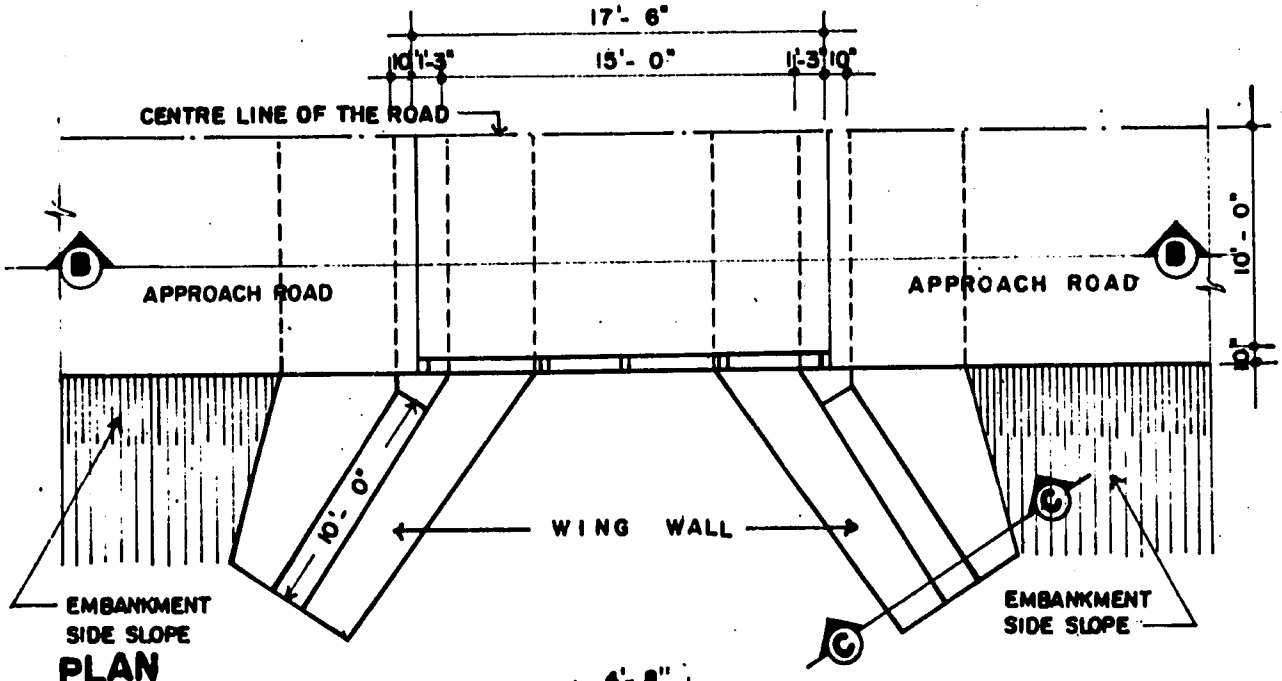
PLAN

SCALE : 1/8" = 1'-0"



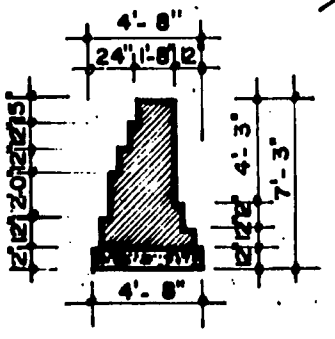
SECTION A-A

SCALE : 1/16" = 1'-0"



PLAN

SCALE : 1/8" = 1'-0"



SECTION C-C

SCALE : 1/8" = 1'-0"

DESIGN EXAMPLE C-11

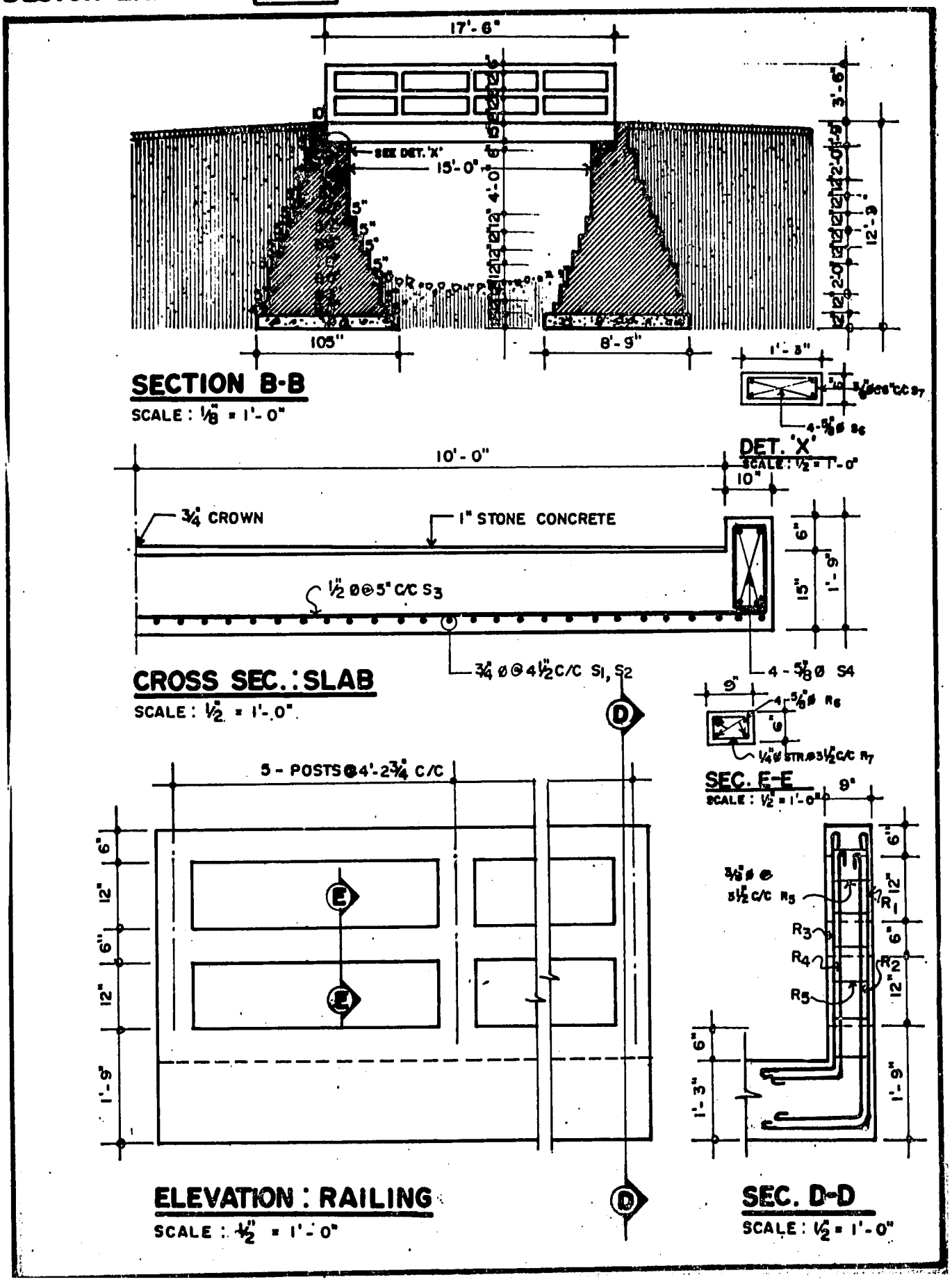


Table VIII-10 (Contd)

Conc. cft.	Cement		Sand cft.	Khoa/st. chip cft.	Conc. cft.	Cement		Sand cft.	Khoa/st. chip cft.
	cft.	Bags				cft.	Bags		
57.	8.55	6.84	25.65	51.30	84.	12.60	10.08	37.80	75.60
58.	8.70	6.96	26.10	52.20	85.	12.75	10.20	37.25	76.50
59.	8.85	7.08	26.55	53.10	86.	12.90	10.32	38.70	77.40
60.	9.00	7.20	27.00	54.00	87.	13.05	10.44	39.15	78.30
61.	9.15	7.32	27.45	54.90	88.	13.20	10.56	39.60	79.20
62.	9.30	7.44	27.90	55.80	89.	13.35	10.68	40.05	80.10
63.	9.45	7.56	28.35	56.70	90.	13.50	10.80	40.50	81.00
64.	9.60	7.68	28.80	57.60	91.	13.65	10.92	40.95	81.90
65.	9.75	7.80	29.25	58.50	92.	13.80	11.04	41.40	82.80
66.	9.90	7.92	29.70	59.40	93.	13.95	11.16	41.85	83.70
67.	10.05	8.04	30.15	60.30	94.	14.10	11.28	42.30	84.60
68.	10.20	8.16	30.60	61.20	95.	14.25	11.40	42.75	85.50
69.	10.35	8.28	31.05	62.10	96.	14.40	11.52	43.20	86.40
70.	10.50	8.40	31.50	63.00	97.	14.55	11.64	43.65	87.30
71.	10.65	8.52	31.95	63.90	98.	14.70	11.76	44.10	88.20
72.	10.80	8.64	32.40	64.80	99.	14.85	11.88	44.55	89.10
73.	10.95	8.76	32.85	65.70	100.	15.00	12.00	45.00	90.00
74.	11.10	8.88	33.30	66.60	200.	30	24	90	180
75.	11.25	9.00	33.75	67.50	300.	45	36	135	270
76.	11.40	9.12	34.20	68.40	400.	60	48	180	360
77.	11.55	9.24	34.65	69.30	500.	75	60	225	450
78.	11.70	9.36	35.10	70.20	600.	90	72	270	540
79.	11.85	9.48	35.55	71.10	700.	105	84	315	630
80.	12.00	9.60	36.00	72.00	800.	120	96	360	720
81.	12.15	9.72	36.45	72.90	900.	135	108	405	810
82.	12.30	9.84	36.90	73.80	1000.	150	120	450	900
83.	12.45	9.96	37.35	74.70					

(k) **Quantities of Materials required for Masonry Construction with 1 : 4 Mortar Mix and ½ Inch Joint Between Bricks.**

Table VIII-11

Brick Masonry cft.	Bricks	5" wall			10" wall			Mass wall		
		Cement		Sand	Cement		Sand	Cement		Sand
		cft.	Bags	cft.	cft.	Bags	cft.	cft.	Bags	cft.
10	113	0.5	0.4	2	0.6	0.5	3	0.8	0.6	3
20	226	0.9	0.8	4	1.2	1.0	5	1.5	1.2	6
30	339	1.4	1.1	6	1.8	1.5	8	2.3	1.8	9
40	452	1.8	1.5	8	2.4	2.0	10	3.0	2.4	12
50	565	2.3	1.8	9	3.0	2.4	12	3.8	3.0	15
60	678	2.7	2.2	11	3.6	2.9	15	4.5	3.6	18
70	791	3.2	2.6	13	4.2	3.4	17	5.3	4.2	21
80	904	3.7	2.9	15	4.8	3.9	20	6.0	4.8	24
90	1017	4.1	3.3	17	5.4	4.4	22	6.8	5.4	27
100	1130	4.5	3.6	18	6.0	4.8	24	7.5	6.0	30
110	1243	5.0	4.0	20	6.6	5 3	27	8.3	6.6	33
120	1365	5.4	4.4	22	7.2	5.8	29	9.0	7.2	36
130	1469	5.9	4.7	24	7.8	6.3	32	9.8	7.8	39
140	1582	6.3	5.1	26	8.4	6.8	34	10.5	8.4	42
150	1695	6.8	5.4	27	9.0	7.2	36	11.3	9.0	45
160	1808	7.2	5.7	29	9.6	7.7	39	12.0	9.6	48
170	1921	7.7	6.2	31	10.2	8.2	41	12.8	10.2	51
180	2034	8.1	6.5	33	10.8	8.7	44	13.5	10.8	54
190	2147	8.6	6.9	35	11.4	9.2	46	14.3	11.4	57
200	2260	9.0	7.2	36	12.0	9.6	48	15.0	12.0	60
210	2393	9.5	7.6	38	12.6	10.1	51	15.8	12.6	63
220	2486	9.9	7.9	40	13.2	10.6	53	16.5	13.2	66
230	2599	10.4	8.3	42	13.8	11.1	56	17.3	13.8	69
240	2712	10.8	8.7	44	14.4	11.5	58	18.0	14.4	72
250	2825	11.3	9.0	45	15.0	12.0	60	18.8	15.0	75
260	2938	11.7	9.4	47	15.6	12.5	63.5	19 5	15.6	78
270	3051	12.2	9.8	49	16.2	13.0	65	20.3	16.2	81
280	3164	12.6	10.1	51	16.8	13.5	68	20.0	16.8	84
290	3277	13.1	10.5	53	17.4	14.0	70	21.8	17.4	87
300	3390	13.5	10.8	54	18.0	14.4	72	22.5	18.0	90
310	3503	14.0	11.2	56	18.6	14.9	75	23.3	18.6	93
320	3616	14.4	11.6	58	19.2	15.4	77	24.4	19.2	96
330	3727	14.9	11.9	60	19.8	15.9	80	24.8	19.8	99
340	3842	15.3	12.3	62	20.4	16.4	82	25.5	20.4	102
350	3955	15.8	12.6	63	21.0	16.8	84	26.3	21.0	105
360	4068	16.2	13.0	65	21.6	17.3	87	27.0	21.6	108
370	4181	16.7	13.4	67	22.2	17.8	89	27.8	22.2	111
380	4294	17.1	13.7	69	22.8	18.3	92	28.5	22.8	114
390	4407	17.6	14.1	71	23.4	18.8	94	29.3	23.4	117
400	4520	18.0	14.4	72	24.0	19.2	96	30.0	24.0	120

Table VIII-11 (Contd.)

Brick Masonry cft.	Bricks	5" wall			10" wall			Mass wall		
		Cement		Sand	Cement		Sand	Cement		Sand
		cft.	Bags	cft.	cft.	Bags	cft.	cft.	Bags	cft.
410	4633	18.5	14.4	74	24.6	19.7	99	30.8	24.6	123
420	4746	18.9	15.2	76	25.2	20.2	101	31.5	25.2	126
430	4859	19.4	15.5	78	25.8	20.6	104	32.3	25.8	129
440	4972	19.8	15.9	80	26.4	21.2	106	33.0	26.4	132
450	5058	20.3	16.2	81	27.0	21.6	108	33.8	27.0	135
460	5198	20.7	16.6	83	27.6	22.1	111	34.5	27.6	138
470	5311	21.2	16.9	85	28.2	22.6	113	35.3	28.2	141
480	5424	21.6	17.3	87	28.8	23.1	116	36.0	28.8	144
490	5537	22.1	17.7	89	29.4	23.4	118	36.8	29.4	147
500	5650	22.5	18.0	90	30.0	24.0	120	37.5	30.0	150
510	5763	23.0	18.4	92	30.6	24.5	123	38.3	30.6	153
520	5876	23.4	18.8	94	31.2	25.0	125	39.0	31.2	156
530	5989	23.9	19.1	96	31.8	25.5	128	39.8	31.8	159
540	6102	24.3	19.5	98	32.4	26.0	130	40.5	32.4	162
550	6215	24.8	19.8	99	33.0	26.4	132	41.3	33.0	165
560	6328	25.2	20.2	101	33.6	26.9	135	42.0	33.6	168
570	6441	25.7	20.6	103	34.2	27.4	137	42.8	34.2	171
580	6554	26.1	20.9	105	34.8	27.9	140	43.5	34.8	174
590	6667	26.6	21.3	107	35.4	28.4	142	44.3	35.4	177
600	6780	27.0	21.6	108	36.0	28.8	144	45.0	36.0	180
610	6893	27.5	22.0	110	36.6	29.3	147	45.8	36.6	183
620	7006	27.9	22.3	112	37.2	29.8	149	46.5	37.2	186
630	7116	28.4	22.7	114	37.8	30.3	152	47.3	37.8	189
640	7232	28.8	23.1	196	38.4	30.7	154	48.0	38.4	192
650	7345	29.3	23.4	117	39.0	31.2	156	48.8	39.0	195
660	7458	29.9	23.8	119	39.6	31.7	159	49.5	39.6	198
670	7571	30.2	24.1	121	40.2	32.3	161	50.3	40.2	201
680	7684	30.6	24.5	123	40.8	32.7	164	51.0	40.8	204
690	7797	31.1	24.9	125	41.4	33.2	166	51.8	41.4	207
700	7910	31.5	25.2	126	42.0	33.6	168	52.5	42.0	210
710	8023	32.0	25.6	128	42.6	34.1	171	53.3	42.6	213
720	8136	32.4	25.9	130	43.2	34.7	173	54.0	43.2	216
730	8249	32.9	26.3	132	43.8	35.1	176	54.8	43.8	219
740	8262	33.3	26.7	134	44.4	35.5	178	55.5	44.4	222
750	8475	33.8	27.0	135	45.0	36.0	180	56.3	45.0	225
760	8588	34.2	27.4	137	45.6	36.5	183	57.0	45.6	228
770	8701	34.7	27.8	139	46.2	37.0	185	57.8	46.2	231
780	8814	35.1	28.1	141	46.8	37.5	188	58.5	46.8	234
790	8927	45.6	28.5	142	47.4	38.0	190	59.3	47.4	237
800	9040	36.0	28.8	144	48.0	38.4	192	60.0	48.0	240

Table VIII-11 (Contd.)

Brick Masonry cft.	Bricks	5" wall			10" wall			Mass wall		
		Cement		Sand cft.	Cement		Sand cft.	Cement		Sand cft.
		cft.	Bags		cft.	Bags		cft.	Bags	
810	9153	36.5	29.2	146	48.6	38.9	195	60.8	48.6	243
820	9266	36.9	29.5	148	49.2	39.4	197	61.5	49.2	246
830	9379	37.4	29.9	150	49.8	39.9	200	62.3	49.8	249
840	9492	37.8	30.3	151	50.4	40.4	202	63.0	50.4	252
850	9605	38.3	30.6	152	51.0	40.8	204	63.8	51.0	255
860	9718	38.7	31.0	154	51.6	41.3	207	64.5	51.6	258
870	9831	39.2	31.4	157	52.2	41.8	209	65.3	52.2	261
880	9944	39.6	31.7	158	52.8	42.3	212	66.0	52.8	264
890	10057	40.1	32.0	160	53.4	42.8	214	66.8	53.4	267
900	10170	40.5	32.4	162	54.0	43.2	216	67.5	54.0	270
910	10283	41.0	32.8	164	54.6	43.7	219	68.3	54.6	273
920	10396	41.4	33.1	166	55.2	44.2	221	69.0	55.2	276
930	10509	41.9	33.5	168	55.8	44.7	224	69.8	55.8	279
940	10622	42.3	33.9	170	56.4	45.2	226	70.5	56.4	282
950	10735	42.8	34.2	171	57.0	45.6	228	71.3	57.0	285
960	10848	43.2	34.6	173	57.6	46.1	230	72.0	57.6	288
970	10961	43.7	35.0	175	58.2	46.6	233	72.8	58.2	291
980	10074	44.1	35.3	177	58.8	47.1	236	73.5	58.8	294
990	11187	44.6	35.7	179	59.5	47.5	238	74.3	59.4	297
1000	11300	45.0	36.0	180	60.0	48.0	240	75.0	60.0	300
2000	22600	90.0	72.0	360	120.0	96.0	480	150.0	120.0	600
3000	33900	135.0	108.0	540	180.0	144.0	720	225.0	180.0	900
4000	45200	180.0	144.0	720	240.0	192.0	960	300.0	240.0	1200
5000	56500	225.0	180.0	900	300.0	240.0	1200	375.0	390.0	1500

(e) Quantities of Materials Required for Masonry Construction with 1 : 6 Mortar Mix and ½ inch Joint Between Bricks.

Table VIII-12

Brick Masonry cft.	Bricks	5" wall			10" wall			Mass wall		
		Cement		Sand	Cement		Sand	Cement		Sand
		cft.	Bags	cft.	cft.	Bags	cft.	cft.	Bags	cft.
10	113	0.3	0.3	2	0.4	0.3	4	0.5	0.3	3
20	226	0.6	0.5	4	0.8	0.7	5	1.0	0.8	6
30	339	0.9	0.8	6	1.2	1.0	8	1.5	1.2	9
40	452	1.2	1.0	8	1.6	1.3	10	2.0	1.6	12
50	565	1.5	1.2	9	2.0	1.6	12	2.5	2.0	15
60	678	1.8	1.5	11	2.4	2.0	15	3.0	2.4	18
70	791	2.1	1.7	13	2.8	2.3	17	3.5	2.8	21
80	904	2.4	2.0	15	3.2	2.6	20	4.0	3.2	24
90	1017	2.7	2.2	17	3.6	2.9	22	4.5	3.6	27
100	1130	3.0	2.4	18	4.0	3.2	24	5.0	4.0	30
110	1243	3.3	2.7	20	4.4	3.6	27	5.5	4.4	33
120	1356	3.6	2.9	22	4.8	3.9	29	6.0	4.8	36
130	1459	3.9	3.2	24	5.2	4.2	32	6.5	5.2	39
140	1582	4.2	3.4	26	5.6	4.5	34	7.0	5.6	42
150	1695	4.5	3.6	27	6.0	4.8	36	7.5	6.0	45
160	1868	4.8	3.9	29	6.4	5.2	39	8.0	6.4	48
170	1921	5.1	4.1	31	6.8	5.5	41	8.5	6.8	51
180	2034	5.4	4.4	33	7.2	5.8	44	9.0	7.2	54
190	2147	5.7	4.6	35	7.6	6.1	46	9.5	7.6	57
200	2260	6.0	4.8	36	8.0	6.4	48	10.0	8.0	60
210	2373	6.3	5.1	38	8.4	6.8	51	10.5	8.4	63
220	2486	6.6	5.3	40	8.8	7.1	53	11.0	8.8	66
230	2599	6.9	5.6	42	9.2	7.4	56	11.5	9.2	69
240	2712	7.2	5.8	44	9.6	7.7	58	12.0	9.6	72
250	2825	7.5	6.0	45	10.0	8.0	60	12.5	10.0	75
260	2938	7.8	6.3	47	10.4	8.4	63	13.0	10.4	78
270	3051	8.1	6.5	49	10.8	8.7	65	13.5	10.8	81
280	3164	8.4	6.8	51	11.2	9.0	68	14.0	11.2	84
290	3277	8.7	7.0	53	11.6	9.3	70	14.5	11.6	87
300	3390	9.0	7.2	54	12.0	9.6	72	15.0	12.0	90
310	3503	9.3	7.5	56	12.4	10.0	75	15.5	12.4	93
320	3616	9.6	7.7	58	12.8	10.3	77	16.0	12.8	96
330	3729	9.9	8.0	60	13.2	10.6	80	16.5	13.2	99
340	3842	10.2	8.2	62	13.6	10.9	82	17.0	13.6	102
350	3955	10.5	8.4	63	14.0	11.2	84	17.5	14.0	105
360	4068	10.8	8.7	65	14.4	11.6	87	18.0	14.4	108
370	4181	11.1	8.9	67	14.8	11.9	89	18.5	14.8	111
380	4294	11.4	9.2	69	15.2	12.2	92	19.0	15.2	114
390	4407	11.7	9.4	71	15.6	12.5	94	19.5	15.6	117
400	4520	12.0	9.6	72	16.0	12.8	96	20.0	16.0	120

Table VIII-12 (Contd.)

Brick Masonry cft.	Bricks	5" wall			10" wall			Mass wall		
		Cement		Sand	Cement		Sand	Cement		Sand
		cft.	Bags	cft.	cft.	Bags	cft.	cft.	Bags	cft.
410	4633	12.3	9.9	74	16.4	13.2	99	20.5	16.4	123
420	4746	12.6	10.1	76	16.8	13.5	101	21.0	16.8	126
430	4859	12.9	10.4	78	17.2	13.8	104	21.5	17.2	129
440	4972	13.2	10.6	80	17.6	14.1	106	22.0	17.6	132
450	5058	13.5	10.8	81	18.0	14.4	108	22.5	18.0	135
460	5198	13.8	11.1	83	18.4	14.8	111	23.0	18.4	138
470	5311	14.1	11.3	85	18.8	15.1	113	23.5	18.8	141
480	5424	14.4	11.5	87	19.2	15.4	116	24.0	19.2	144
490	5537	14.7	11.8	89	19.6	15.7	118	24.5	19.6	147
500	5650	15.0	12.0	90	20.0	16.0	120	25.0	20.0	150
510	5763	15.3	12.3	92	20.4	16.4	123	25.5	20.4	153
520	5876	15.6	12.5	94	20.8	16.7	125	26.0	20.8	156
530	5989	15.9	12.8	96	21.2	17.0	128	26.5	21.2	159
540	6102	16.2	13.0	98	21.8	17.3	130	27.0	21.6	162
550	6215	16.5	13.2	99	22.0	17.6	132	27.5	22.0	165
560	6328	16.8	13.5	101	22.4	17.9	135	28.0	22.4	168
570	6441	17.1	13.7	103	22.8	18 3	137	28.5	22.8	171
580	6554	17.4	13.9	105	23.2	18.6	140	29.0	23.2	174
590	6667	177	14.2	107	23.6	18.9	142	29.5	23.6	177
600	6780	18.0	14.4	108	24.0	19.2	144	30.0	24.0	180
610	6893	18.3	14.7	110	24.4	19.5	147	30.5	24.4	183
620	7006	18.6	14.9	112	24.8	19.9	149	31.0	24.8	186
630	7116	18.9	15.2	114	25.2	20.2	152	31.5	25.2	189
640	7232	19.2	15.4	116	25.6	20.5	154	32.0	25.6	192
650	7345	19 5	15.6	117	26.0	20.8	156	32.5	26.0	195
660	7458	19.8	15.9	119	26.4	21.1	159	33.0	26.4	198
670	7571	20.1	16.1	121	26.8	21.5	161	33.5	26.8	201
680	7684	20.4	16.4	123	27.2	21.8	164	34.0	27.2	204
690	7797	20.7	16.6	125	27.6	22.1	166	34.5	27.6	207
700	7910	21.0	16.8	126	28.0	22.4	168	35.0	28.0	210
710	8023	21.3	17.1	128	28.4	22.8	171	35.5	28.4	213
720	8136	21.6	17.3	130	28.8	23.1	173	36.0	28.8	216
730	8249	21.9	17.5	132	29.2	23.4	176	36.5	29.2	219
740	8262	22.2	17.8	134	29.6	23.7	178	37.0	29.6	222
750	8475	22.5	18.0	135	30.0	24.0	180	37.5	30.0	225
760	8588	22.8	18.2	137	30.4	24.3	183	38.0	30.4	228
770	8701	23.1	18.5	139	30.8	24.7	185	38.5	30.8	231
780	8814	23.4	18.7	141	31.2	25.0	188	39.0	31.2	234
790	8927	23.7	19.0	142	31.6	25.3	190	39.5	31.6	237
800	9040	24.0	19.2	144	32.0	25.6	192	40.0	32.0	240

Table VIII-12 (Contd.)

Brick Masonry cft.	Bricks	5" wall			10" wall			Mass wall		
		Cement		Sand	Cement		Sand	Cement		Sand
		cft.	Bags	cft.	cft.	Bags	cft.	cft.	Bags	cft.
810	9153	24.3	19.5	146	32.4	26.0	195	40.5	32.4	243
820	9266	24.6	19.7	148	32.8	26.3	197	41.0	32.8	246
830	9379	24.9	19.9	150	33.2	26.6	200	41.5	33.2	249
840	9492	25.2	20.2	151	33.6	26.9	202	42.0	33.6	252
850	9605	25.5	20.4	152	34.0	27.2	204	42.5	34.0	255
860	9718	25.8	20.7	154	34.4	27.6	207	43.0	34.4	258
870	9831	26.1	20.9	157	34.8	27.9	209	43.5	34.8	261
880	9944	26.4	21.2	158	35.2	28.2	212	44.0	35.2	264
890	10057	27.7	21.4	160	35.6	28.5	214	44.5	35.6	267
900	10170	27.0	21.6	162	36.0	28.8	216	45.0	36.0	270
910	10283	27.3	21.9	164	36.4	29.2	219	45.5	36.4	273
920	10396	27.6	22.1	166	36.8	29.5	221	46.0	36.8	276
930	10509	27.9	22.3	168	37.2	29.8	224	46.5	37.2	279
940	10622	28.2	22.6	170	37.6	30.1	226	47.0	37.6	282
950	10735	28.5	22.8	171	38.0	30.4	228	47.5	38.0	285
960	10848	28.8	23.1	173	38.4	30.8	230	48.0	38.4	288
970	10961	29.1	23.3	175	38.8	31.0	233	48.5	38.8	291
980	10074	29.4	23.5	177	39.2	31.4	236	49.0	39.2	294
990	11187	29.7	23.8	179	39.6	31.7	238	49.5	39.6	297
1000	11300	30.0	24.0	180	40.0	32.0	240	50.0	40.0	300
2000	22600	60.0	48.0	360	80.0	64.0	480	100.0	80.0	600
3000	33900	90.0	72.0	540	120.0	96.0	720	150.0	120.0	900
4000	45200	120.0	96.0	720	160.0	128.0	960	200.0	160.0	1200
5000	56500	150.0	120.0	900	200.0	160.0	1200	250.0	200.0	1500

(m) Quantities of Materials for 100 sq. ft. of plaster.

Table VIII-13

Mortar Mix	Thickness Inch.	Cement Bags	Sand cft.
1 : 3	½ ¾	1.24 1.88	5.0 7.03
1 : 4	½ ¾	1.0 1.5	5.0 7.5

(n) Quantities of Materials for Brick Road Surface, 10'-0" wide with soling, 3" and bed, herringbone, brick edming and bituminus carpeting

Table VIII-14

Length of Road	Brick				Bituminous Carpeting		Sand (cft)
	Soling (Nos)	Herring bone (Nos)	Edging (Nos)	Total (Nos)	Bitumen (pounds)	Graded Sylhet single (cft)	
1 mile	158400	264000	44880	467260	31680	5544	28776

(o) Quantities of Materials for water Bound Macadam Road, 10'-0" wide with soling, 3" sand bed, 6" water bound Macadam and bituminous carpeting.

Table VIII-15.

Length of Road	Brick Soling (Nos)	W. B. Macadam		Total Bricks (Nos)	Bituminous carpeting		Sand (cft)
		Graded Aggregate (cft)	Bricks (Nos)		Bitumen (Pounds)	Graded Sylhet Single (cft)	
1 mile	158400	36960	314160	472560	31680	5544	27720

(p) Water. Cement Ratio (gals, per bags of cement) Strenath of Concrte.

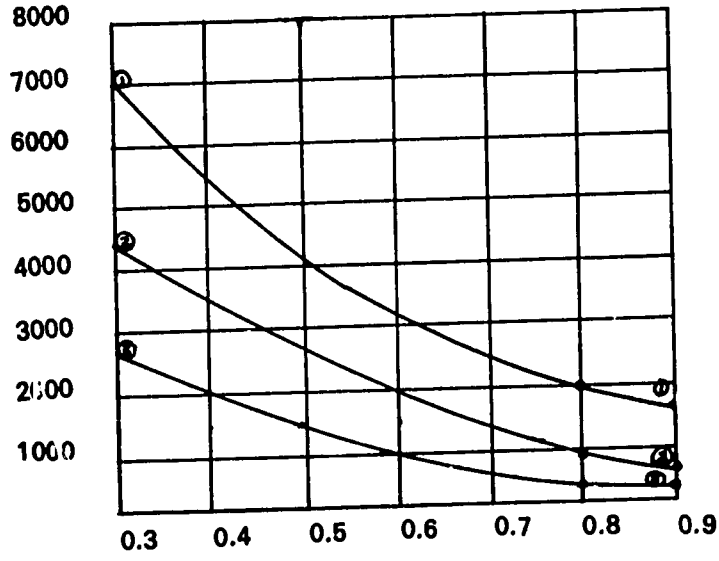
Table VIII-16

Water/Cememt Ratio	Water in gallons Per bag of cement	Water/Cement Ratio	Water in gallons Per bag of cement.
0.1	1.12	1.1	12.32
0.2	2.24	1.2	13.44
0.3	3.36	1.3	14.56
0.4	4.48	1.4	15.68
0.5	5.60	1.5	16.80
0.6	6.72	1.6	17.92
0.7	7.84	1.7	19.04
0.8	8.96	1.8	20.16
0.9	10.08	1.9	21.28
1.0	11.20	2.0	22.44

(q) **Allowable slump for different works**

Table VIII-17

Allowable Slump (inches)	Degree of workability	Suitable works
0-1	Very low	Precast and vibrated concrete works in roads and piles
1-2	Low	Road Works Mass Concrete in Foundation Lightly reinforced sections
2-4	Medium	Slabs Normal reinforced concrete Heavily reinforced Sections
4-7	High	Sections with conjested reinforcement



W/C Ratio ①-① after 1 year

②-② after 28 days

③-③ after 8 days

Water/Cement ratio vs Strength of Concrete (1 : 2 : 4) Fig. VIII-1

(r) Allowable bearing Capacity of soil of various physical descriptions.

Table VIII-18

Description of Soil	Safe Load in tons/sq. ft.
Soft wet pasty or muddy clay, and marshy clay	0.25—0.23
Alluvial deposits of moderate depths in river beds	0.20—0.35
Diluvial clay in beds of river	0.35—1.00
Black cotton soil	0.50—0.75
Alluvial earth loams	0.75—1.50
Moist clay	1.00—1.25
Compact clay, nearly dry	2.00
Solid clay, mixed with very fine sand	3.00
Dry compact clay of considerable Thickness	3.00—6.00
Compact sand	2.00—3.00
Compact sand prevented from spreading	5.00—7.50
Sandy gravel or kankar	2.00—3.00
Compact gravel	7.00—9.00
Red earth	3.00
Murram	4.00

(s) Splicing Length and Development Lenth of Various denominations of M. S. bars.

Table VIII-19

Dia. of M. S. bars in inch	Minm. Splicing length in inches	
	In tension	In compression
1/4	24	10
3/8	24	15
1/2	24	20
5/8	30	25
3/8	36	30
7/8	42	35
1	48	40

Appendix - 1

RURAL WORKS PROGRAMME PROJECT PRO-FORMA

Thana :	
Subdivision :	
District :	
1. Project No. :	
2. Name and location of the proposed project. :	
3. Name and designation of the officer responsible for the technical preparation of the project. :	
4. Name and designation of the officer responsible for the execution of the project. :	
5. Type of project :	New Construction, culvert bridge sluice Reconstruction/repair culvert bridge sluice
6. A full description of what is proposed to be done under the scheme :	
7. Nature of benefit that is sougt to be derived for the people through the project :	
8. Specification of the project to be executed.	Length :- Breadth :- Height :- Depth :-
9. If the project is one of reconstruction or improvement, specification of the project as existing now :	

10. Total quantum of work proposed to be done. (difference between Items 8 and 9) :

11. Whether any work was done on this project in previous years. If so full specification and description of such works and year wise expenditure and total of previous expenditure :

12. Total allocation for the project required during the current financial year : Tk.

13. Whether land required will be voluntarily contributed and if so, whether the owners signified in writing their consent to contribute :

14. Monetary value of voluntary contribution in land : Tk.

15. Estimated expenditure on the following :—

(a) Purchase of cement ; Quantity..... Rate..... Cost.....
(b) Purchase of bricks ; Quantity..... Rate..... Cost.....
(c) M. S. Rods ; Quantity..... Rate..... Cost.....
(d) Sand ; Quantity..... Rate..... Cost.....
(e) Bitumen ; Quantity..... Rate..... Cost.....
(f) Expenditure on wages of unskilled labour ; Tk.....
(g) Expenditure on wages of skilled labour ; Tk.....
(h) Contingency ; Tk.....
(i) Remuneration to Project Secretary ; Tk.....

16. Describe in physical and financial terms the works proposed to be done year by year in the future :

17. Include a detailed estimate in the form given below :

Sl. No. 1	Name of item 2	Physical description, grade, specifications etc. 3	Unit 4	Rate/unit 5	Remark 6

Appendix - II

RECORD KEEPING DUMMY TABLES ETC.

1. Construction Schedule Chart :

Project :

Union :

Thana :

Sub-division :

District :

Estimated progress

Actual progress

Item	Operation	Month/dates					Month/dates			
		7	14	21	28		7	14	21	28

2. Checklist For Materials :

Project :

Union :

Thana :

Sub-division :

District :

Date :

Materials	Quantity reqd.	Quantity ordered	Quantity on hand

3. **PROFORMA for Revised Estimate for Completion of Incomplete Work :**

Project :

Union :

Thana :

Subdivision :

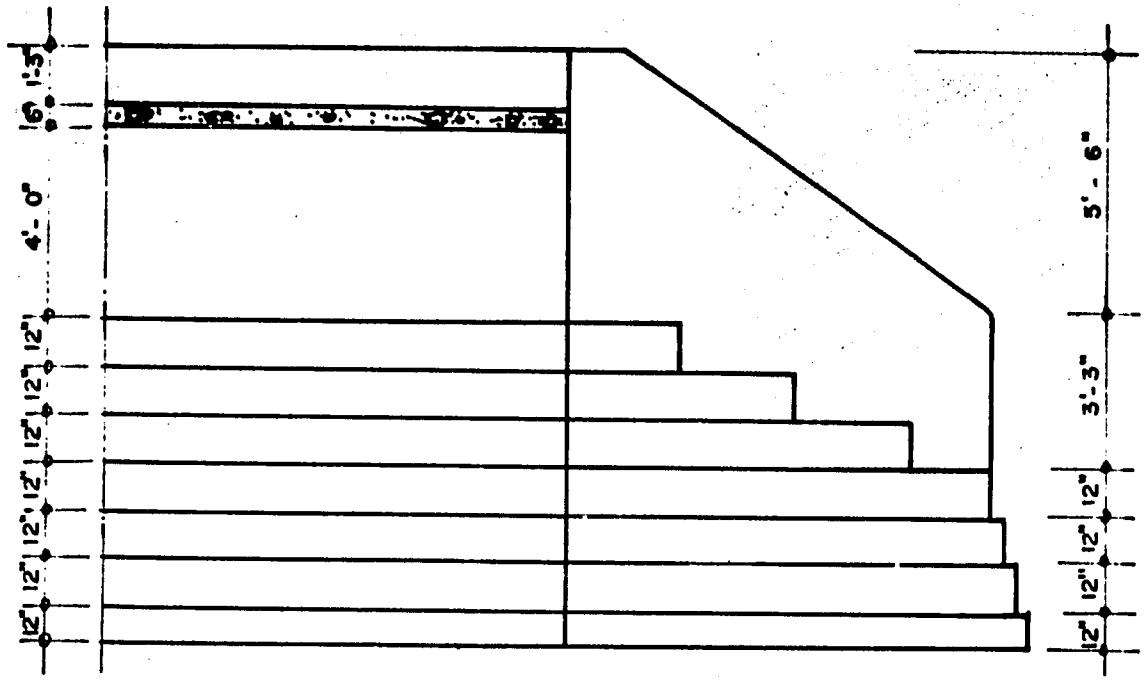
District :

		Original estimate				Work done as per original estimate		
Item	Description of work	Qty. of work sft/cft	No. of such item	Rate per unit	Amount Tk.	Qty. of work, sft/cft	Rate per unit	Amount Tk.
1	2	3	4	5	6	7	8	9

Incomplete work according to original estimate			Revised estimate for incomplete construction work				(a) Additional amount reqd. for incomplete work as per revised estimate. (b) Total amount already spent.
Qty. of work, sft/cft	No. of such item	Rate per unit	Qty. of work, sft/cft	No. of such item	Rate per unit	Amount Tk.	
10	11	12	13	14	15	16	17

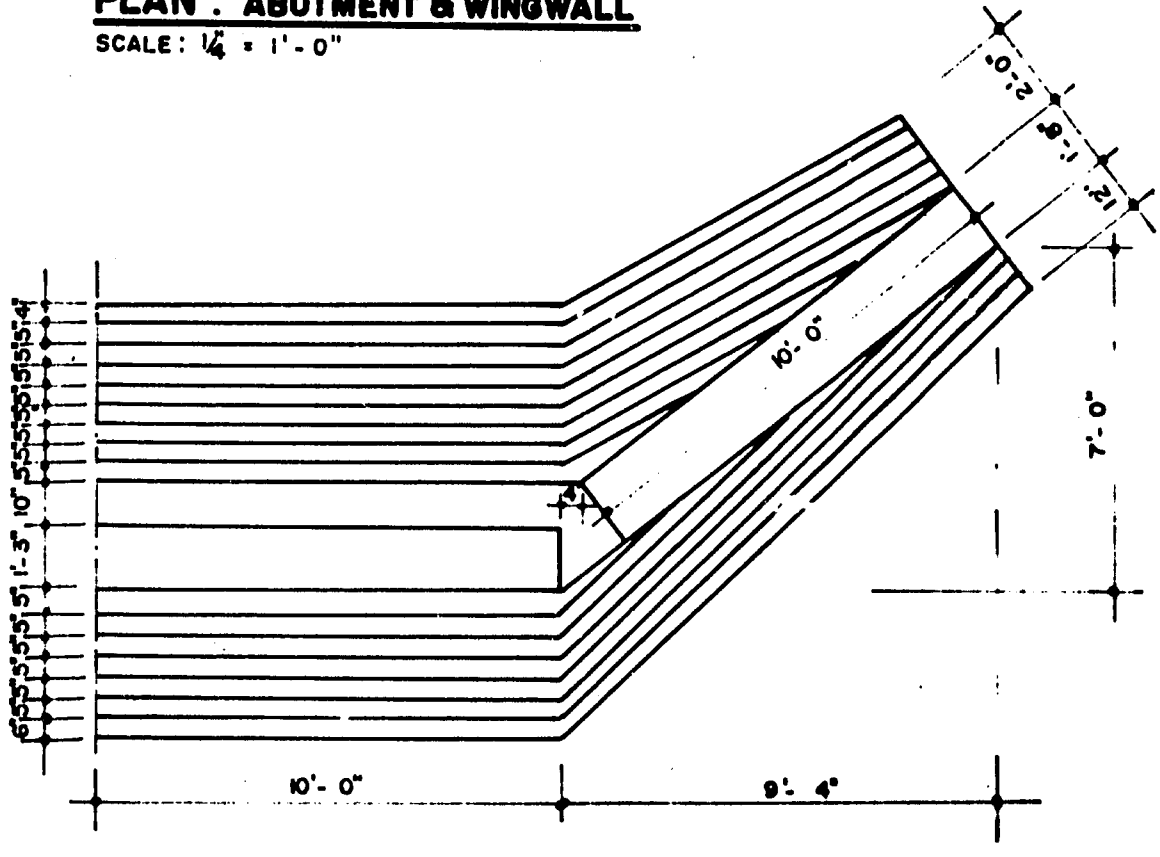
Notes

DESIGN EXAMPLE C-11



PLAN : ABUTMENT & WINGWALL

SCALE : 1/4" = 1'- 0"



ELEVATION : ABUTMENT & WINGWALL

SCALE : 1/4" = 1'- 0"

DESIGN EXAMPLE C-11

SPECIFICATIONS

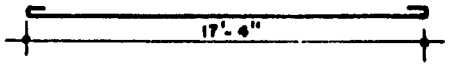
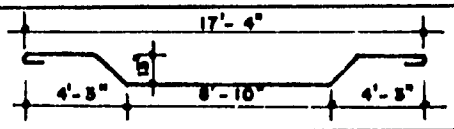
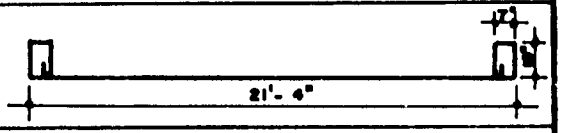
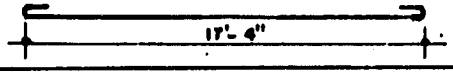
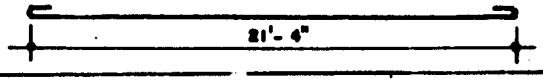
R.C.C SLAB BRIDGE
CHANNEL WIDTH – 15'-0"
CHANNEL DEPTH – 7'-0"
ROADWAY WITH – 20'-0"
SOIL CONDITION SATISFACTORY

- 1ST. CLASS BRICK.
- 1:4 MORTAR MIX. FOR BRICK WORK.
- 1:3 MORTAR MIX. FOR ALL EXPOSED PLASTER WORK.
- 1:1½:3 MIX. FOR REINFORCED CONCRETE WORK.
- 1:3:6 MIX. FOR CEMENT CONCRETE WORK.

MATERIALS

BRICK WORK	CEMENT CONCRETE	BRICKS	CEMENT	SAND	KHOA	STONE CHIPS	M.S. RODS
3456 CFT.	C.C 663 CFT. R.C.C 551 "	399000 NOS.	421 BAG.	1650 CFT.	1095 CFT.	50 CFT.	¼" ø —— 85# ⅜" ø —— 540# ½" ø —— 850# ⅝" ø —— 260# ¾" ø —— 1687# ⅞" ø —— 837#

ROD BENDING SCHEDULE

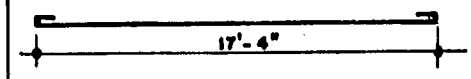
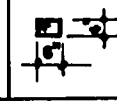
MARK	DIA	NOS.	LENGTH	FINAL SHAPE
S_1	¾" ø	30	18'-4"	
S_2	¾" ø	30	19'-2"	
S_3	½" ø	43	29'-6"	
S_4	⅝" ø	2X2	18'-2"	
S_5	⅝" ø	2X4	22'-2"	
S_6	⅜" ø	2X45	3'-4"	
R_1	⅞" ø	2X2X5	7'-0"	
R_2	⅞" ø	2X2X2X5	6'-9"	

DESIGN EXAMPLE C-11

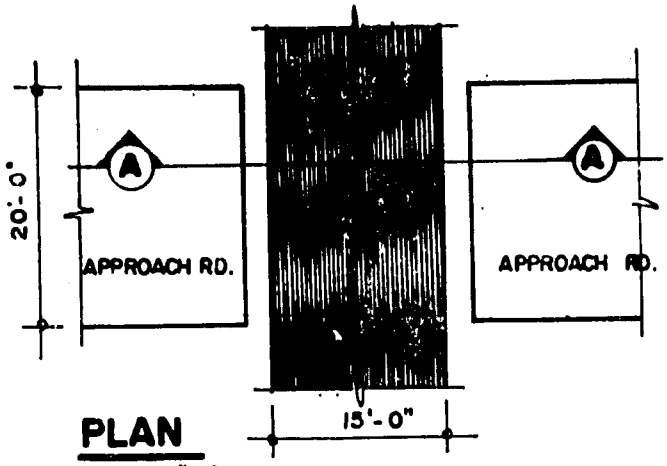
SPECIFICATIONS

- ABUTMENT AND WINGWALLS ARE BRICK MASONRY. BED BLOCKS AND FOUNDATIONS ARE CONCRETE ABUTMENTS AND WINGWALLS ARE BUILT AS ONE UNIT.
- 2" IRON PIPE MAY BE SUBSTITUTED FOR CONCRETE RAILS BETWEEN THE CONCRETE POSTS.
- PROVIDE WEEP HOLES 5"X3" IN ABUTMENT AND WINGWALLS EVERY 5'-0" VERTICALLY AND HORIZONTALY.
- SLAB TO BE POURED AT ONE TIME, PROVIDE DRAINAGE HOLES IN CURB EVERY 5'-0", BARS FOR RAILING POSTS SHALL BE PLACED BEFORE THE SLAB IS POURED.

ROD BENDING SCHEDULE

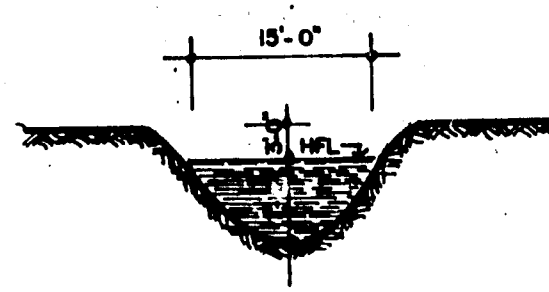
MARK	DIA	NOS.	LENGTH	FINAL SHAPE
R_3	3/8" Ø	13X5X2	2'-6"	
R_4	5/8" Ø	2X2X4	18'-2"	
R_5	1/4" Ø	4 X 61	2'-0"	

DESIGN EXAMPLE C-12



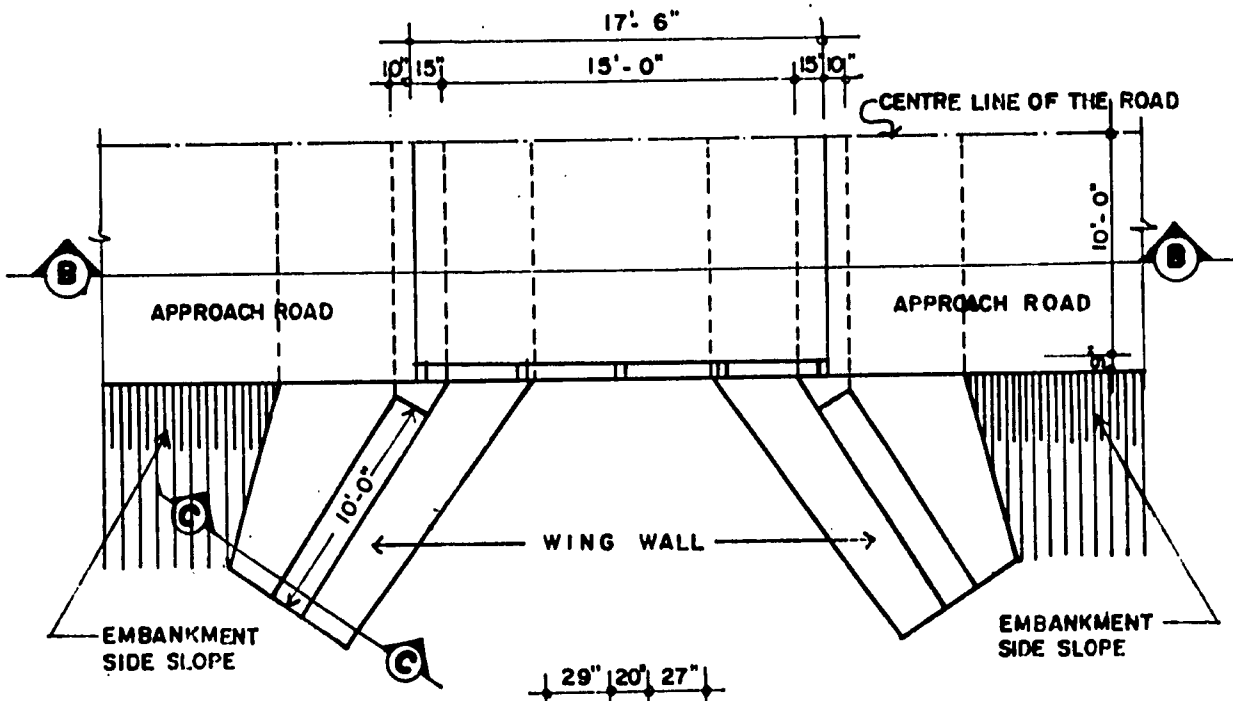
PLAN

SCALE: 1/16" = 1'-0"



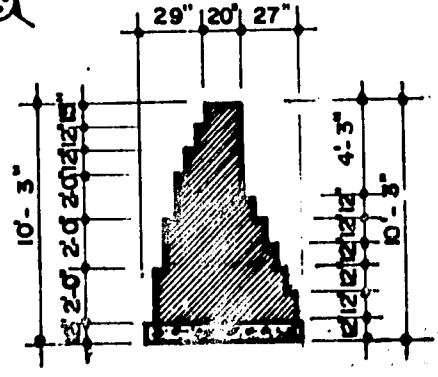
SECTION A-A

SCALE: 1/16" = 1'-0"



PLAN

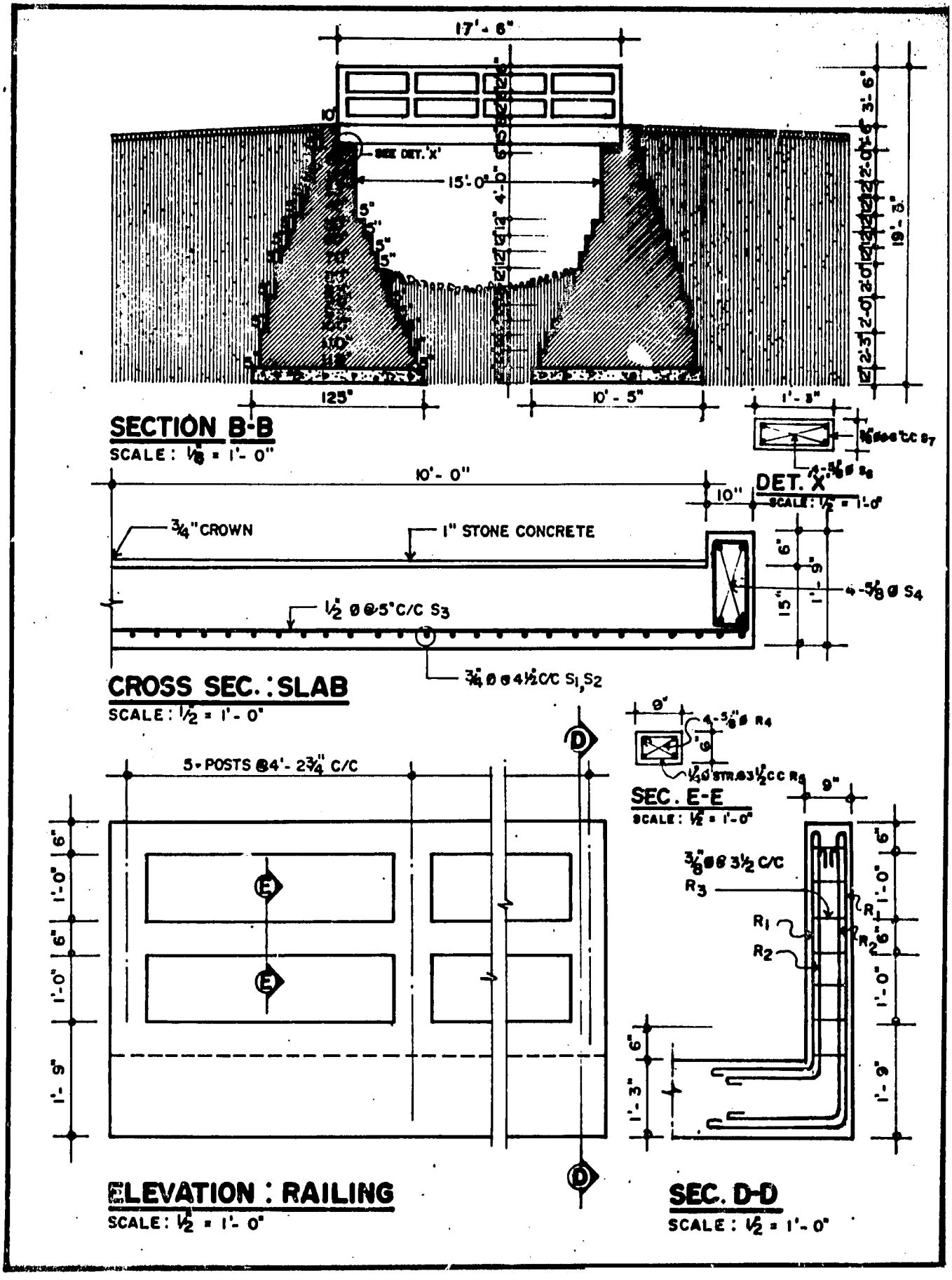
SCALE: 1/8" = 1'-0"



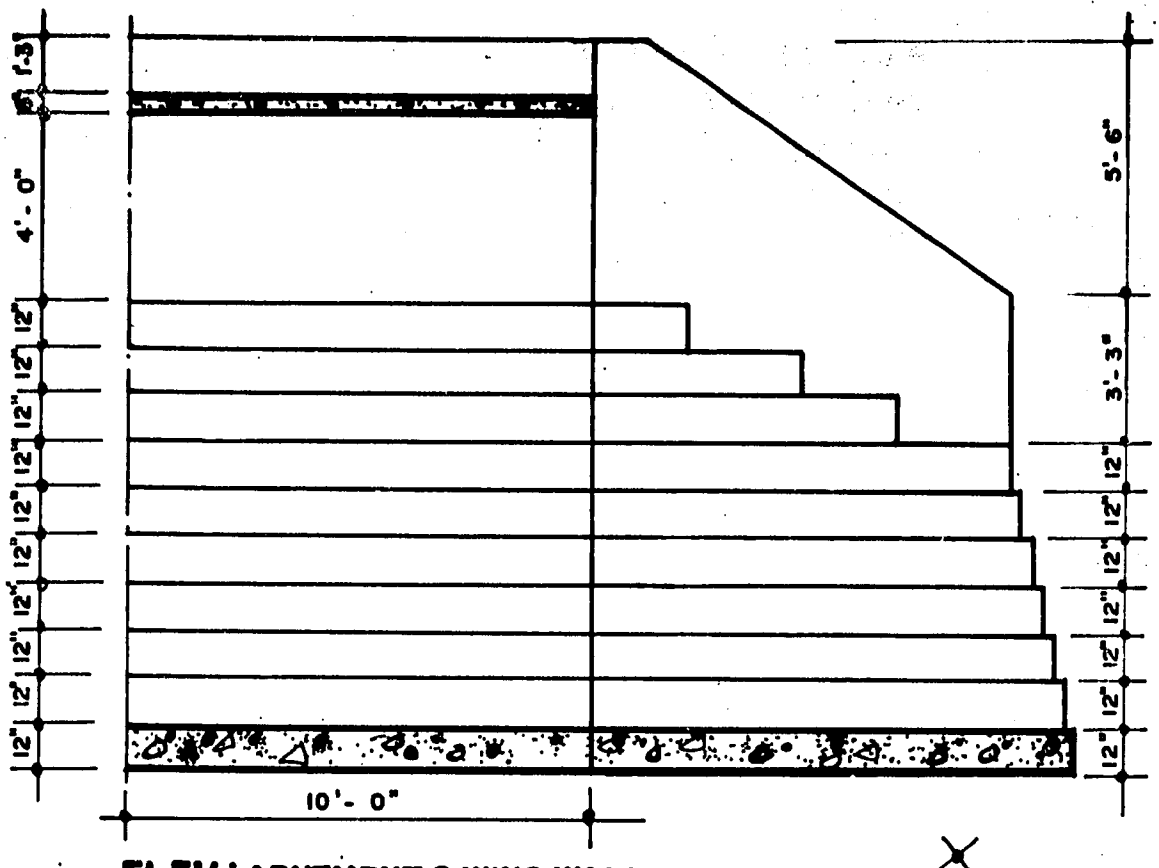
SECTION C-C

SCALE: 1/16" = 1'-0"

DESIGN EXAMPLE C-12

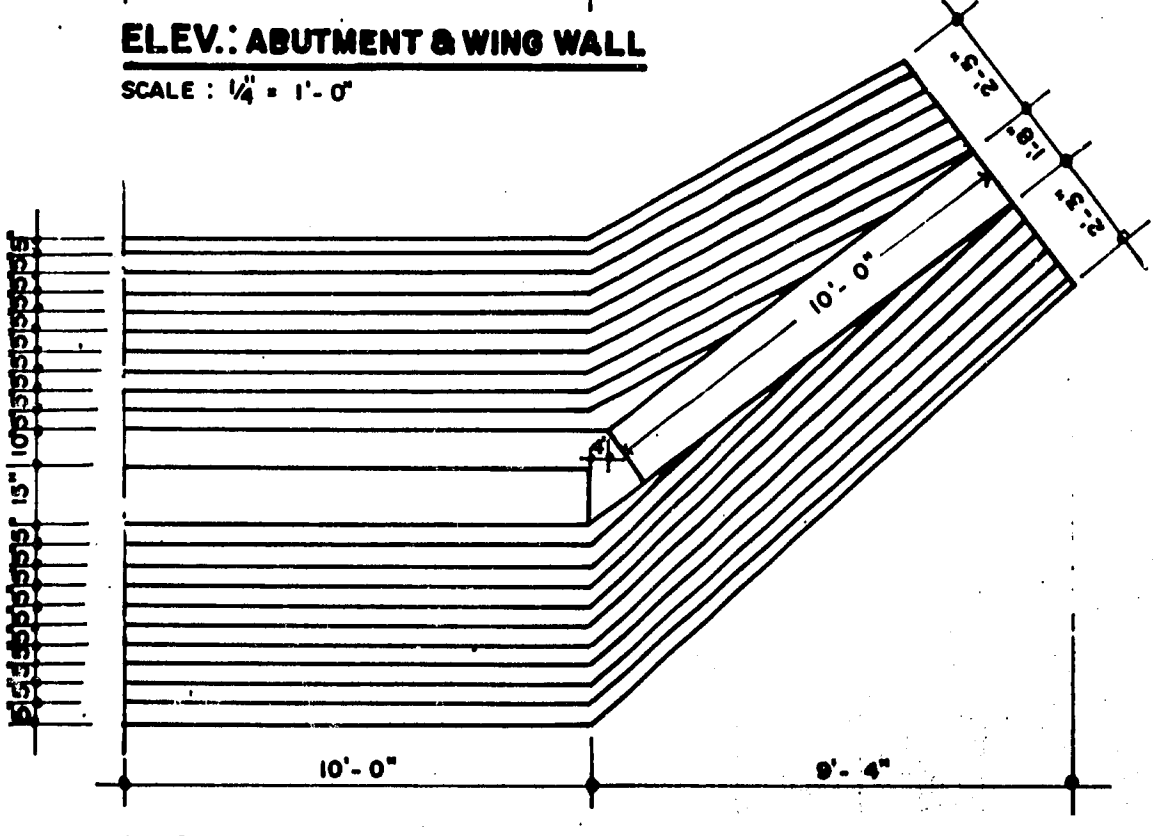


DESIGN EXAMPLE C - 12



ELEV.: ABUTMENT & WING WALL

SCALE : 1/4" = 1'- 0"



PLAN : ABUTMENT & WINGWALL

SCALE : 1/4" = 1'- 0"

DESIGN EXAMPLE C-12

SPECIFICATIONS

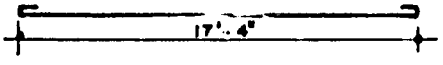
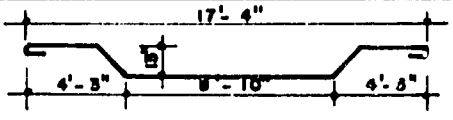
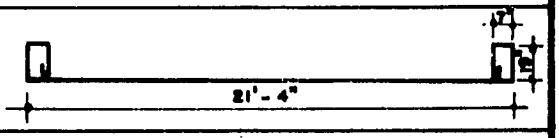
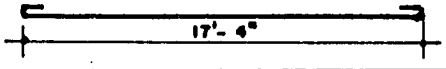
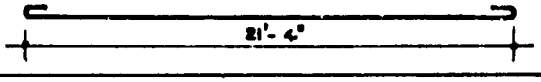
R.C.C SLAB BRIDGE
CHANNEL WIDTH - 15'-0"
CHANNEL DEPTH - 7'-0"
ROADWAY WITH - 20'-0"
SOIL CONDITION : NOT SO SATISFACTORY.

- 1ST. CLASS BRICK.
- 1:4 MORTAR MIX. FOR BRICK WORK
- 1:3 MORTAR MIX. FOR ALL EXPOSED PLASTER WORK.
- 1:1½:3 MIX. FOR RE[illegible]RCED CONCRETE WORK.
- 1:3:6 MIX. FOR CEMENT CONCRETE WORK.

MATERIALS

BRICK WORK	CEMENT CONCRETE	BRICKS	CEMENT	SAND	KHOA	STONE CHIPS	M. S. RODS.
5410 CFT.	C.C 773 CFT. R.C.C. 551 CFT.	62210 NOS.	552 BAG.	2302 CFT.	1196 CFT.	50 CFT.	¼" ø —— 85# ⅜" ø —— 540# ½" ø —— 850# ⅝ ø —— 260# ¾" ø —— 1687# ⅞" ø —— 837#

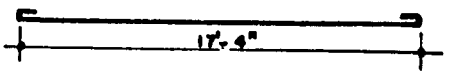
ROD BENDING SCHEDULE

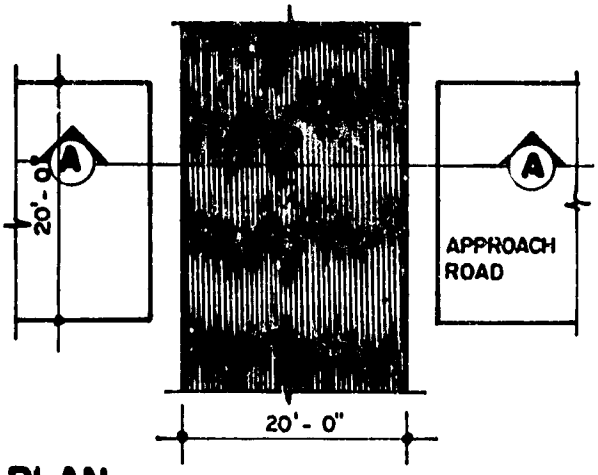
MARK	DIA	NOS.	LENGTH	FINAL SHAPE
S_1	¾" ø	30	18'-4"	
S_2	¾" ø	30	13'-2"	
S_3	½" ø	43	29'-6"	
S_4	⅝" ø	2X2	18'-2"	
S_5	⅝" ø	2X4	22'-2"	
S_6	⅜" ø	2X45	3'-4"	
R_1	⅞ ø	2X2X5	7'-0"	
R_2	⅞" ø	2X2X2X5	6'-9"	

DESIGN EXAMPLE C-12

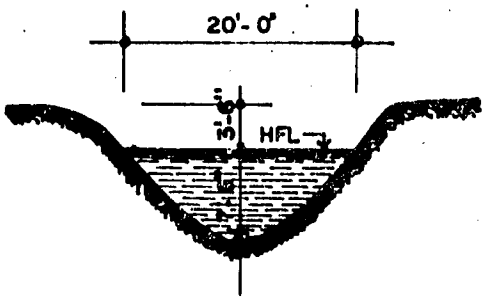
SPECIFICATIONS	• ABUTMENT AND WINGWALLS ARE BRICK MASONRY. BED BLOCKS AND FOUNDATIONS ARE CONCRETE ABUTMENTS AND WINGWALLS ARE BUILT AS ONE UNIT. • SLAB TO BE POURED AT ONE TIME, PROVIDE DRAINAGE HOLES IN CURB EVERY 5'-0", BARS FOR RAILING POSTS SHALL BE PLACED BEFORE THE SLAB IS POURED. • 2" IRON PIPE MAY BE SUBSTITUTED FOR CONCRETE RAILS BETWEEN THE CONCRETE POSTS. • PROVIDE WEEP HOLES 5"X3" IN ABUTMENT AND WINGWALLS EVERY 5'-0" VERTICALLY AND HORIZONTALY.

ROD BENDING SCHEDULE

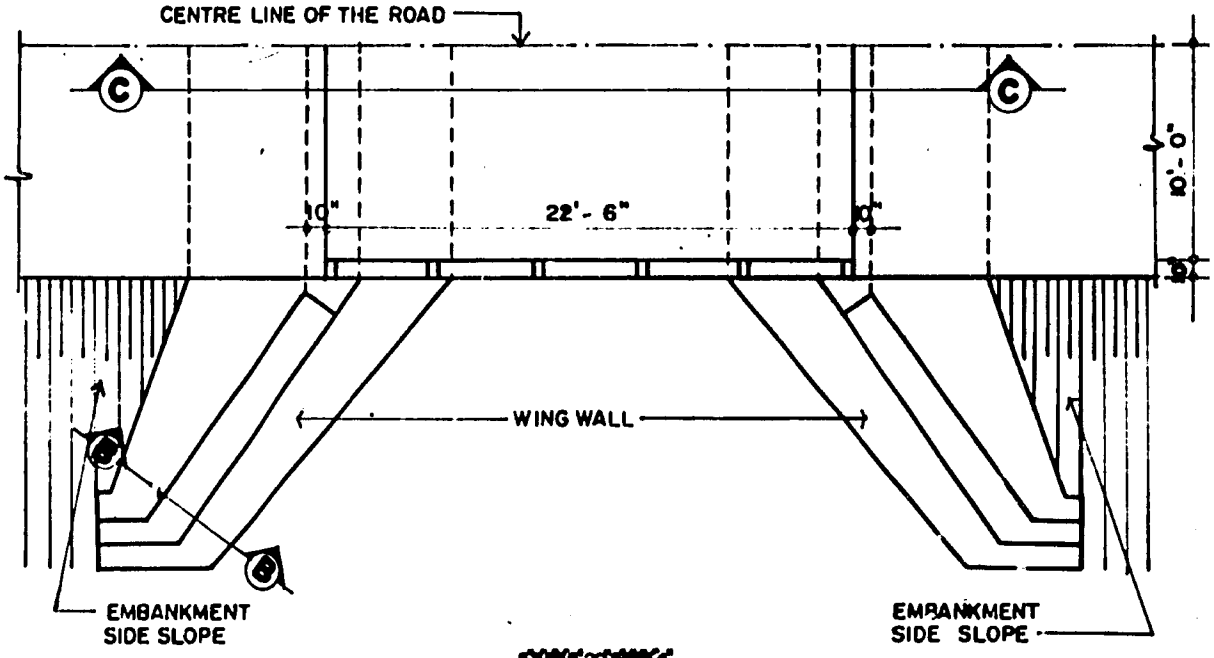
MARK	DIA	NOS.	LENGTH	FINAL SHAPE
R_3	3/8" Ø	13X5X2	2'-6"	
R_4	5/8" Ø	2X2X4	18'-2"	
R_5	1/4" Ø	4X61	2'-0"	



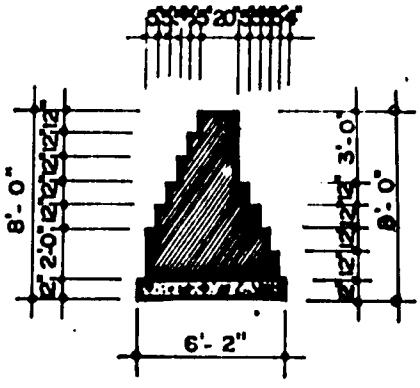
PLAN
SCALE: 1/16" = 1'-0"



SEC. A-A
SCALE: 1/16" = 1'-0"

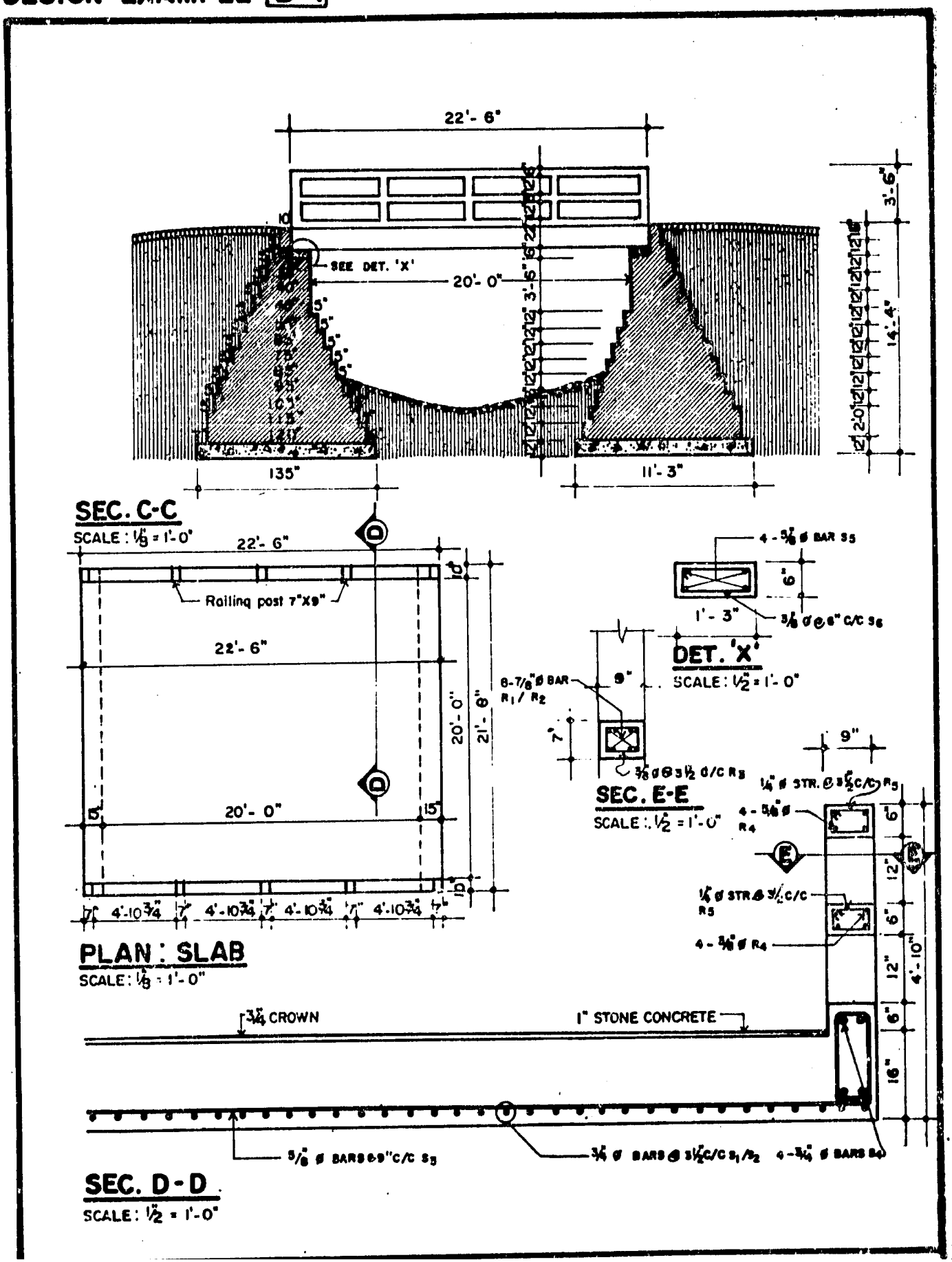


PLAN
SCALE: 1/8" = 1'-0"

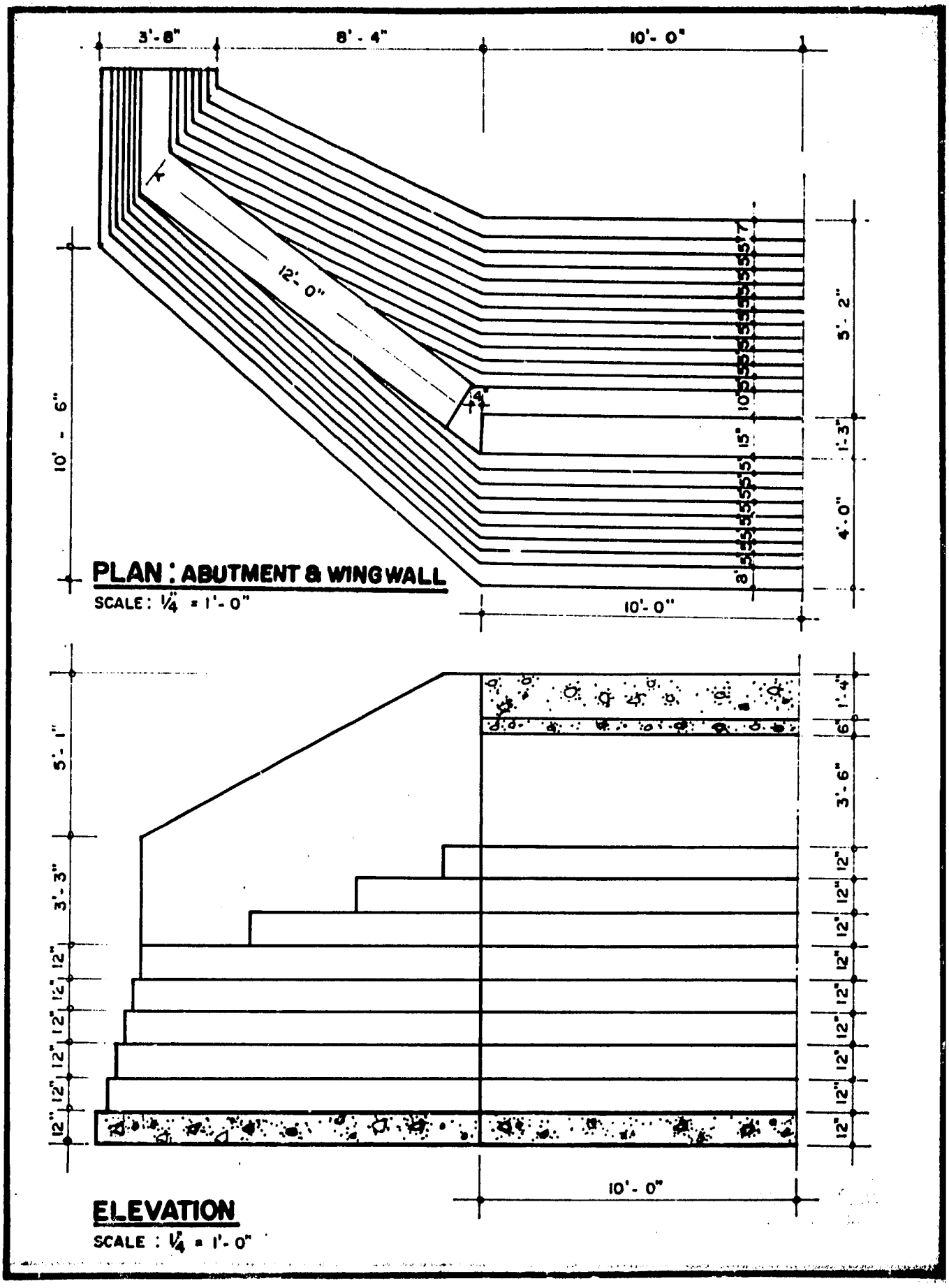


SEC. B-B
SCALE: 1/8" = 1'-0"

DESIGN EXAMPLE B-1



DESIGN EXAMPLE B-1



DESIGN EXAMPLE B-1

SPECIFICATIONS

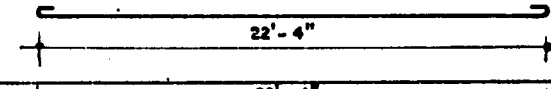
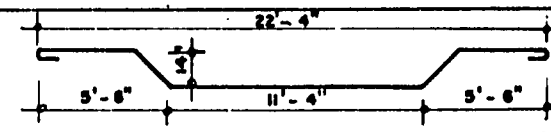
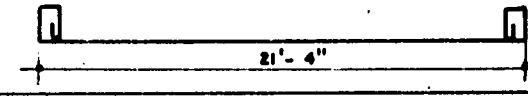
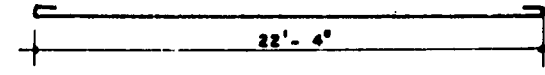
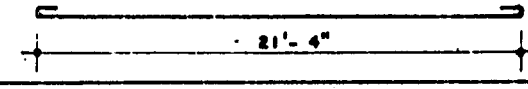
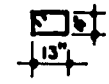
R.C.C SLAB BRIDGE
CHANNEL WIDTH – 20'-0"
CHANNEL DEPTH – 7'-6"
ROAD WAY WITH – 20'-0"
SOIL CONDITION SATISFACTORY

- 1ST. CLASS BRICK.
- 1:4 MORTAR MIX. FOR BRICK WORK.
- 1:3 MORTAR MIX. FOR ALL EXPOSED PLASTER WORK.
- 1:1½:3 MIX. FOR REINFORCED CONCRETE WORK.
- 1:3:6 MIX. FOR CEMENT CONCRETE WORK.

MATERIALS

BRICK WORK	CEMENT CONCRETE	BRICKS	CEMENT	SAND	KHOA	STONE CHIPS	M. S. RODS
6190 CFT	C.C 1041 CFT. R.C.C 744 CFT.	71300 NOS	675 BAG.	2770 CFT.	1615 CFT.	64 CFT.	¼" Ø — 104# 3/8" Ø — 216# 5/8" Ø — 1540# ¾" Ø — 2980# 7/8" Ø — 1122#

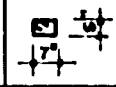
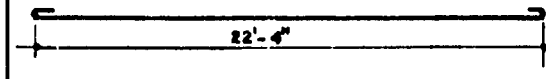
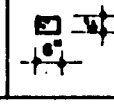
ROD BENDING SCHEDULE

MARK	DIA	NOS.	LENGTH	FINAL SHAPE
S_1	¾" Ø	38	23'-4"	
S_2	¾" Ø	37	24'-4"	
S_3	5/8" Ø	31	30'-6"	
S_4	¾" Ø	2X4	23'-4"	
S_5	5/8" Ø	2X4	22'-2"	
S_6	3/8" Ø	2X45	3'-4"	
R_1	7/8" Ø	2X2X2X5	7'-0"	
R_2	7/8" Ø	2X2X2X5	6'-9"	

DESIGN EXAMPLE B-1

SPECIFICATIONS	● ABUTMENT AND WINGWALLS ARE BRICK MASONRY. BED BLOCKS AND FOUNDATIONS ARE CONCRETE ABUTMENTS AND WING WALLS ARE BUILT AS ONE UNIT. ● 2" IRON PIPE MAY BE SUBSTITUTED FOR CONCRETE RAILS BETWEEN THE CONCRETE POSTS ● PROVIDE WEEP HOLES 5"X3" IN ABUTMENT AND WINGWALLS EVERY 5'-0" VERTICALLY AND HORIZONTALY.

ROD BENDING SCHEDULE

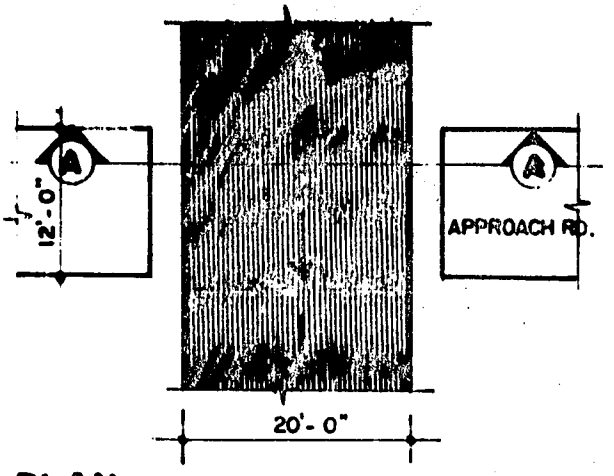
MARK	DIA	NOS.	LENGTH	FINAL SHAPE
R_3	3/8 ø	13X5X2	2'- 6"	
R_4	5/8" ø	2X2X4	23'- 2"	
R_5	1/4" ø	4 X78	2'- 0"	

DESIGN EXAMPLE B-2

- CHANNEL WIDTH : 20'- 0"
  CHANNEL DEPTH : 7'- 6"
  ROAD WAY WIDTH : 20'- 0"
  SOIL CONDITION : NOT SO SATISFACTORY

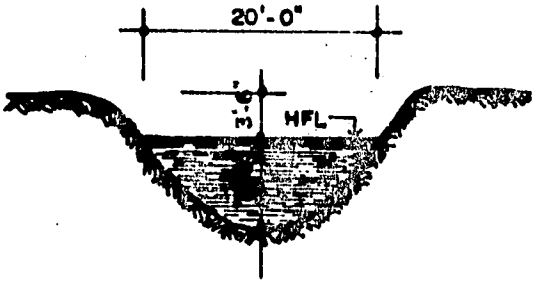
- SAME AS DESIGN EXAMPLE B_1 WITH THE ADDITION SAL BALLAH PILES 6" TO 8" IN DIAMETER AND LENGTH 8'-0".

- 12" CEMENT CONCRETE WILL BE PUT ON TOP OF THE PILES. BEFORE BRICK WORK IS DONE.



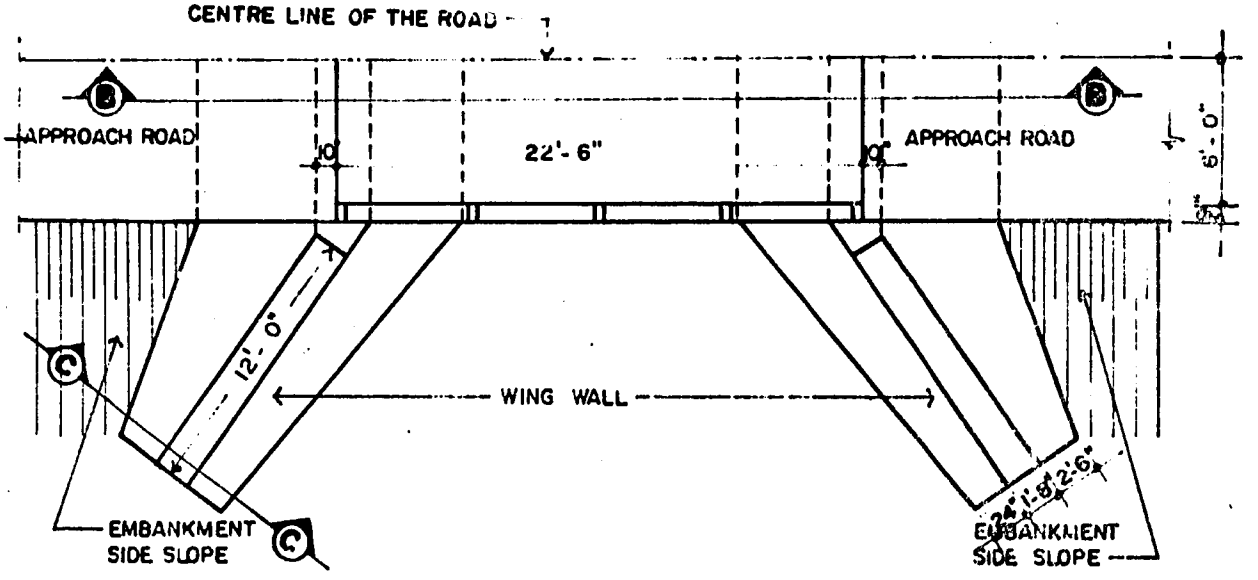
PLAN

SCALE : 1/16" = 1'-0"



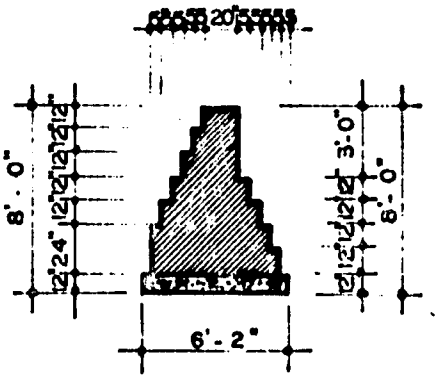
SECTION A-A

SCALE : 1/16" = 1'-0"



PLAN

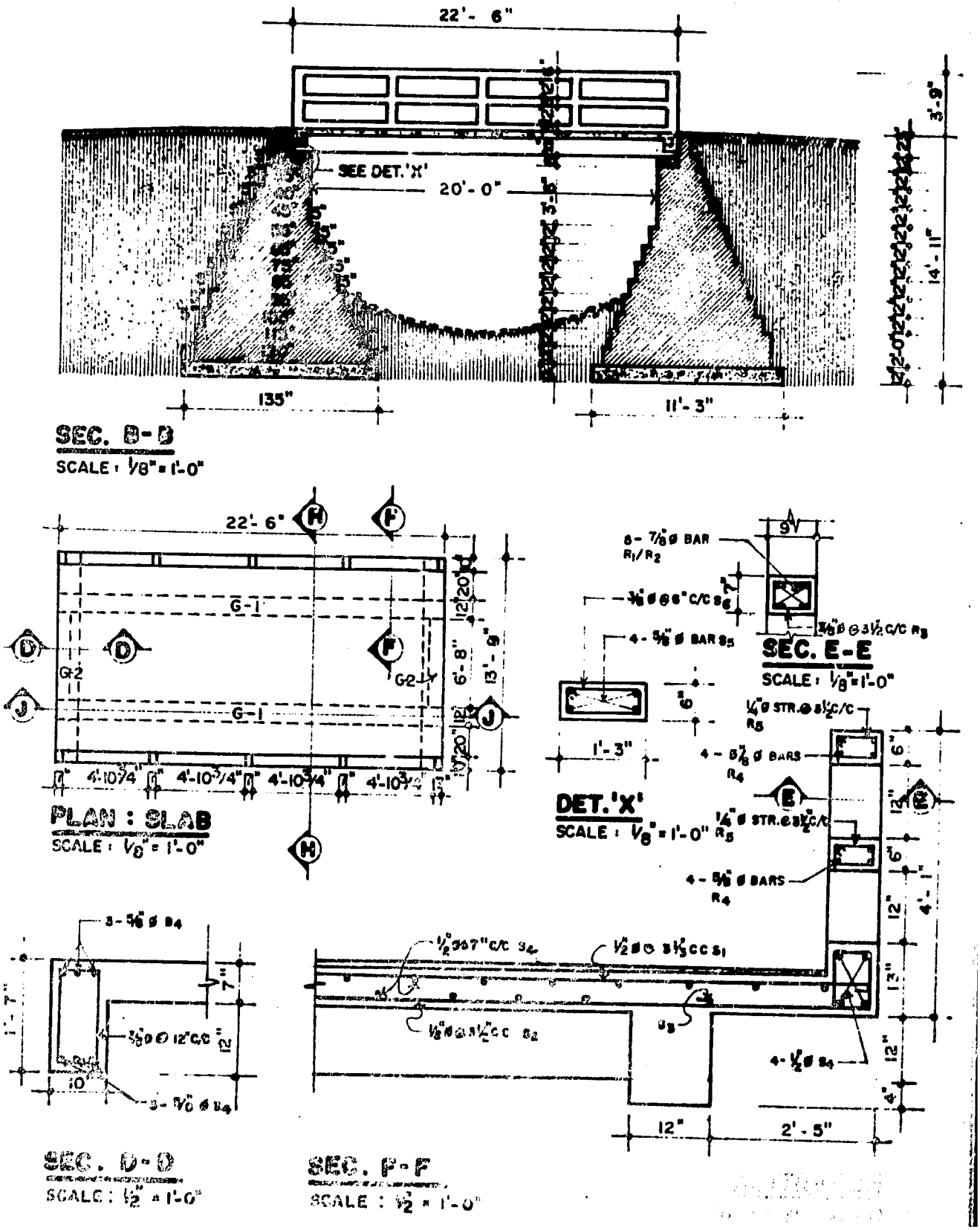
SCALE : 1/8" = 1'-0"



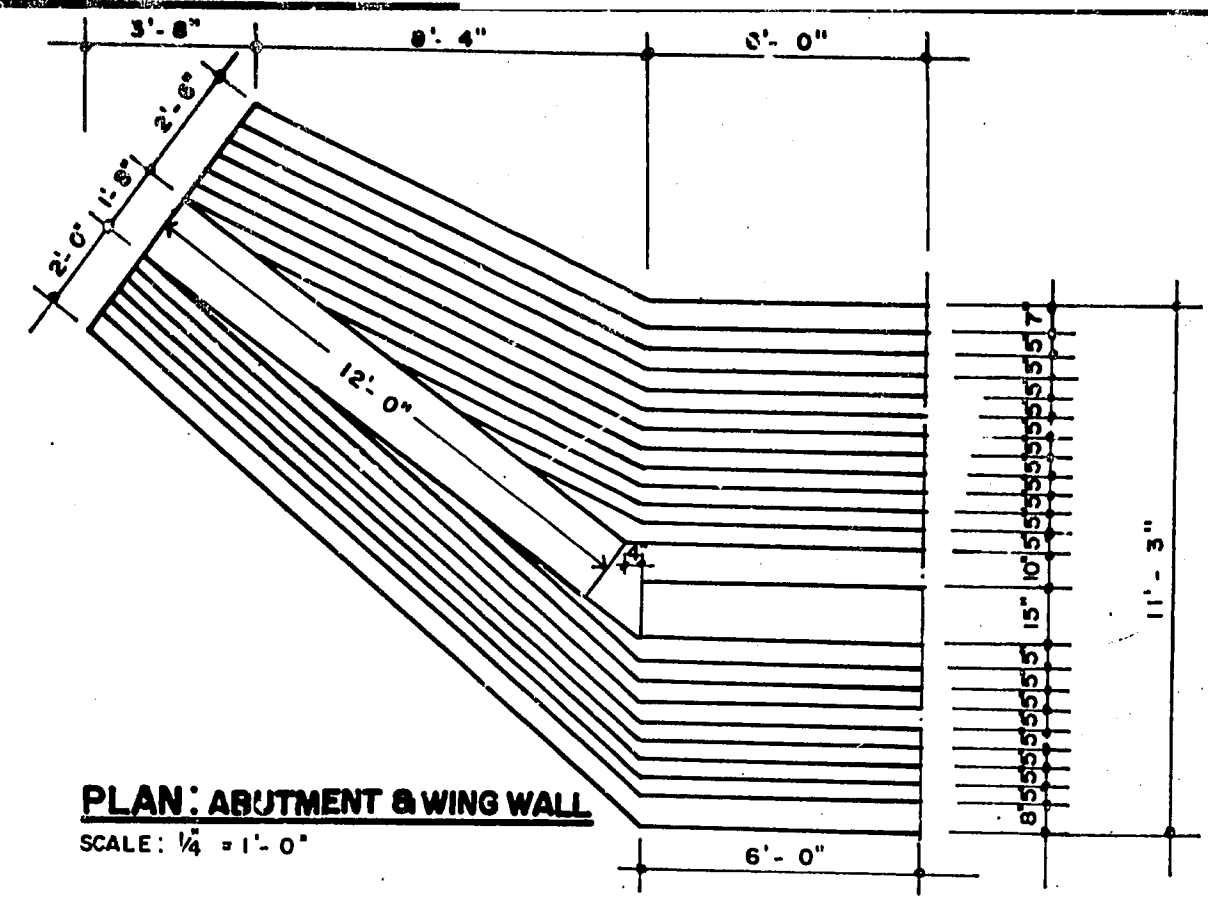
SECTION C-C

SCALE : 1/8" = 1'-0"

DESIGN EXAMPLE B-3

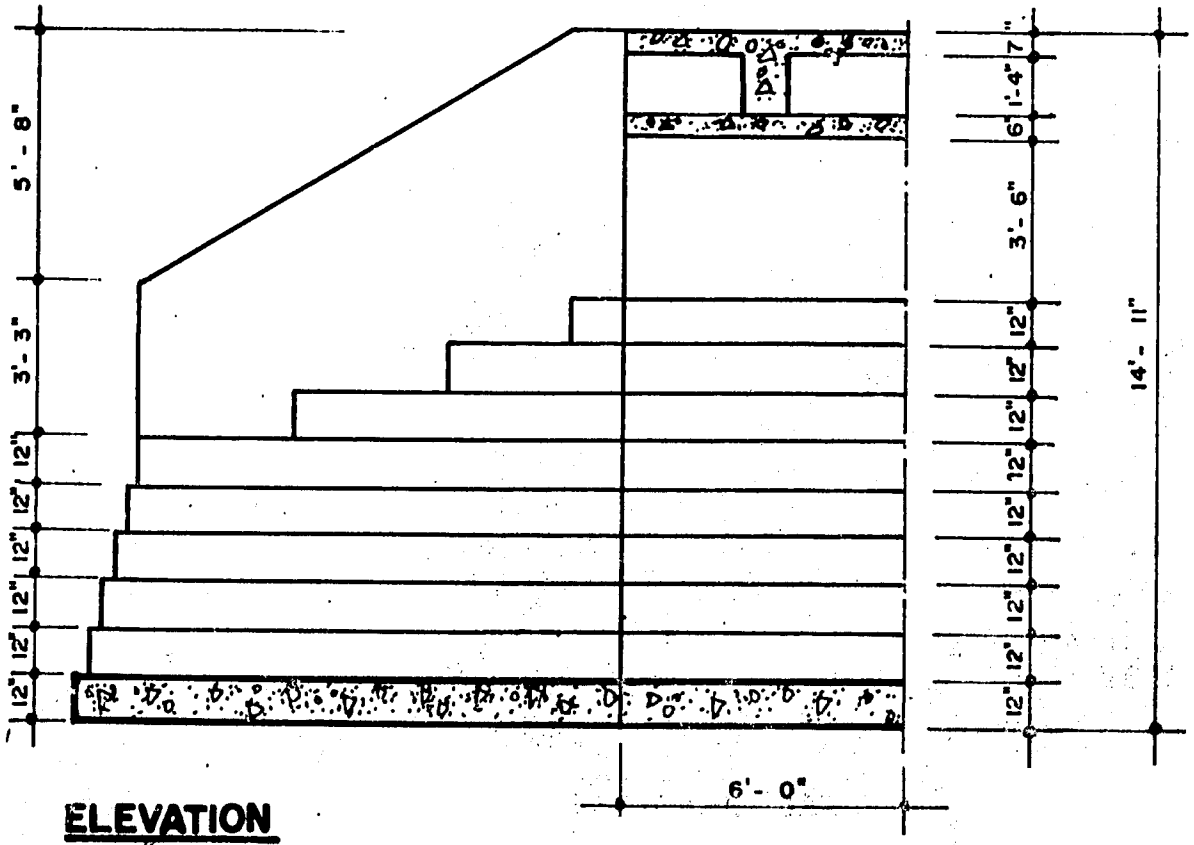


DESIGN EXAMPLE B-3



PLAN: ABUTMENT & WING WALL

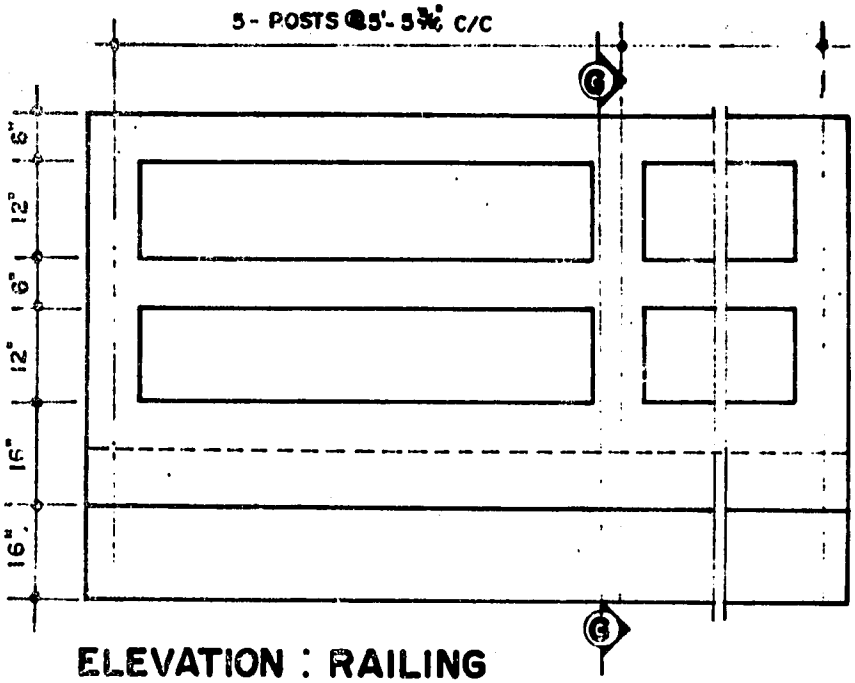
SCALE: 1/4" = 1'- 0"



ELEVATION

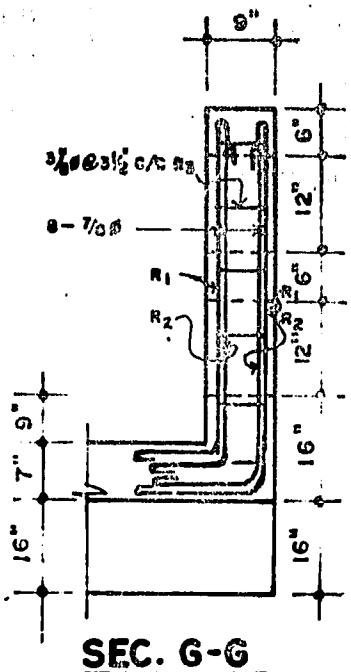
SCALE: 1/4" = 1'-0"

DESIGN EXAMPLE 3-3



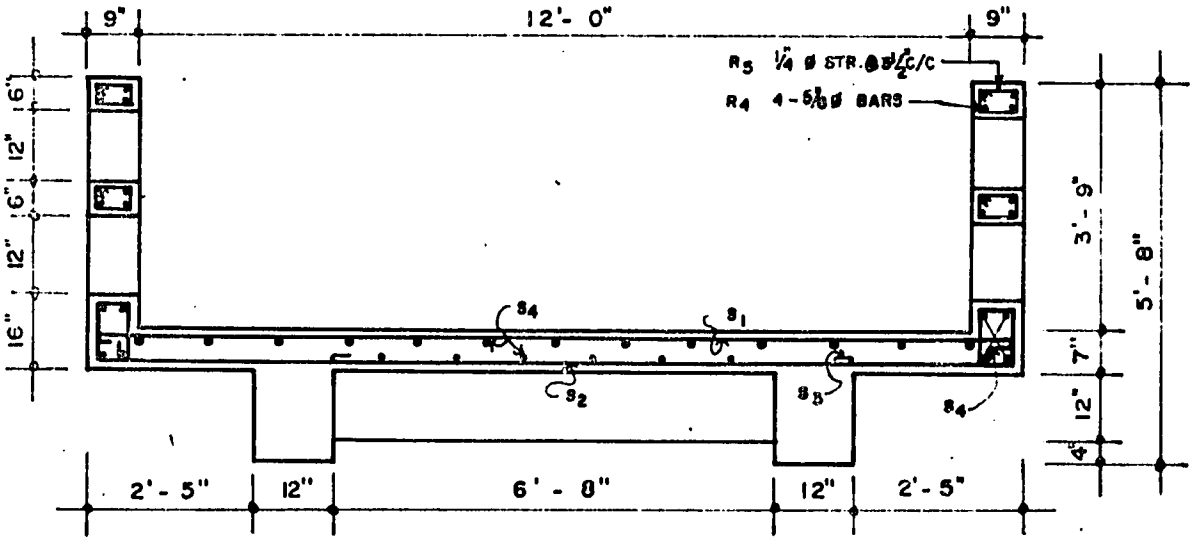
ELEVATION : RAILING

SCALE : 1/2" = 1' - 0"



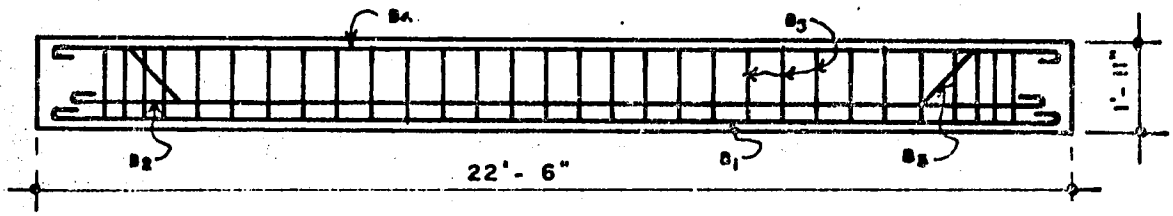
SEC. G-G

SCALE : 1/2" = 1'- 0"



SEC. H-H

SCALE : 3/8" = 1'- 0"



SEC. J-J

SCALE : 1/4" = 1'-0"

DESIGN EXAMPLE B-3

SPECIFICATIONS

R.C.C. T-BEAM BRIDGE.
CHANNEL WIDTH — 20'-0"
CHANNEL DEPTH — 7'-6"
ROADWAY WIRTH — 12'-0"
SOIL CONDITION SATISFACTORY

- IST. CLASS BRICK.
- 1:4 MORTAR MIX. FOR BRICK WORK
- 1:3 MORTAR MIX. FOR ALL EXPOSED PLASTER WORK.
- 1:1½:3 MIX. FOR REINFORCED CONCRETE WORK.
- 1:3:6 MIX. FOR CEMENT CONCRETE WORK.

MATERIALS

BRICK WORK	CEMENT CONCRETE	BRICKS	CEMENT	SAND	KHOA	STONE CHIPS	M.S. RODS.
4420 CFT.	C.C 730 CFT RCC. 298 CFT.	51000 NOS.	431 BAGS	1780 CFT.	930 CFT.	40 CFT.	¼" Ø — 105# ⅜" Ø — 800# ½" Ø — 2220# ⅝" Ø — 590# ⅞" Ø — 1040# 1" Ø — 1025#

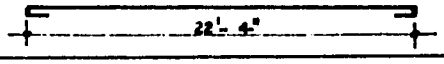
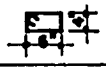
ROD BENDING SCHEDULE

MARK	DIA	NOS.	LENGTH	FINAL SHAPE
B_1	1" Ø	2X3	23'-11"	22'-3"
B_2	1" Ø	2X3	23'-5"	21'-9"
B_3	1" Ø	2X2	24'-10"	1'-9", 14'-6", 22'-3"
B_4	⅝" Ø	2X2	23'-1"	22'-3"
B_5	⅜" Ø	2X33	5'-4"	2'-0", 9"
S_1	½" Ø	78	14'-0"	13'-4"
S_2	½" Ø	39	18'-8"	13'-4", 1"
S_3	½" Ø	39	9'-4"	8'-8"
S_4	½" Ø	50	22'-10"	22'-4"
S_5	⅝" Ø	4X2	12'-10"	12'-0"
S_6	⅜" Ø	25X2	3'-4"	9"
R_1	⅞" Ø	4X10	6'-7"	3"

DESIGN EXAMPLE B-3

SPECIFICATIONS	● ABUTMENT AND WINGWALLS ARE BRICK MASONRY. BED BLOCKS AND FOUNDATIONS ARE CONCRETE ABUTMENTS AND WINGWALLS ARE BUILT AS ONE UNIT. ● SLAB AND BEAMS TO BE POURE AT ONE TIME, PROVIDE DRAINAGE IN CURB EVERY 5'-0". BARS FOR RAILING POSTS SHALL BE PLACED BEFORE THE SLAB IS POURED. ● 2" IRON PIPE MAY BE SUBSTITUTED FOR CONCRETE RAILS BETWEEN THE CONCRETE POSTS. ● PROVIDE WEEP HOLES 5"X3" IN ABUTMENT AND WINGWALLS EVERY 5'-0" VERTICALLY AND HORIZONTALY.

ROD BENDING SCHEDULE

MARK	DIA	NOS.	LENGTH	FINAL SHAPE
R_2	7/8" Ø	4X10	6'X1"	
R_3	3/8" Ø	10X11	2'-6"	
R_4	5/8" Ø	4X4	23'-2"	
R_5	1/4" Ø	4X78	2'-0"	

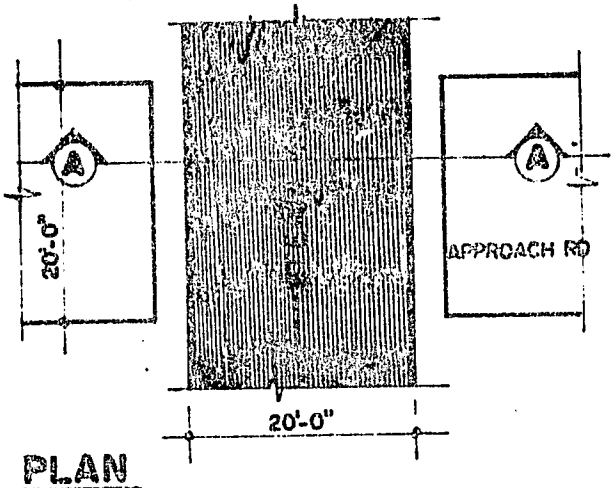
DESIGN EXAMPLE B-4

- CHANNEL WIDTH : 20'-0"
  CHANNEL DEPTH : 7'-6"
  ROAD WAY WIDTH : 12'-0"
  SOIL CONDITION : NOT SO SATISFACTORY

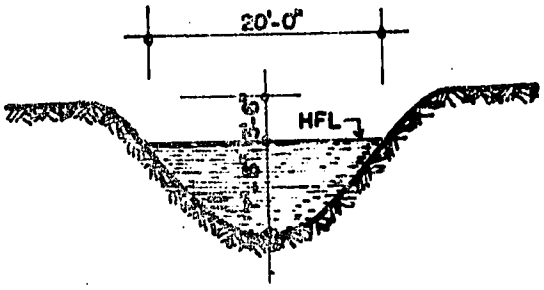
- SAME AS DESIGN EXAMPLE B_2 WITH THE ADDITION SAL BALLAH PILES 6" TO 8" IN DIAMETER AND LENGTH 8'-0"

- 12" CEMENT CONCRETE WILL BE PUT ON TOP OF THE PILES. BEFORE BRICK WORK IS DONE.

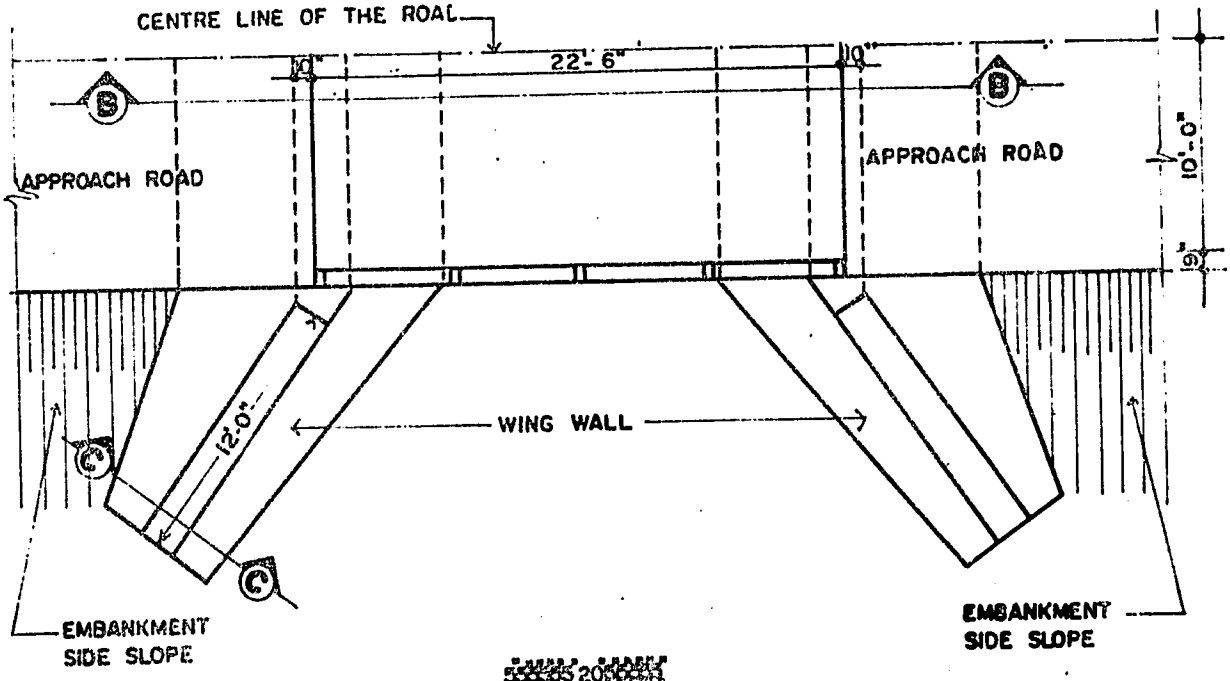
DESIGN EXAMPLE B-5



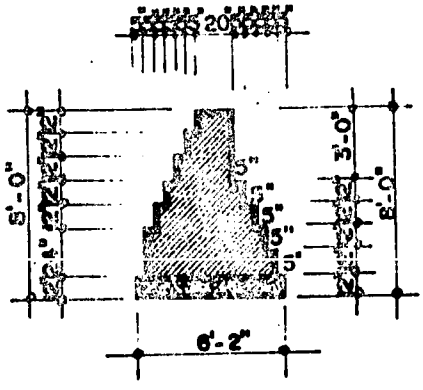
PLAN
SCALE : 1/16" = 1'- 0"



SECTION A-A
SCALE : 1/16" = 1'- 0"

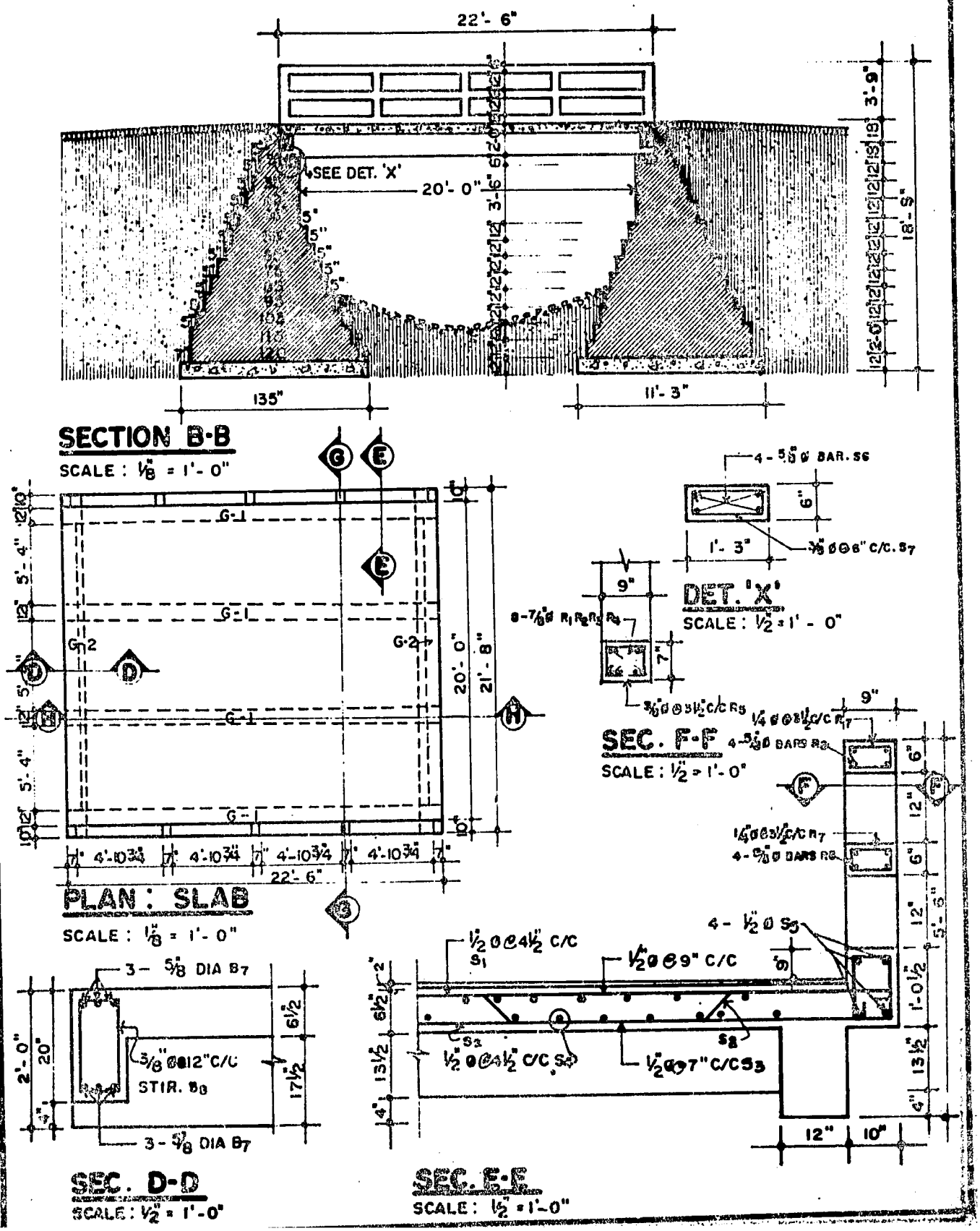


PLAN
SCALE : 1/8" = 1'- 0"

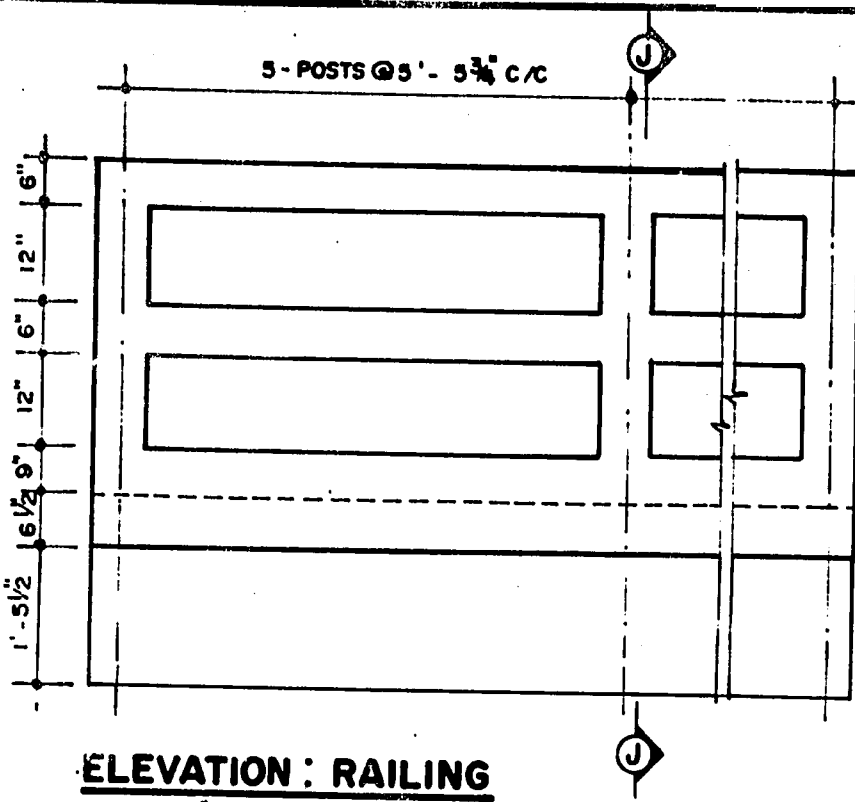


SECTION C-C
SCALE : 1/8" = 1'- 0"

DESIGN EXAMPLE B-5

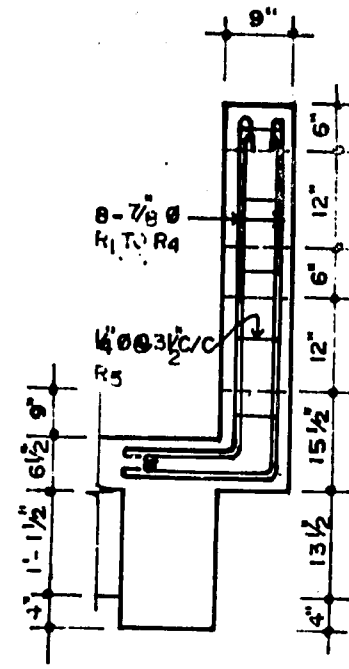


DESIGN EXAMPLE B-5



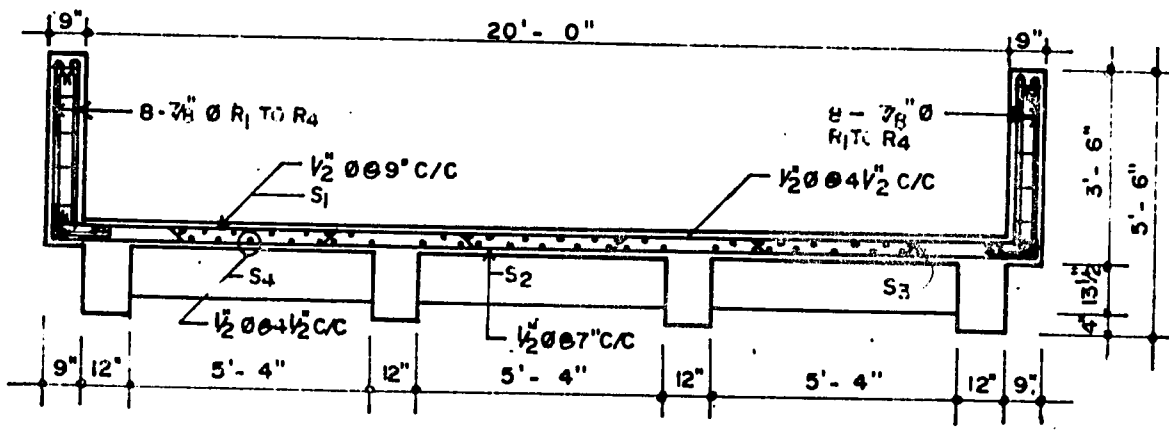
ELEVATION : RAILING

SCALE : ½" = 1' - 0"



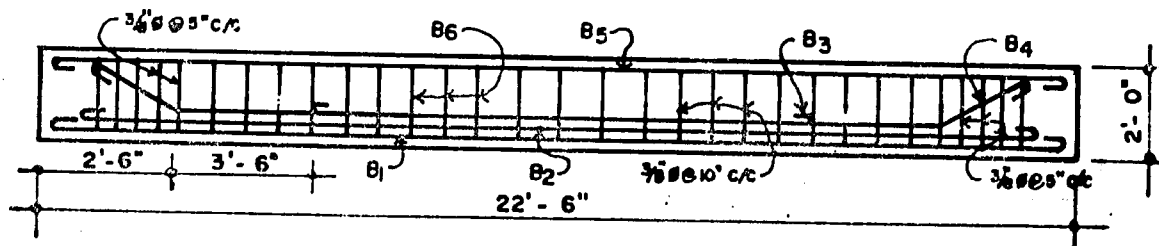
SEC. J-J

SCALE: ½" = 1' - 0"



SECTION G-G

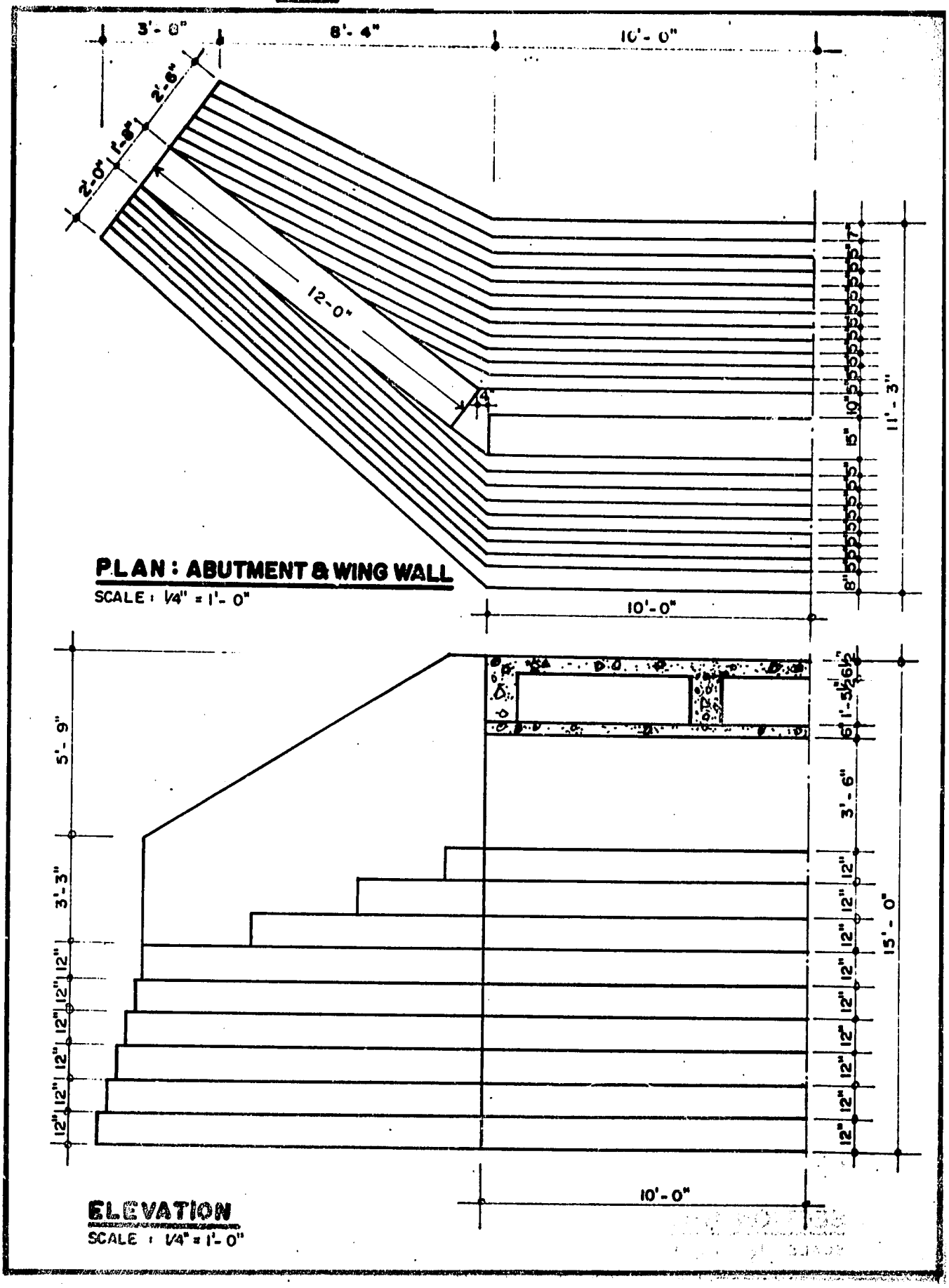
SCALE : ¼" = 1' - 0"



SECTION H-H

SCALE : ¼" = 1' - 0"

DESIGN EXAMPLE B-5



DESIGN EXAMPLE B-5

SPECIFICATIONS.

CHANNEL WIDTH- 20'-0"
CHANNEL DEPTH- 7'-6"
ROADWAY WIDTH- 20'-0"
SOIL CONDITION - SATISFACTORY

- IST CLASS BRICK.
- 1:4 MORTAR MIX. FOR BRICKWORK.
- 1:3 MORTAR MIX. FOR ALL EXPOSED PLASTER WORK.
- 1:1½:3 MIX. FOR REINFORCED CONCRETE WORK.
- 1:3:6 MIX. FOR CEMENT CONCRETE WORK.

MATERIALS.

BRICK WORK	CEMENT CONCRETE	BRICKS	CEMENT	SAND	KHOA	STONE CHIPS.	M.S RODS
4416 cft.	C.C. 730. cft. R.C.C. 295 cft.	51,000	431 Bags.	1780 cft.	930 cft.	40 cft.	3/4" ø 104 # 3/8" ø 700 # 1/2" ø 2020 # 5/8" ø 1020 # 7/8" ø 1620 #

ROD BENDING SCHEDULE.

MARK.	DIA.	NOS.	LENGTH.	FINAL SHAPE.
B_1	7/8" ø	3 X4	23'-5"	22'-3"
B_2	7/8" ø	3X4	22'-11"	21'-9"
B_3	7/8" ø	2X4	24'-0"	2'-4" 17'-6" 2'-4"
B_4	7/8" ø	1X4	11'-8"	10'-6"
B_5	5/8" ø	2X4	23'-1"	22'-3"
B_6	3/8" ø	4X45	5'-6"	21" 9"
B_7	5/8" ø	6X2	20'-7"	19'-9"
B_8	3/8" ø	7X3X2	4'-6"	17" 7"
S_1	1/2" ø	31	22'-2"	21'-6"
S_2	1/2" ø	31	23'-2"	2'-9" 3'-2" 21'-6"
S_3	1/2" ø	31	27'-10"	21'-6"
S_4	1/2" ø	3X10	23'-0"	22'-4"

DESIGN EXAMPLE B-5

SPECIFICATIONS

- ABUTMENT AND WINGWALLS ARE BRICK MASONRY. BED BLOCKS AND FOUNDATIONS ARE CONCRETE. ABUTMENTS AND WING WALLS ARE BUILT AS ONE UNIT.
- SLAB AND BEAMS TO BE POURE AT ONE TIME, PROVIDE DRAINAGE IN CURB EVERY 5'-0". BARS FOR RAILING POSTS SHALL BE PLACED BEFORE THE SLAB IS POURED.
- 2" IRON PIPE MAY BE SUBSTITUTED FOR CONCRETE RAILS BETWEEN THE CONCRETE POSTS.
- PROVIDE WEEPHOLES 5"X3" IN ABUTMENT AND WINGWALLS EVERY 5'-0" VERTICALLY AND HORIZONTALY.

ROD BENDING SCHEDULE.

MARK.	DIA.	NOS.	LENGTH	FINAL SHAPE.
S_5	1/2" Ø	2X4	23'-0"	22'-4"
S_6	5/8" Ø	4X2	20'-8"	19'-10"
S_7	3/8" Ø	2X40	3'-4"	4" 1'-1"
R_1	7/8" Ø	2X10	7'-8"	4'-0" 2'-6"
R_2	7/8" Ø	2X10	7'-2"	3'-6" 2'-6"
R_3	7/8" Ø	2X10	7'-5"	2'-6" 3'-9"
R_4	7/8" Ø	2X10	6'-11"	2'-6" 3'-3"
R_5	3/8" Ø	14X10	2'-6"	5" 7"
R_6	5/8" Ø	4X2X2		22'-4"
R_7	1/4" Ø	78X4	2'-0"	4" 6"

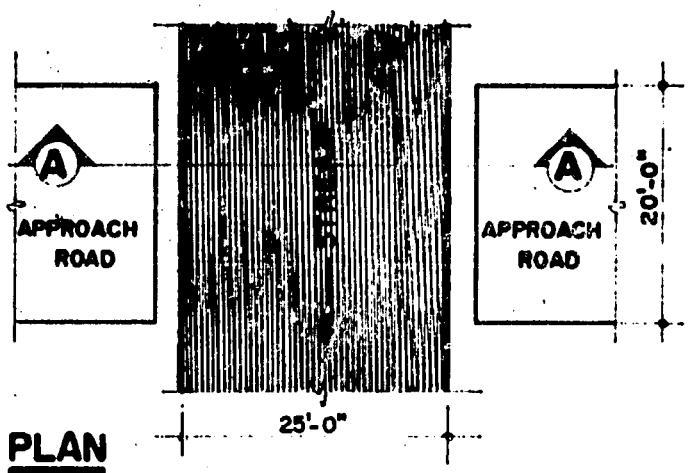
DESIGN EXAMPLE B-6

- CHANNEL WIDTH : 20'-0"
  CHANNEL DEPTH : 7'-6"
  ROAD WAY WIDTH : 20'-0"
  SOIL CONDITION : NOT SO SATISFACTORY

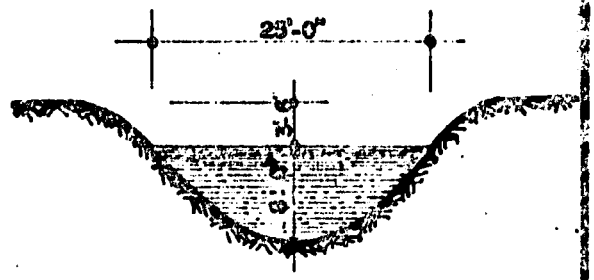
- SAME AS DESIGN EXAMPLE B_5 WITH THE ADDITION SAL BALLAH PILES 6" TO 8" IN DIAMETER AND LENGTH 8'-0"

- 12" CEMENT CONCRETE WILL BE PUT ON TOP OF THE PILES. BEFORE BRICK WORK IS DONE.

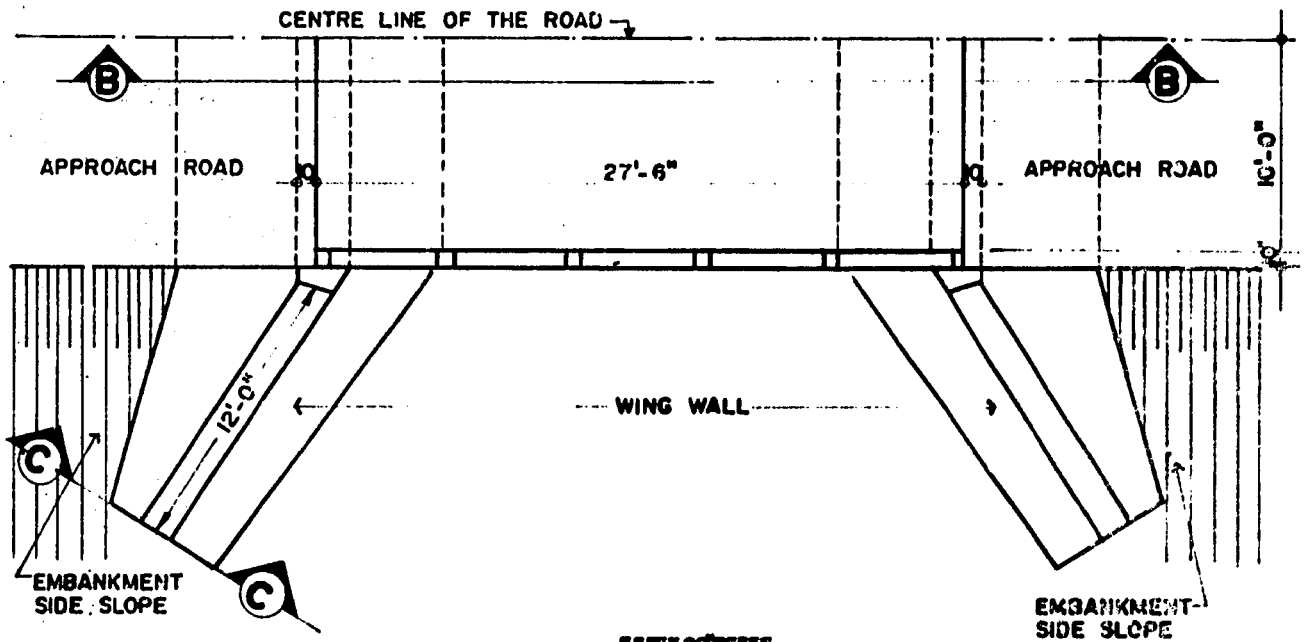
DESIGN EXAMPLE B-7



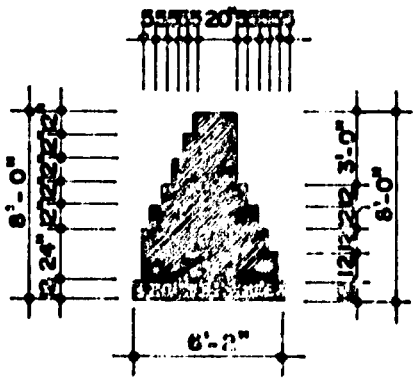
PLAN
SCALE: 1/16" = 1'-0"



SECTION A-A
SCALE: 1/16" = 1'-0"

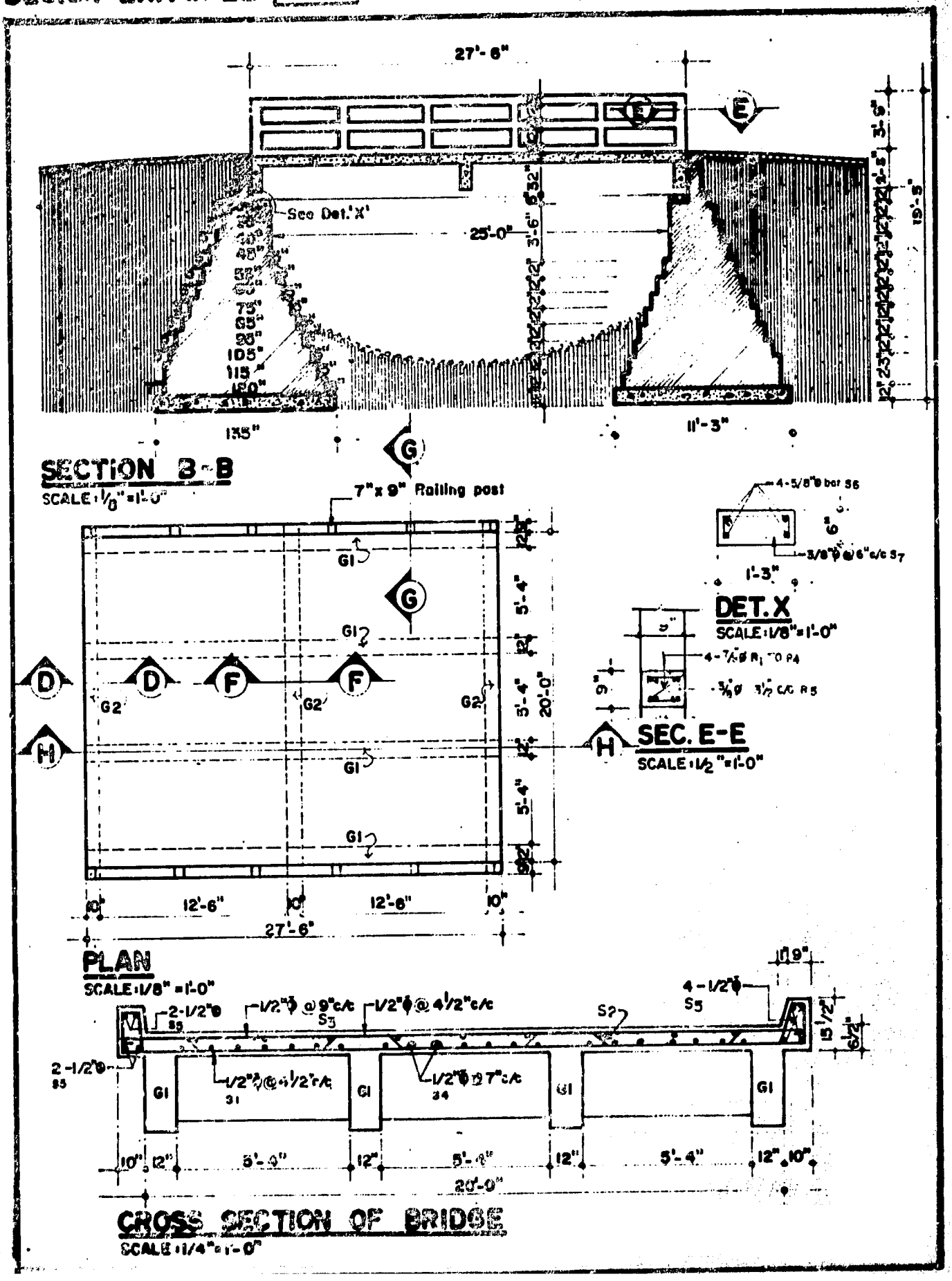


PLAN
SCALE: 1/8" = 1'-0"

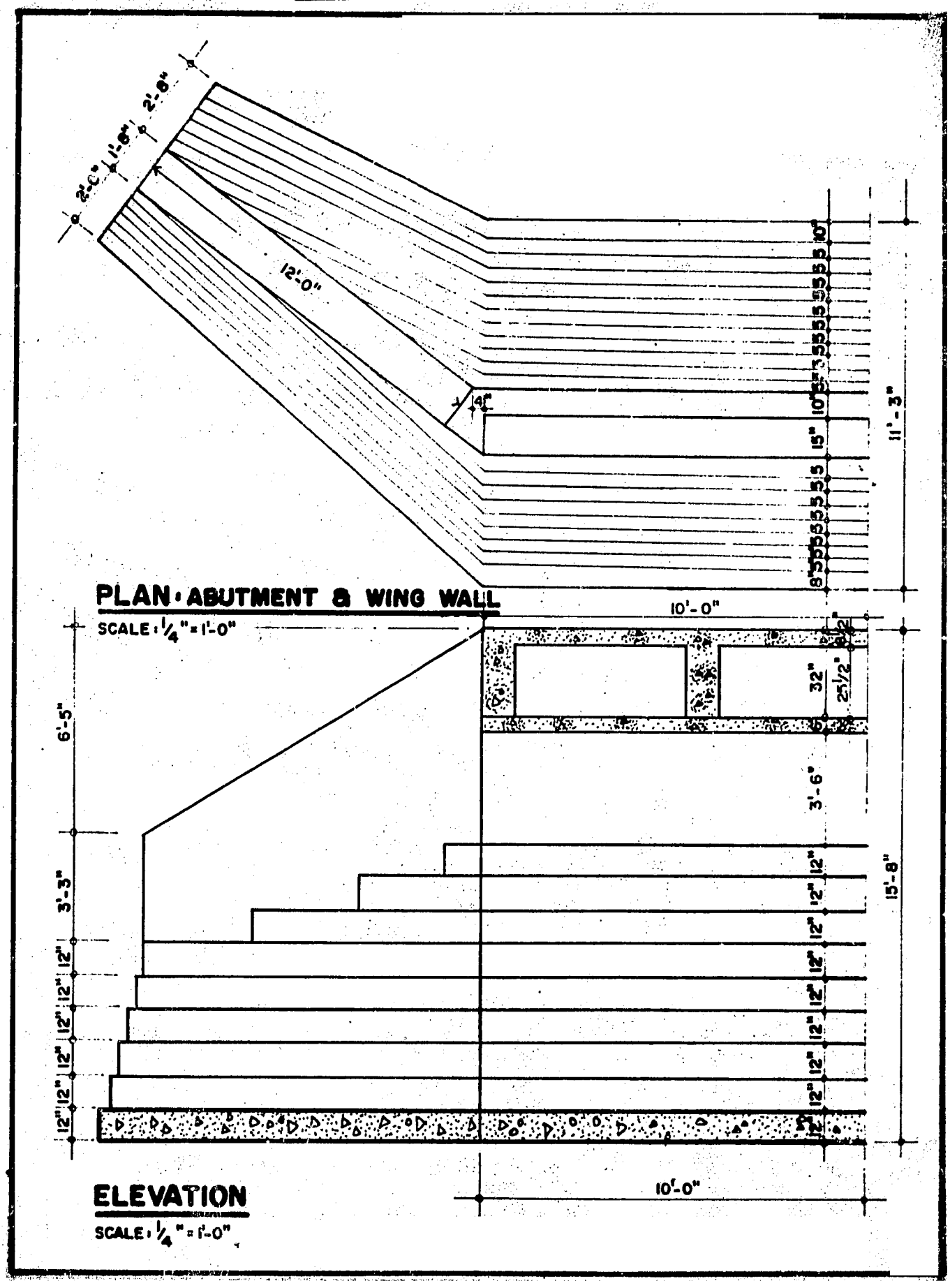


SECTION C-C
SCALE: 1/8" = 1'-0"

DESIGN EXAMPLE B-7



DESIGN EXAMPLE B - 7



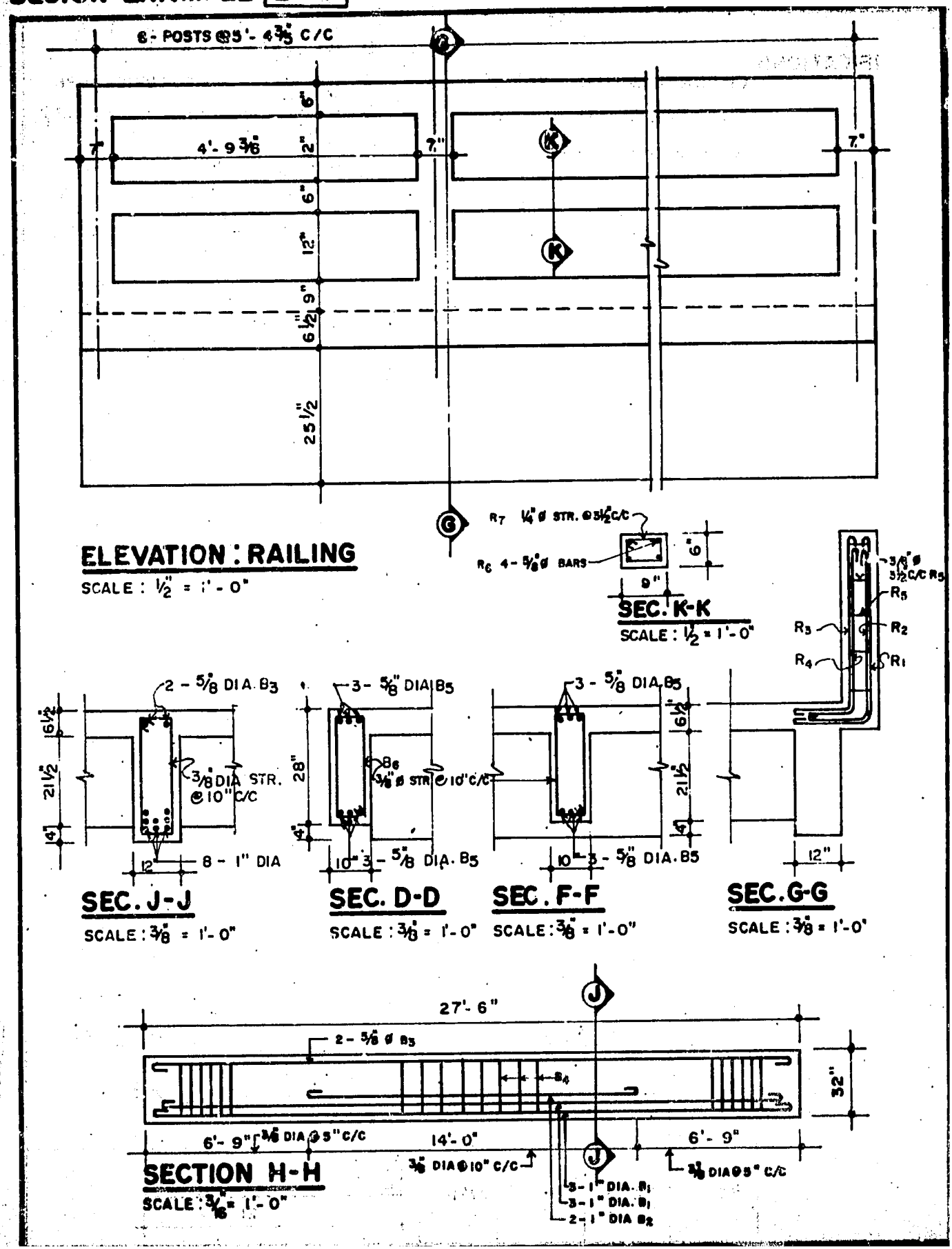
PLAN: ABUTMENT & WING WALL

SCALE: 1/4" = 1'-0"

ELEVATION

SCALE: 1/4" = 1'-0"

DESIGN EXAMPLE B-7



ELEVATION : RAILING
SCALE : 1/2" = 1'- 0"

SEC. K-K
SCALE : 1/2" = 1'- 0"

SEC. J-J
SCALE : 3/8" = 1'- 0"

SEC. D-D
SCALE : 3/8" = 1'- 0"

SEC. F-F
SCALE : 3/8" = 1'- 0"

SEC. G-G
SCALE : 3/8" = 1'- 0"

SECTION H-H
SCALE : 3/16" = 1'- 0"

DESIGN · EXAMPLE B-7

SPECIFICATIONS

CHANNEL WIDTH- 25'-0"
CHANNEL DEPTH- 8'-0"
ROADWAY WIDTH- 20'-0"
SOIL CONDITION- SATISFACTORY

- 1ST CLASS BRICK.
- 1:4 MORTAR MIX. FOR BRICKWORK.
- 1:3 MORTAR MIX. FOR ALL EXPOSED PLASTER WORK.
- 1:1½:3 MIX. FOR REINFORCED CONCRETE WORK.
- 1:3:6 MIX. FOR CEMENT CONCRETE WORK.

MATERIALS.

BRICK WORK	CEMENT CONCRETE	BRICKS	CEMENT	SAND	KHOA	STONE CHIPS	M.S RODS.
5480 cft.	C.C. 910 cft R.C.C 742 cft.	68,700 Nos.	620 Bags	2480 cft.	1490 cft.	80 cft.	1/4" ø 130 # 3/8" ø 921 # 1/2" ø 2570 # 5/8" ø 1262 # 7/8" ø 1420 # 1" ø 2154 #

ROD BENDING SCHEDULE.

MARK.	DIA	NOS.	LENGTH.	FINAL SHAPE.
B_1	1" ø	3X2X4	28'-7"	27'-3"
B_2	1" ø	2X4	15'-1"	13'-9"
B_3	5/8" ø	2X4	28'-1"	27'-3"
B_4	3/8" ø	51X4	6'-10"	29" / 9"
B_5	5/8" ø	6X3	20'-7"	19'-9"
B_6	3/8" ø	21X3	5'-10"	25" / 7"
S_1	1/2" ø	38	22'-2"	21'-6"
S_2	1/2" ø	38	23'-2"	9½" / 2'-8" 5'-2" / 21'-6"
S_3	1/2" ø	38	27'-10"	21'-8"

DESIGN EXAMPLE B-7

SPECIFICATIONS

- ABUTMENT AND WINGWALLS ARE BRICK MASONRY. BED BLOCKS AND FOUNDATIONS ARE CONCRETE. ABUTMENTS AND WINGWALLS ARE BUILT AS ONE UNIT.
- SLAB AND BEAMS TO BE POURED AT ONE TIME. PROVIDE DRAINAGE IN CURB EVERY 5'-0". BARS FOR RAILING POSTS SHALLBE PLACED BEFORE THE SLAB IS POURED.
- 2" IRON PIPE MAY BE SUBSTITUTED FOR CONCRETE RAILS BETWEEN THE CONCRETE POSTS.
- PROVIDE WEEPHOLES 3"X3" IN ABUTMENT AND WINGWALL EVERY 3'-0" VERTICALLY AND HORIZONTALY.

ROD BENDING SCHEDULE.

MARK.	DIA	NOS	LENGTH	FINAL SHAPE.
S_4	1/2" ø	3X10	28'-0"	27'-4"
S_5	1/2" ø	2X4	28'-0"	27'-4"
S_6	5/8" ø	4X2	20'-8"	19'-10"
S_7	3/8" ø	2X40	3'-4"	4" 1'-1"
R_1	7/8" ø	2X12	7'-8"	4'-0" 2'-6"
R_2	7/8" ø	2X12	7'-2"	3'-6" 2'-6"
R_3	7/8" ø	2X12	7'-5"	3'-9" 2'-6"
R_4	7/8" ø	2X12	6'-11"	3'-3" 2'-6"
R_5	3/8" ø	14X12	2'-6"	5" 7"
R_6	5/8" ø	4X2X2	28'-2"	27'-4"
R_7	1/4" ø	65X2X2	2'-0"	4" 6"

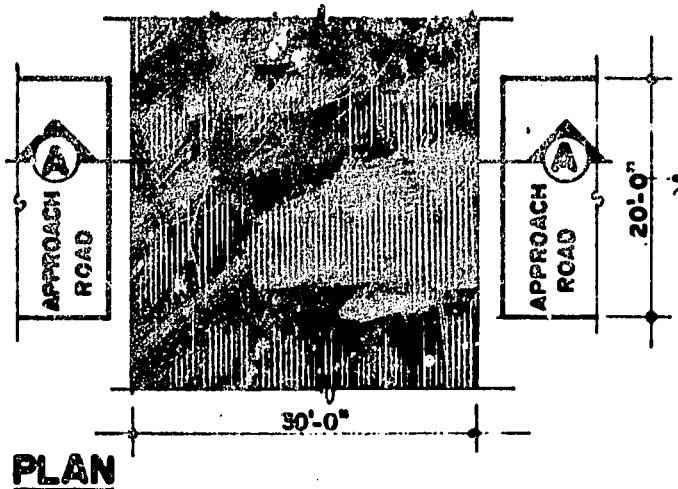
DESIGN EXAMPLE B-8

- CHANNEL WIDTH : 25'-0"
  CHANNEL DEPTH : 8'-0"
  ROAD WAY WIDTH : 20'-0"
  SOIL CONDITION : NOT SO SATISFACTORY

- SAME AS DESIGN EXAMPLE B_7 WITH THE ADDITION BAL BALLAH PILES 6" TO 8" IN DIAMETER AND LENGTH 10'-0"

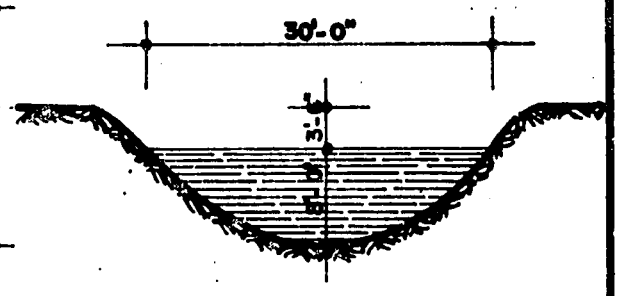
- 12" CEMENT CONCRETE WILL BE PUT ON TOP OF THE PILES. BEFORE BRICK WORK IS DONE.

DESIGN EXAMPLE B - 9



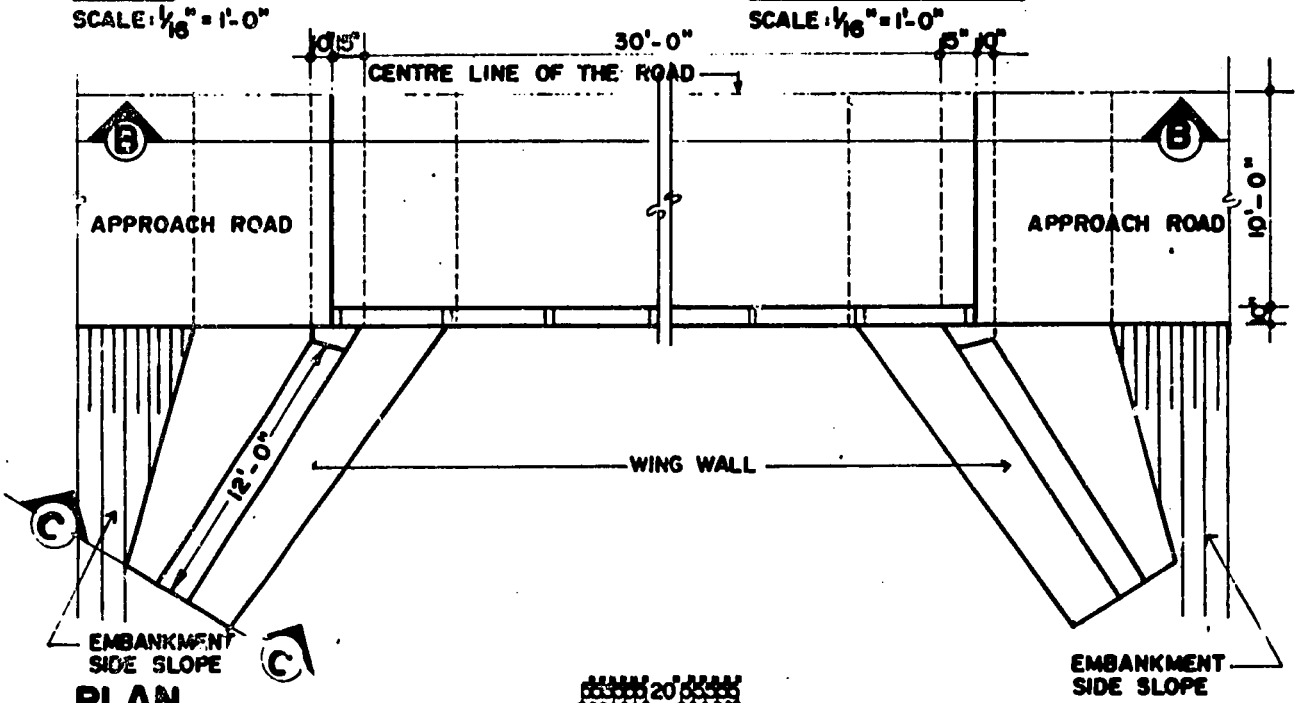
PLAN

SCALE: 1/16" = 1'-0"



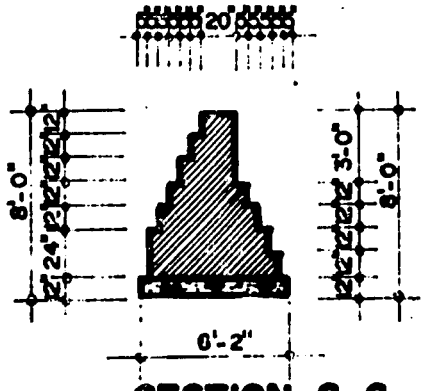
SECTION A-A

SCALE: 1/16" = 1'-0"



PLAN

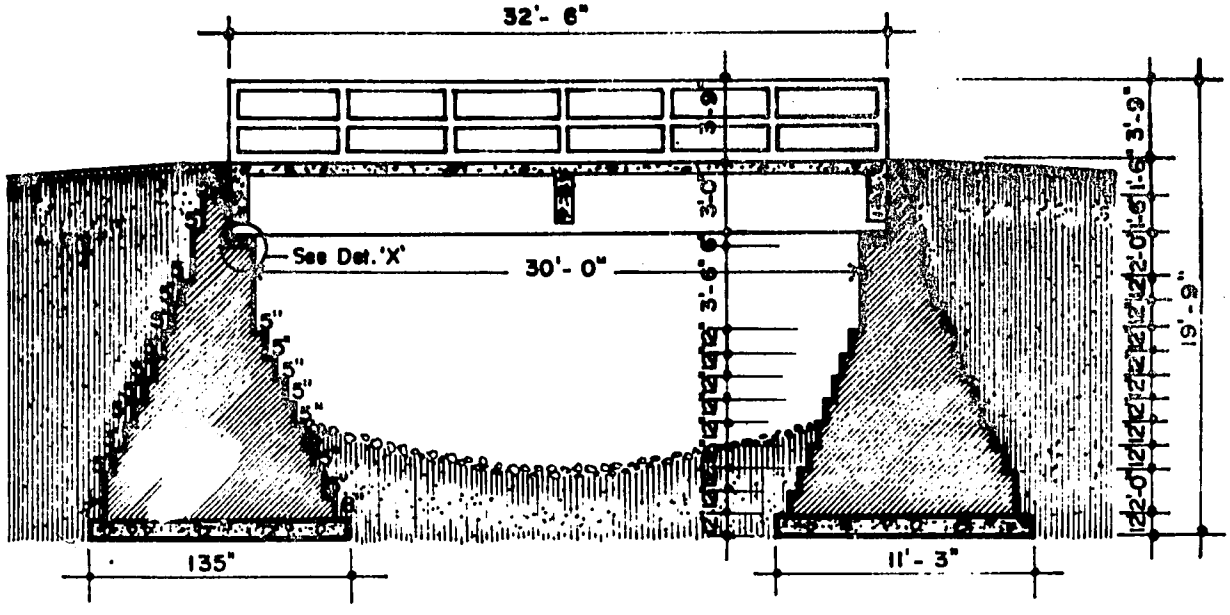
SCALE: 1/8" = 1'-0"



SECTION C-C

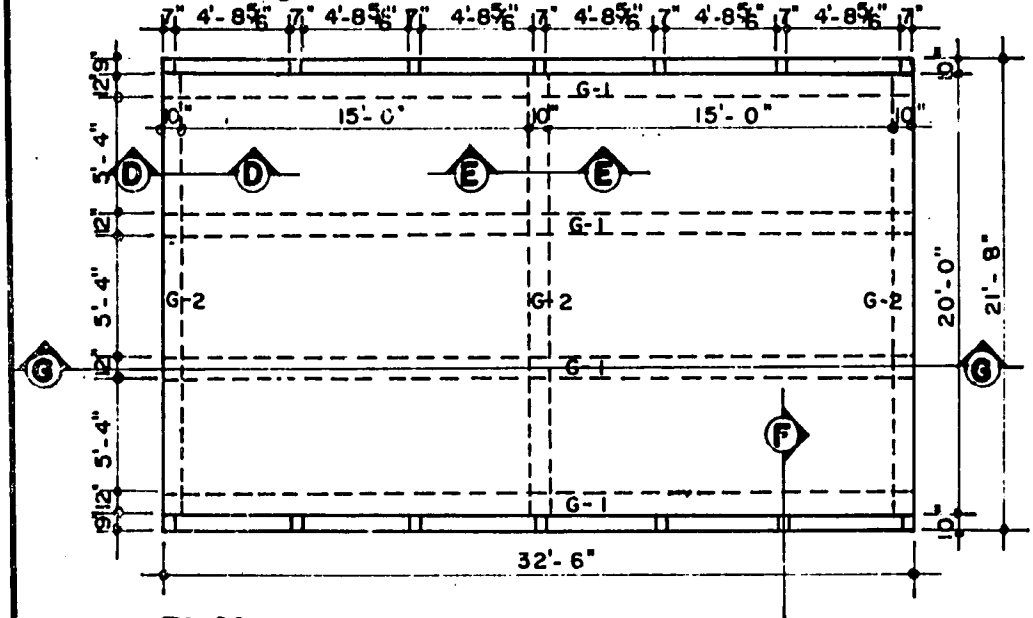
SCALE: 1/8" = 1'-0"

DESIGN EXAMPLE B-9



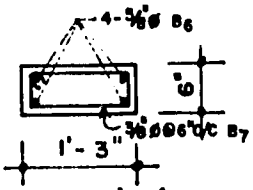
SECTION B - B

SCALE: 1/8" = 1'- 0"



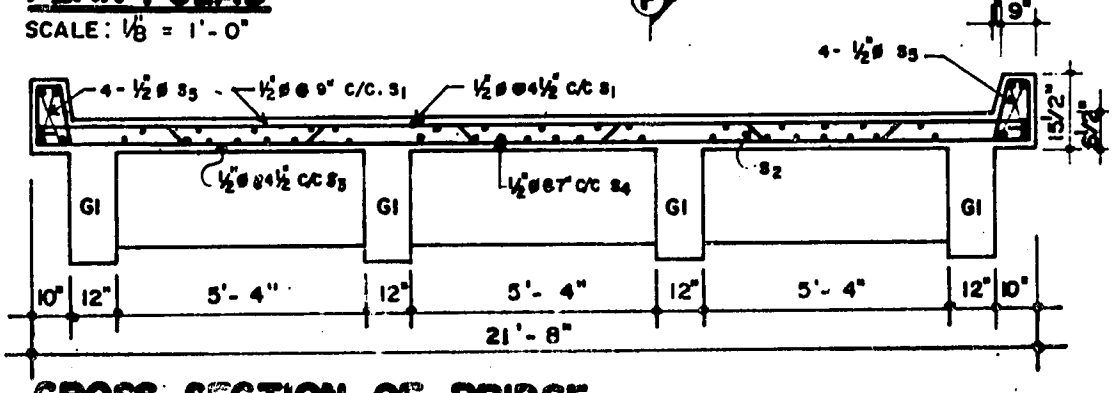
PLAN : SLAB

SCALE: 1/8" = 1'- 0"



DET. 'X'

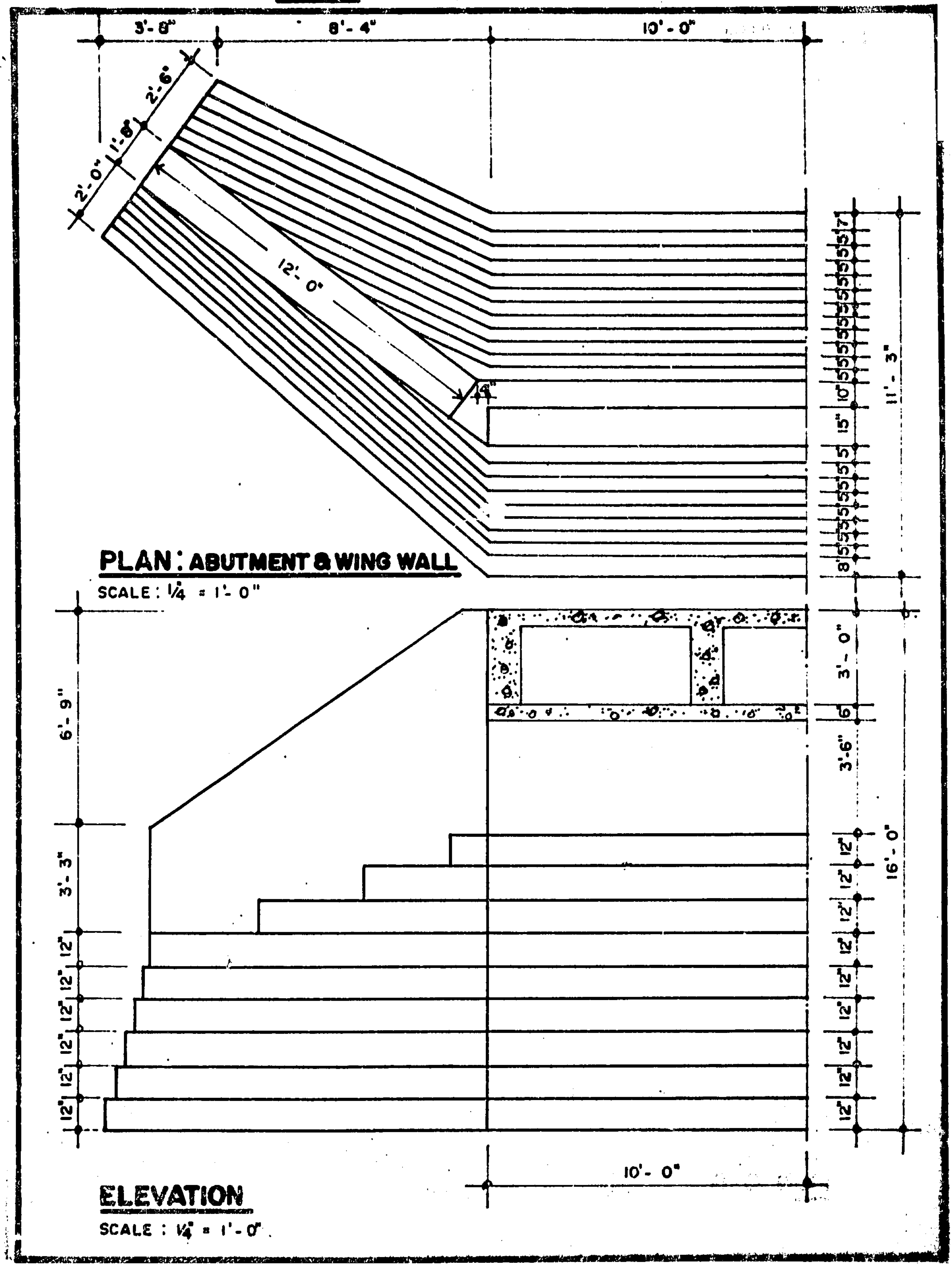
SCALE : 1/2" = 1'-0"



CROSS SECTION OF BRIDGE

SCALE: 1/4" = 1'- 0"

DESIGN EXAMPLE B - 9



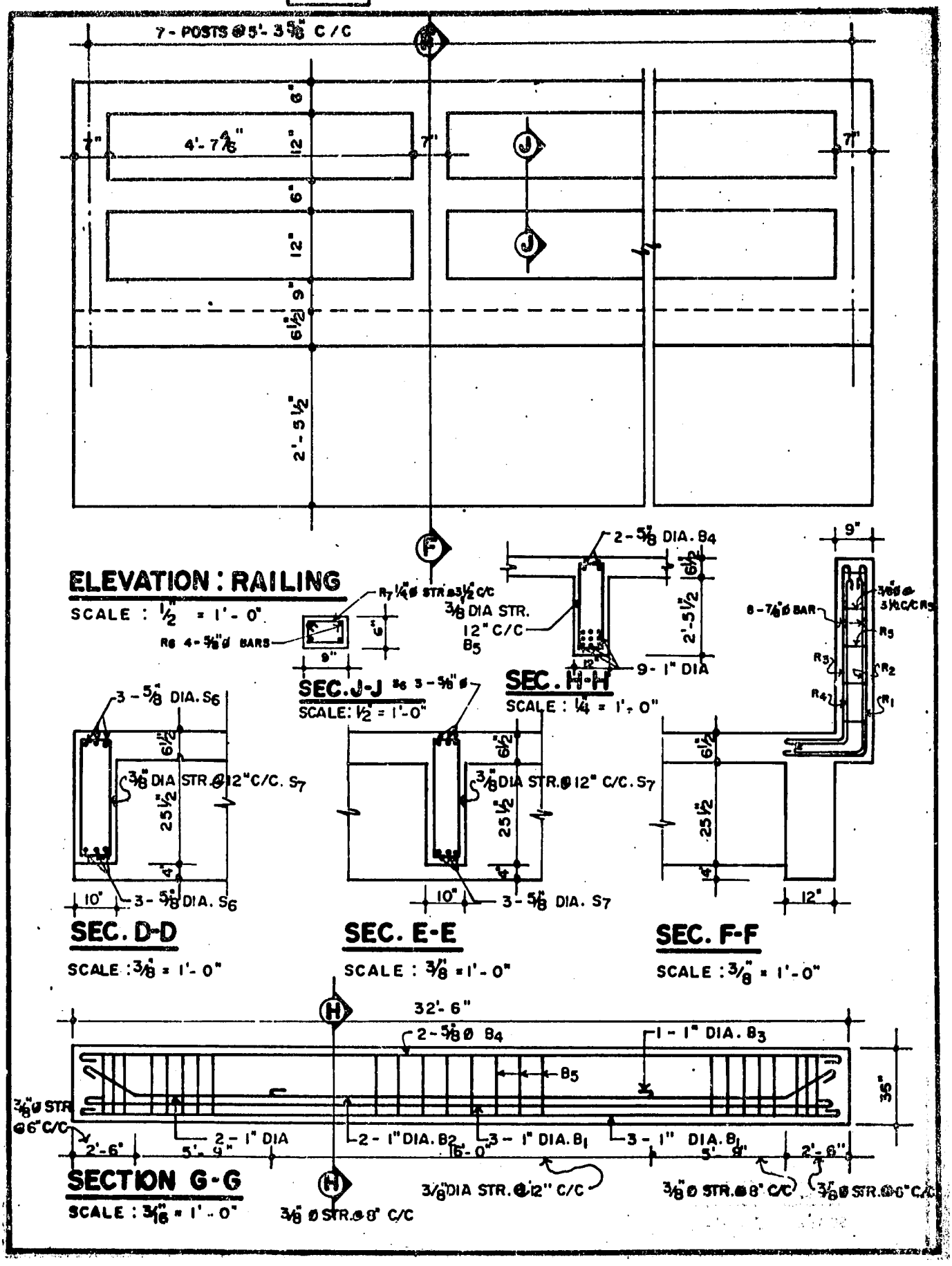
PLAN : ABUTMENT & WING WALL

SCALE : 1/4" = 1'- 0"

ELEVATION

SCALE : 1/4" = 1'- 0"

DESIGN EXAMPLE B - 9



DESIGN EXAMPLE B-9

SPECIFICATIONS	CHANNEL WIDTH- 30'-0" CHANNEL DEPTH- 8'-0" ROADWAY WIDTH - 20'-0" SOIL CONDITION — SATISFACTORY ● 1ST CLASS BRICK. ● 1:4 MORTAR MIX. FOR BRICKWORK. ● 1:3 MORTAR MIX. FOR ALL EXPOSED PLASTER WORK. ● 1:1½":3 MIX. FOR REINFORCED CONCRETE WORK. ● 1:3:6 MIX. FOR CEMENT CONCRETE WORK.

MATERIALS.

BRICK WORK.	CEMENT CONCRETE	BRICKS	CEMENT	SAND	KHOA	STONE CHIPS	M.S RODS.
5830 cft.	C.C. 937 cft R.C.C. 915 cft.	67,100 Nos.	690 Bags	2610 cft.	1660 cft.	90 cft.	1/4" ø 151 # 3/8" ø 925 # 1/2" ø 2985 # 5/8" ø 1390 # 7/8" ø 1690 # 1" ø 3100 #

ROD BENDING SCHEDULE.

MARK.	DIA.	NOS.	LENGTH	FINAL SHAPE.
B_1	1" ø	3X2X4	33'-7"	32'-3"
B_2	1" ø	2X4	35'-4"	2'-4" 27'-6" 2'-4" 2'-4"
B_3	1" ø	1X4	17'-4"	16'-0"
B_4	5/8" ø	2X4	33'-1"	32'-3"
B_5	3/8" ø	45X4	7'-6"	33" 9"
B_6	5/8" ø	3X2X3	20'-7"	19'-9"
B_7	3/8" ø	18X3	6'-6"	29" 7"
S_1	1/2" ø	44	22'-2"	21'-6"
S_2	1/2" ø	44	23'-2"	4½" 4½" 2'-8" 3'-2" 3'-2" 3'-2" 3'-2" 2'-8"

DESIGN EXAMPLE B-9

SPECIFICATIONS

- ABUTMENT AND WINGWALLS ARE BRICK MASONRY. BEDBLOCKS AND FOUNDATIONS ARE CONCRETE. ABUTMENTS AND WINGWALLS ARE BUILT AS ONE UNIT.
- SLAB AND BEAMS TO BE POURED AT ONE TIME. PROVIDE DRAINAGE IN CURB EVERY 5'-0", BARS FOR RAILING POSTS SHALL BE PLACED BEFORE THE SLAB IS POURED.
- 2" IRON PIPE MAY BE SUBSTITUTED FOR CONCRETE RAILS BETWEEN THE CONCRETE POSTS.
- PROVIDE WEEPHOLES 5"x3" IN ABUTMENT AND WINGWALLS EVERY 5'-0" VERTICALLY AND HORIZONTALY.

ROD BENDING SCHEDULE.

MARK	DIA	NOS	LENGTH	FINAL SHAPE.
S_3	1/2" ø	44	27'-10"	21'-6"
S_4	1/2" ø	3X10	33'-0"	32'-4"
S_5	1/2" ø	2X4	33'-0"	32'-4"
S_6	5/8" ø	4X2	20'-8"	19'-10"
S_7	3/8" ø	2X40	3'-4"	4" 1'-1"
R_1	7/8" ø	2X14	7'-8"	4'-0" 2'-6"
R_2	7/8" ø	2X14	7'-2"	3'-6" 2'-6"
R_3	7/8" ø	2X14	7'-5"	3'-9" 2'-6"
R_4	7/8" ø	2X14	6'-11"	3'-3" 2'-6"
R_5	3/8" ø	14X14	2'-6"	5" 7"
R_6	5/8" ø	4X2X2	33'-2"	32'-4"
R_7	1/4" ø	113X2X2	2'-0"	4" 6"

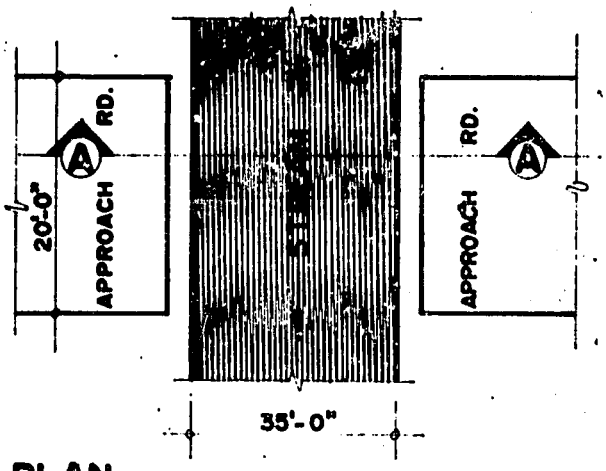
DESIGN EXAMPLE B-10

- CHANNEL WIDTH : 30'-0"
  CHANNEL DEPTH : 8'-0"
  ROAD WAY WIDTH : 20'-0"
  SOIL CONDITION : NOT SO SATISFACTORY

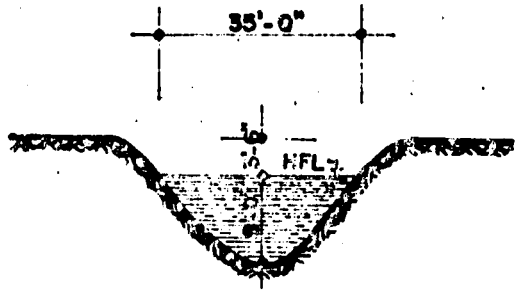
- SAME AS DESIGN EXAMPLE 8a WITH THE ADDITION SAL BALLAH PILES 6" TO 8" IN DIAMETER AND LENGTH 10'-0"

- 12" CEMENT CONCRETE WILL BE PUT ON TOP OF THE PILES. BEFORE BRICK WORK IS DONE.

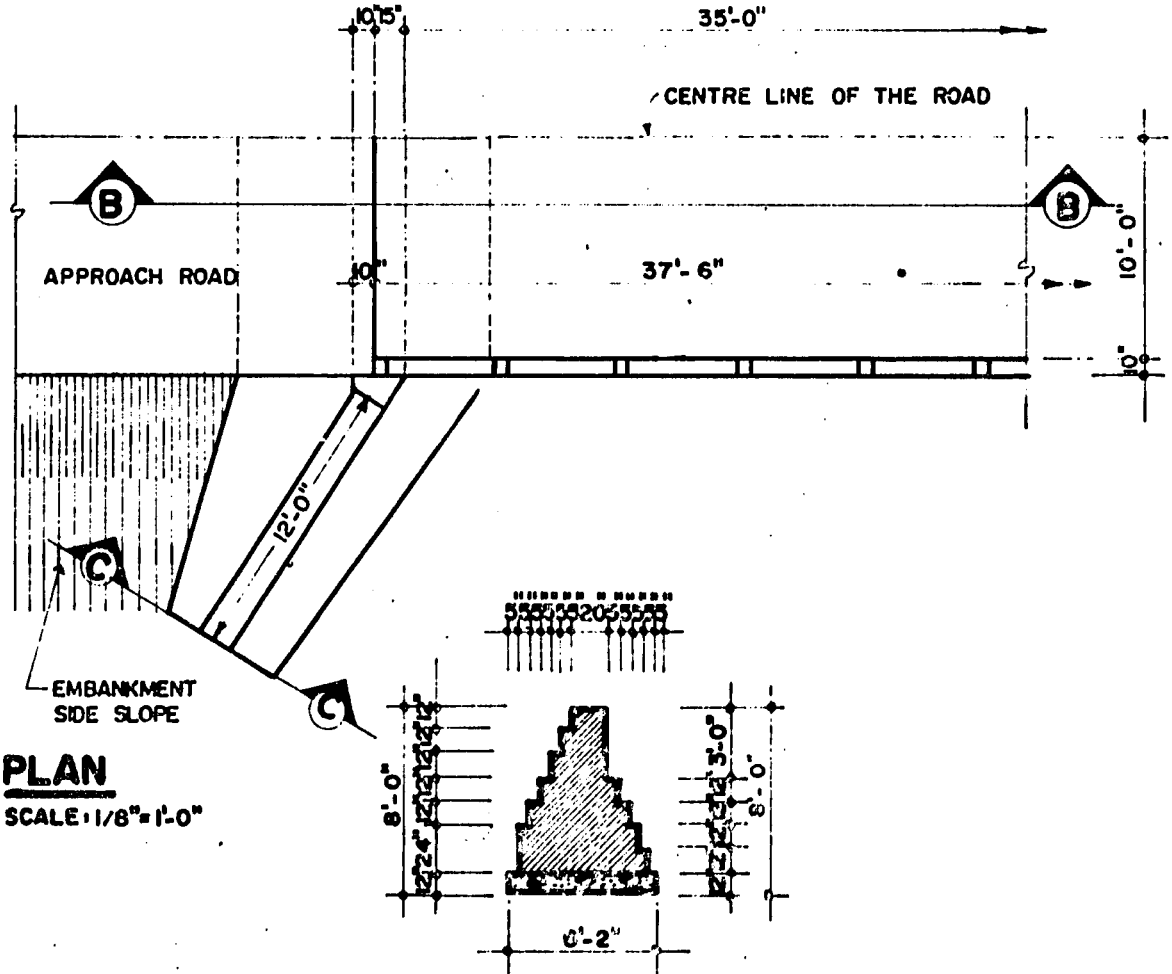
DESIGN EXAMPLE B-11



PLAN
SCALE: 1/32" = 1'-0"



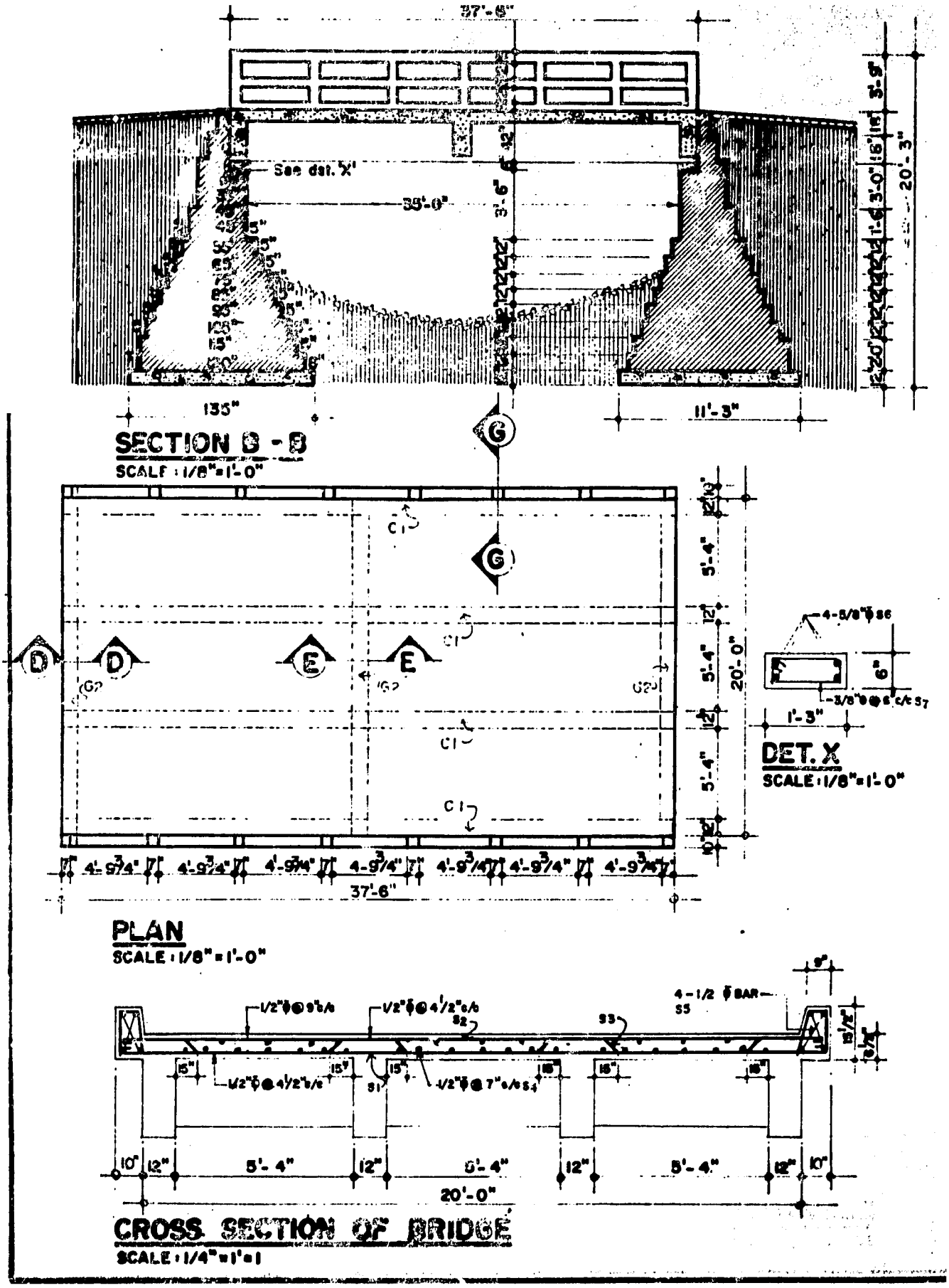
SECTION A-A
SCALE: 1/32" = 1'-0"



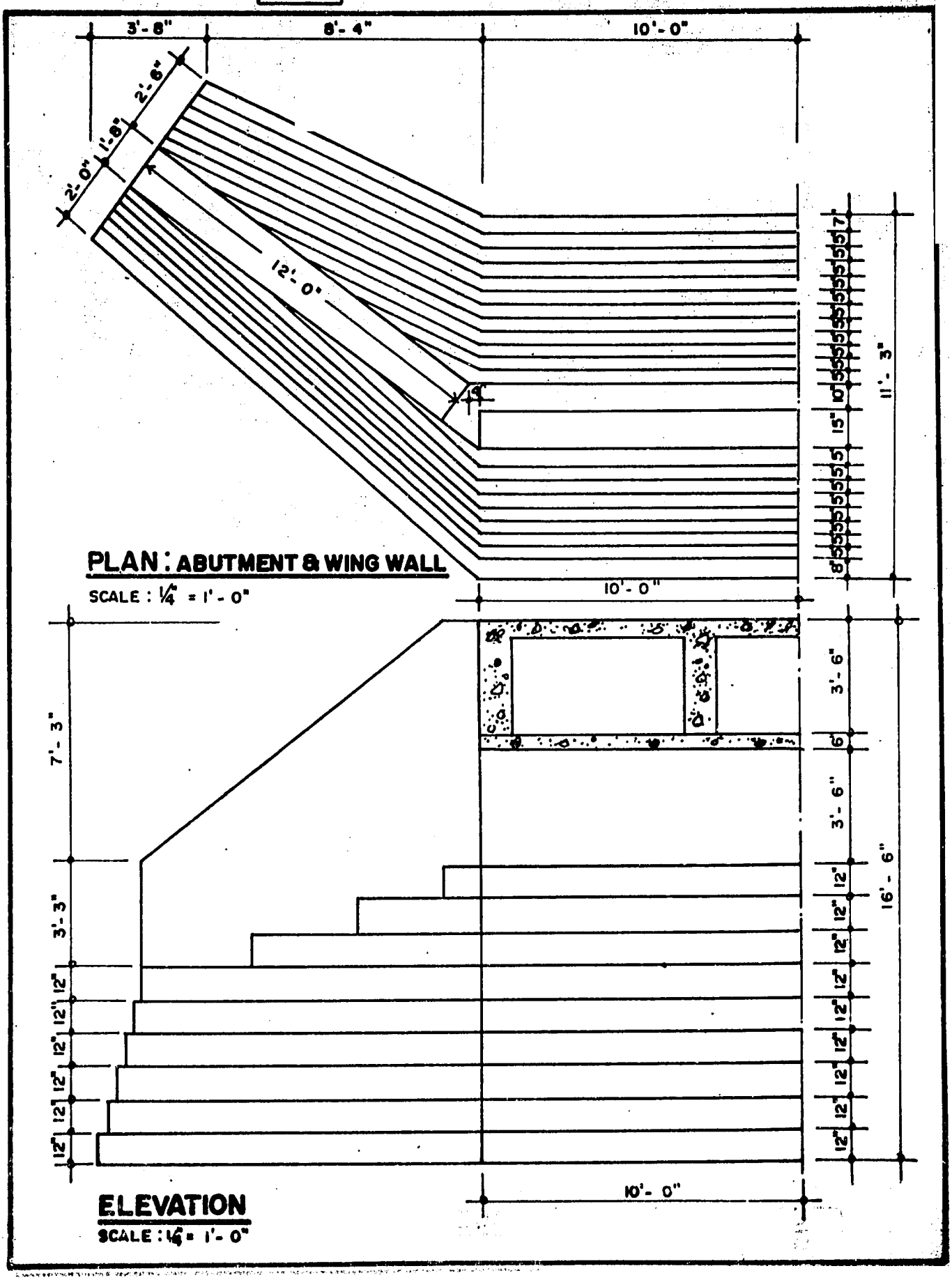
PLAN
SCALE: 1/8" = 1'-0"

SEC. C-C
SCALE: 1/8" = 1'-0"

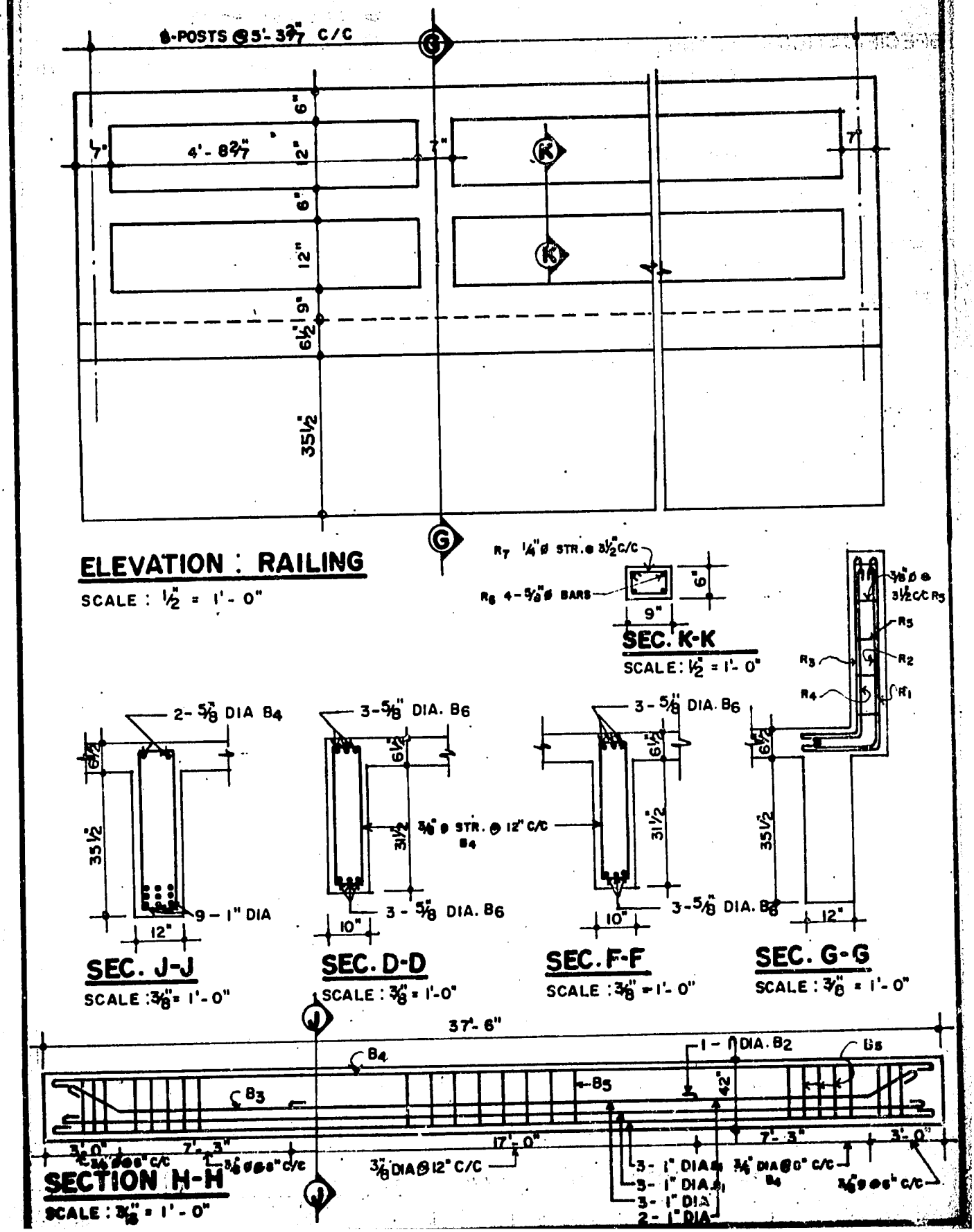
DESIGN EXAMPLE B-11



DESIGN EXAMPLE B-11



DESIGN EXAMPLE B-11



DESIGN EXAMPLE B - 11

SPECIFICATIONS

CHANNEL WIDTH — 35'-0"
CHANNEL DEPTH — 5'-0"
ROADWAY WIDTH — 20'-0"
SOIL CONDITION — SATISFACTORY

- 1ST CLASS BRICK.
- 1:4 MORTAR MIX. FOR BRICKWORK.
- 1:3 MORTAR MIX. FOR ALL EXPOSED PLASTERWORK.
- 1:1½:3 MIX. FOR RE-INFORCED CONCRETE WORK.
- 1:3:6 MIX. FOR CEMENT CONCRETE WORK.

MATERIALS.

BRICKWORK	CEMENT CONCRETE	BRICK.	CEMENT.	SAND	KHOA	STONE CHIPS	M.S. RODS.
5771 cft.	C.C. 890 cft R.C.C. 1120 cft.	65,000 Nos.	714 Bags.	2680 cft.	1910 cft.	31 cft.	1/4" ø 174 # 3/8" ø 1193 # 1/2" ø 3452 # 5/8" ø 1515 # 7/8" ø 1910 # 1" ø 3456 #

ROD BENDING SCHEDULE.

MARK.	DIA.	NOS.	LENGTH.	FINAL SHAPE.
B_1	1" ø	3X2X4.	38'-7"	37'-3"
B_2	1" ø	1X4	18'-4"	17'-0"
B_3	1" ø	2X4	40'-10"	2'-10" 2'-10" 31'-6"
B_4	5/8" ø	2X4	38'-1"	37'-3"
B_5	3/8" ø	55X4	8'-6"	39" 9"
B_6	5/8" ø	6X3	20'-7"	19'-9"
B_7	3/8" ø	21X3	7'-6"	35" 7"
S_1	1/2" ø	51	22'-2"	21'-6"
S_2	1/2" ø	51	23'-2"	4½" 4½" 2'-6" 2'-2"
S_3	1/2" ø	51	27'-10"	21'-6"

DESIGN EXAMPLE B-11

SPECIFICATIONS	● ABUTMENT AND WINGWALS ARE BRICK MASONRY. BEDBLOCKS AND FOUNDATIONS ARE CONCRETE. ABUTMENTS AND WINGWALLS ARE BUILT AS ONE UNIT. ● SLAB AND BEAMS TO BE POURED AT ONE TIME, PROVIDE DRAINAGE IN CURB EVERY 5'-0", BARS FOR RAILING POSTS SHALL BE PLACED BEFORE THE SLAB IS POURED. ● 2" IRON PIPE MAY BE SUBSTITUTED FOR CONCRETE RAILS BETWEEN THE CONCRETE POSTS. ● PROVIDE WEEPHOLES 5"X3" IN ABUTMENT AND WINGWALL 5'-0" VERTICA--LLY AND HORIZONTALLY.

ROD BENDING SCHEDULE.

MARK.	DIA.	NOS.	LENGTH.	FINAL SHAPE.
S_4	1/2" ø	3X10	38'-0"	37'-4"
S_5	1/2" ø	2X4	38'-0"	27'-4"
S_6	5/8	4X2	20'-8"	19'-10"
S_7	3/8" ø	2X40	3'-4"	4" 1'-1"
R_1	7/8" ø	2X16	7'-8"	4'-0" 2'-6"
R_2	7/8" ø	2X16	7'-2"	3'-6" 2'-6"
R_3	7/8" ø	2X16	7'-5"	3'-9" 2'-6"
R_4	7/8" ø	2X16	6'-1"	3'-3" 2'-6"
R_5	3/8" ø	14X16	2'-6"	5" 7"
R_6	5/8" ø	4X2X2	38'-2"	37'-4"
R_7	1/4" ø	130X2X2	2'-0"	4" 6"

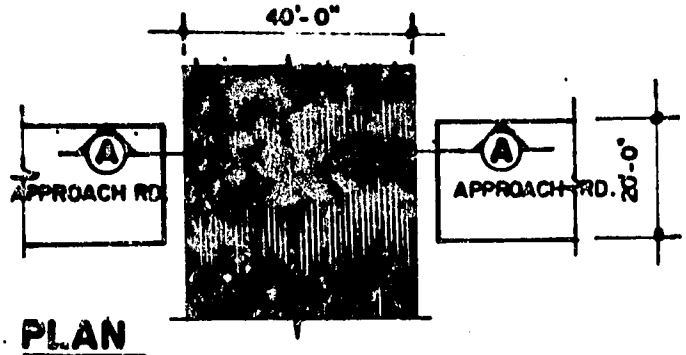
DESIGN EXAMPLE B-12

- CHANNEL WIDTH : 35'-0"
  CHANNEL DEPTH : 8'-0"
  ROAD WAY WIDTH : 20'-0"
  SOIL CONDITION : NOT SO SATISFACTORY

- SAME AS DESIGN EXAMPLE B_{11} WITH THE ADDITION SAL BALLAH PILES 6" TO 8" IN DIAMETER AND LENGTH 10'-0".

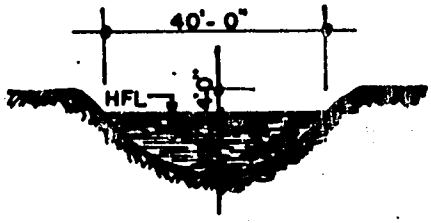
- 12" CEMENT CONCRETE WILL BE PUT ON TOP OF THE PILES. BEFORE BRICK WORK IS DONE.

DESIGN EXAMPLE B-13



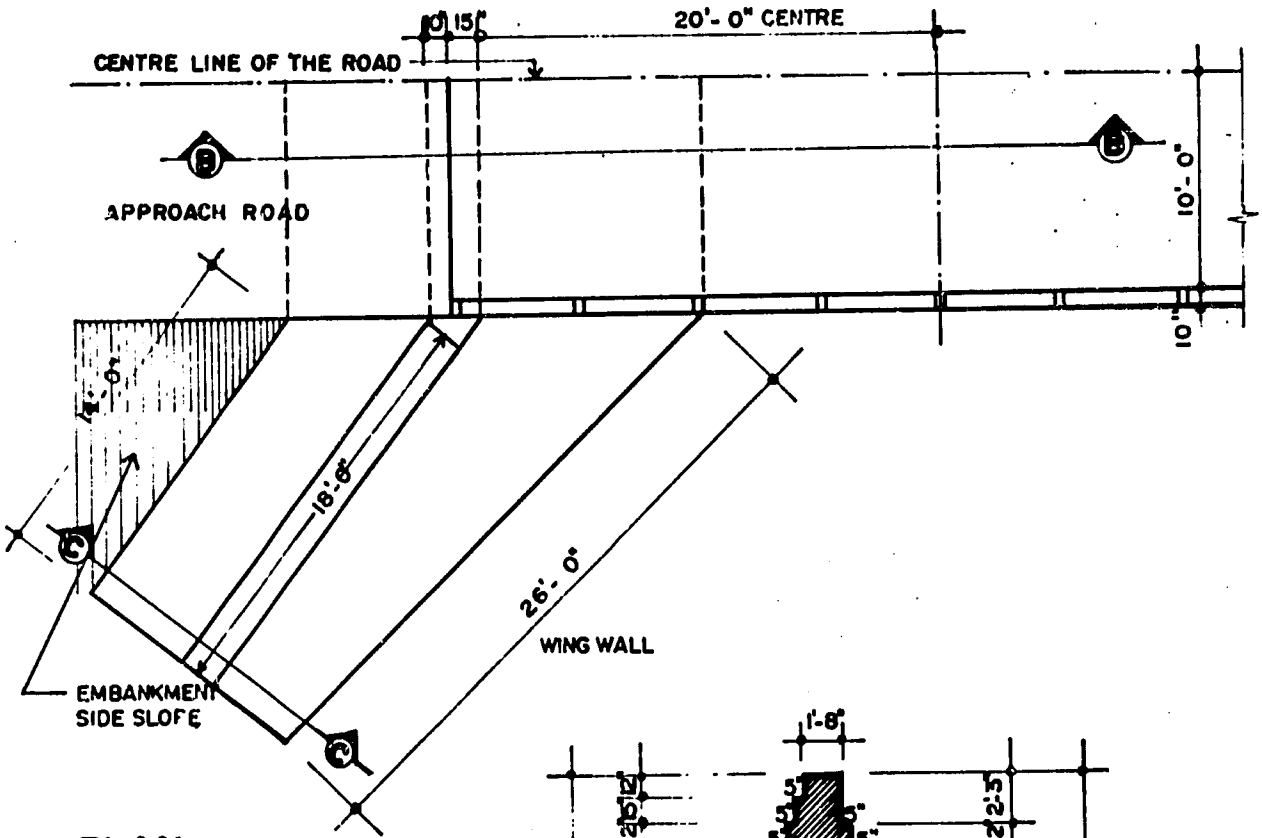
PLAN

SCALE : 1/32" = 1'-0"



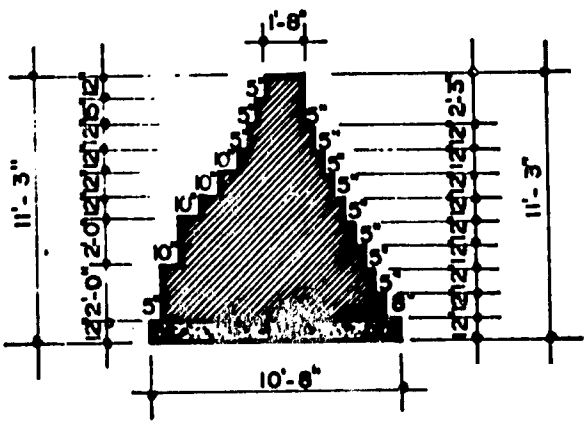
SECTION A-A

SCALE: 1/32" = 1'- 0"



PLAN

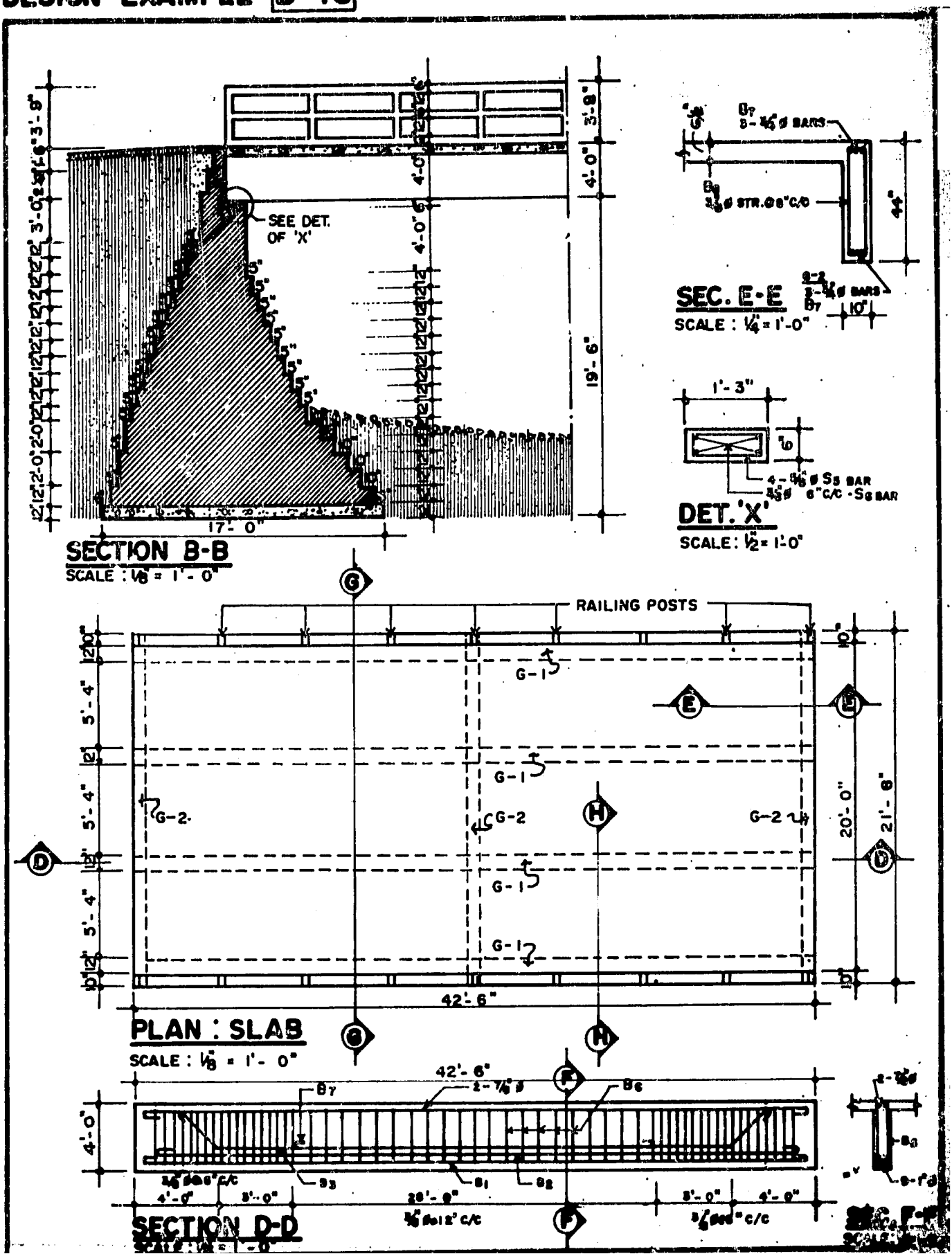
SCALE : 1/8" = 1'-0"



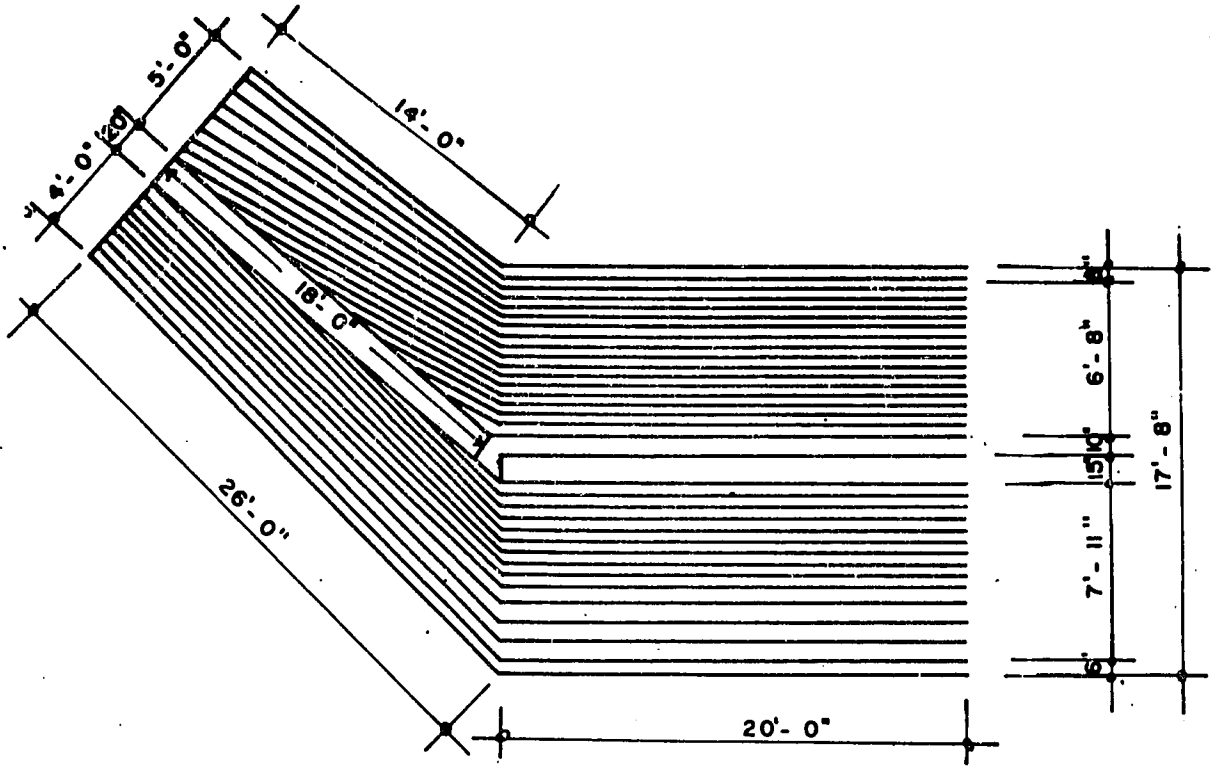
SECTION C-C

SCALE : 1/8" = 1'-0"

DESIGN EXAMPLE B-13

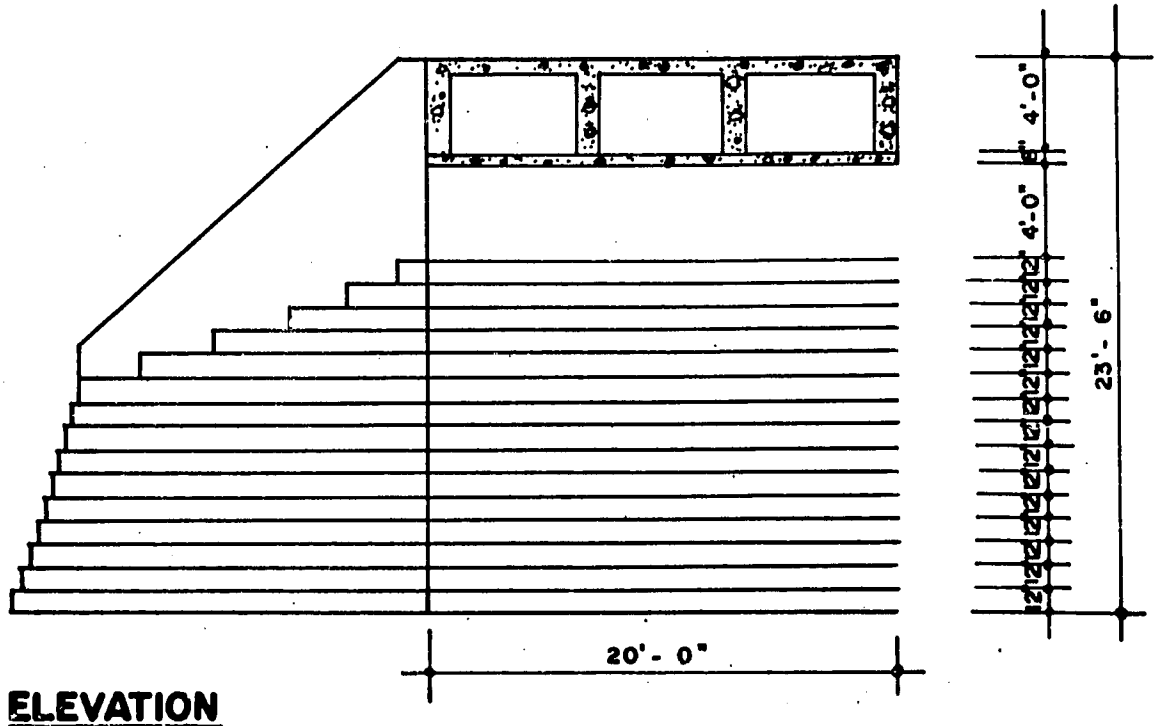


DESIGN EXAMPLE B-13



PLAN

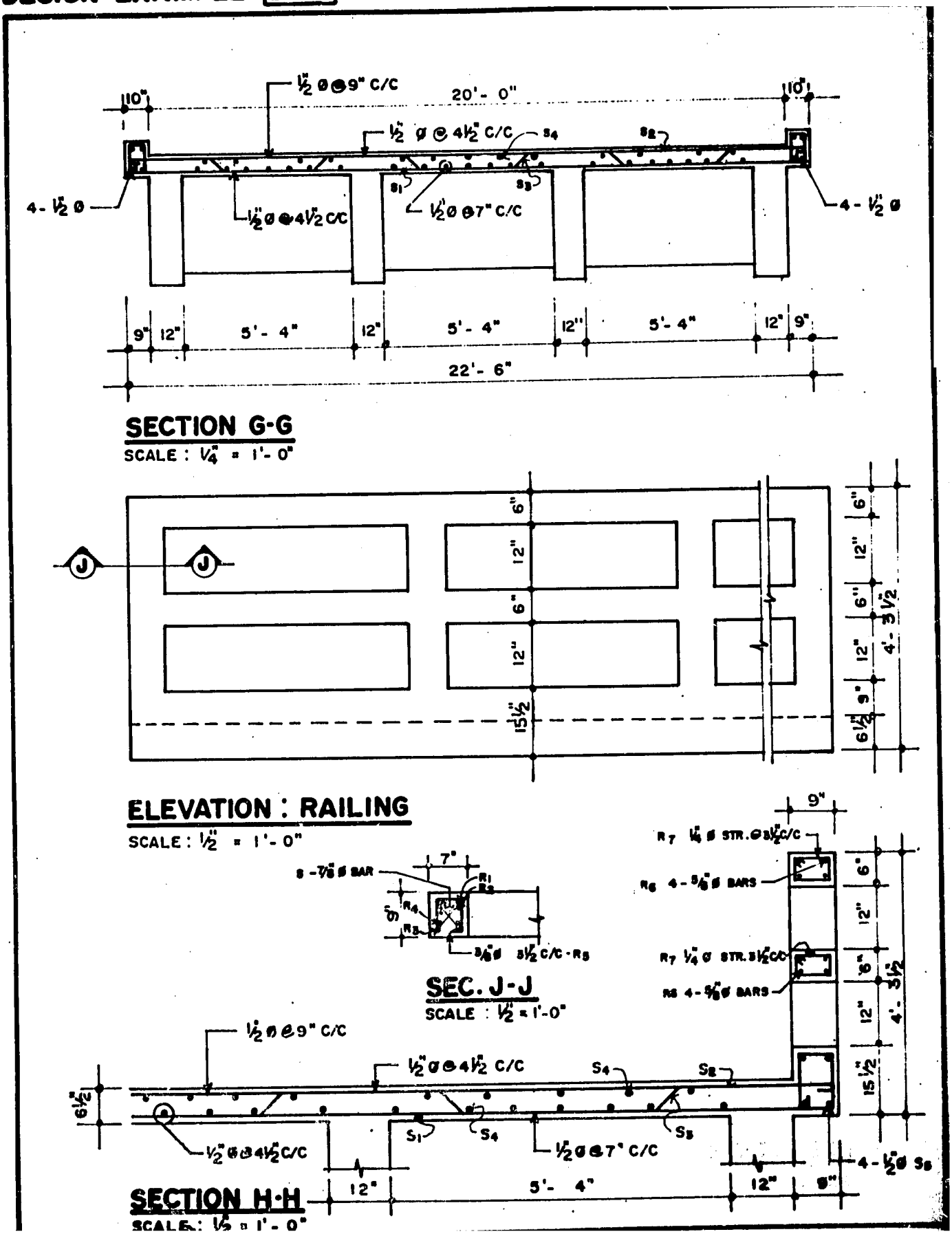
SCALE : 1/8" = 1'-0"



ELEVATION

SCALE : 1/8" = 1'-0"

DESIGN EXAMPLE B-13



DESIGN EXAMPLE B-13

SPECIFICATIONS

R.C.C. T-BEAM BRIDGE.
CHANNEL WIDTH - 40'-0"
CHANNEL DEPTH - 10'-0"
ROADWAY WIDTH - 20'-0"
SOIL CONDITION. SATISFACTORY.

- 1ST CLASS BRICK.
- 1:4 MORTAR MIX. FOR BRICKWORK.
- 1:3 MORTAR MIX. FOR ALL EXPOSED PLASTER WORK.
- 1:1 1/2:3 MIX. FOR REINFORCED CONCRETE WORK.
- 1:3:6 MIX. FOR CEMENT CONCRETE WORK.

MATERIALS.

BRICK WORK.	CEMENT CONCRETE	BRICKS	CEMENT	SAND	KHOA	STONE CHIPS	M.S. RODS.
13,156 cft.	C.C. 1855 cft. R.C.C. 1375 cft.	151560 Nos.	1340 Bags	5480 cft.	2915 cft.	120 cft.	1/4" ø 196 # 3/8" ø 1442 # 1/2" ø 3871 # 5/8" ø 895 # 3/4" ø 561 # 7/8" ø 2852 # 1" ø 4064 #

ROD BENDING SCHEDULE.

MARK.	DIA.	NOS.	LENGTH	FNAL SHAPE.
B_1	1" ø	3X4	43'-7"	42'-3"
B_2.	1" ø	3X4	4'-1"	41'-9"
B_3	1" ø	2X4	45'-4"	3" 3'-0" 35'-6" 3'-0"
B_4	1" ø	1X4	29'-10"	28'-6"
B_5	7/8" ø	2X4	43'-5"	42'-3"
B_6	3/8" ø	59X4	9'-6"	45" 9"
B_7	3/4" ø	6X3	20'-9"	19'-9"
B_8	3/8" ø	27X3	8'-6"	41" 7"
S_1	1/2" ø	57	22'-2"	21'-6"
S_2	1/2" ø	57	23'-2"	
S_3	1/2" ø	57	27'-10"	

DESIGN EXAMPLE B-13

SPECIFICATIONS	• ABUTMENT AND WINGWALLS ARE BRICK MASONRY. SEDBLOCKS AND FOUNDATIONS ARE CONCRETE. ABUTMENTS AND WINGWALLS ARE BUILT AS ONE UNIT. • SLAB AND BEAMS TO BE POURED AT ONE TIME, PROVIDE DRAINAGE IN CURB EVERY 5'-0". BARS FOR RAILING POSTS SHALL BE PLACED BEFORE THE SLAB IS POURED. • 2" IRON PIPE MAY BE SUBSTITUTED FOR CONCRETE RAILS BETWEEN THE CONCRETE POSTS. • PROVIDE WEEPHOLES 5"X3" IN ABUTMENT AND WINGWALL EVERY 5'-0" VERTICALLY AND HORIZONTALY.

ROD BENDING SCHEDULE

MARK	DIA	NOS	LENGTH	FINAL SHAPE.
S_4	1/2" ø	3X10	43'0"	42'-4"
S_5	1/2" ø	2X4	33'-2"	32'-4"
S_6	5/8" ø	4X2	20'-8"	19'-10"
S_7	3/8" ø	2X40	3'-4"	4" 1'-1"
R_1	7/8" ø	2X18	7'-8"	4'-0" 2'-6"
R_2	7/8" ø	2X18	7'-2"	3'-6" 2'-6"
R_3	7/8" ø	2X18	7'-5"	3'-9" 2'-6"
R_4	7/8" ø	2X18	6'-11"	3'-3" 2'-4"
R_5	3/8" ø	18X14	2'-6"	5" 7"
R_6	5/8" ø	4X2X2	43'-2"	42'-4"
R_7	1/4" ø	147X2X2	2'-0"	4" 6"

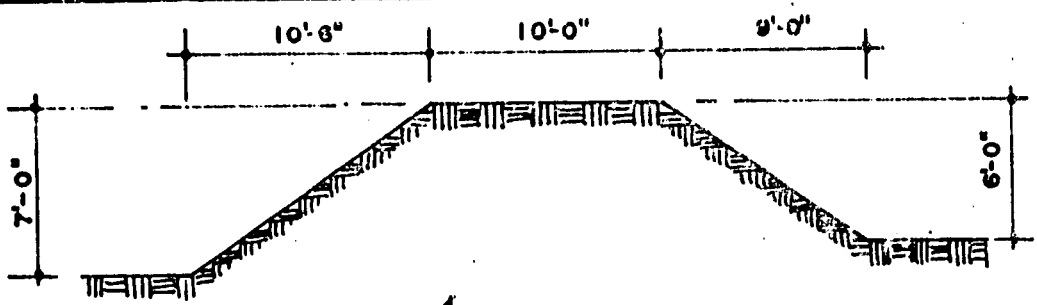
DESIGN EXAMPLE B-14

- CHANNEL WIDTH : 40'- 0"
  CHANNEL DEPTH : 10'- 0"
  ROAD WAY WIDTH : 20'- 0"
  SOIL CONDITION : NOT SO SATISFACTORY

- SAME AS DESIGN EXAMPLE B_{13} WITH THE ADDITION SAL BALLAH PILES 6" TO 8" IN DIAMETER AND LENGTH 10'- 0"

- 12" CEMENT CONCRETE WILL BE PUT ON TOP OF THE PILES. BEFORE BRICK WORK IS DONE.

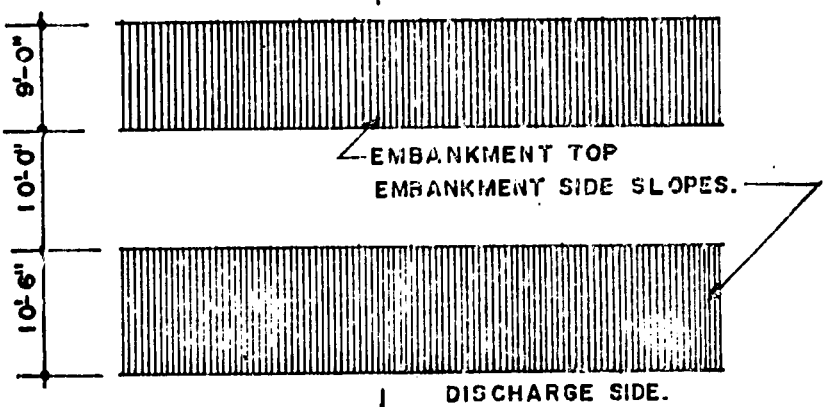
DESIGN EXAMPLE S-1 R. C. Pipe Type Sluice



SECTION-A.A.

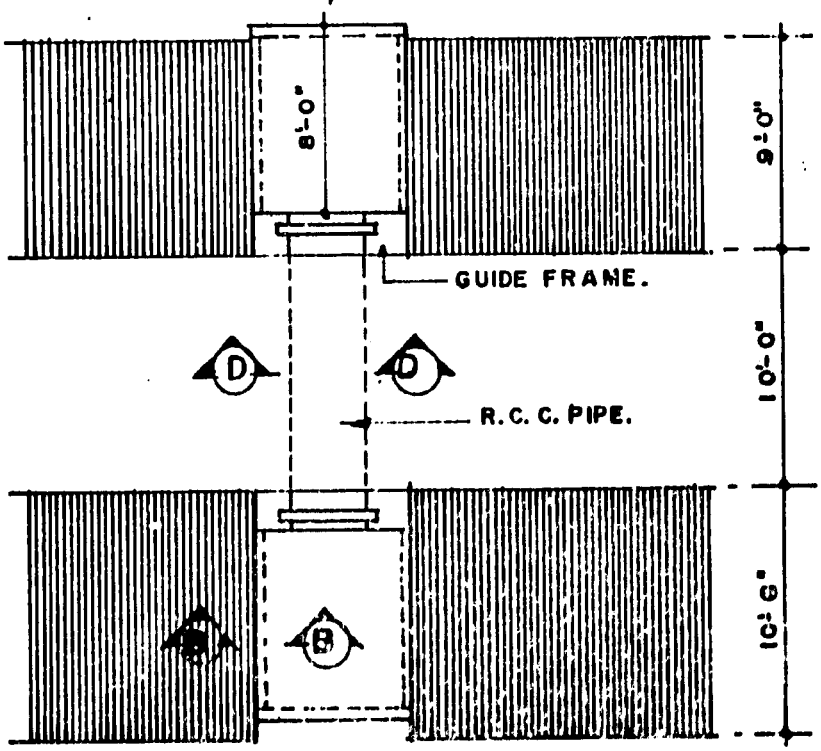
SCALE- 1/8" = 1'-0"

STORAGE BASIN SIDE.

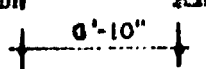


PLAN

SCALE- 1/16" = 1'-0"

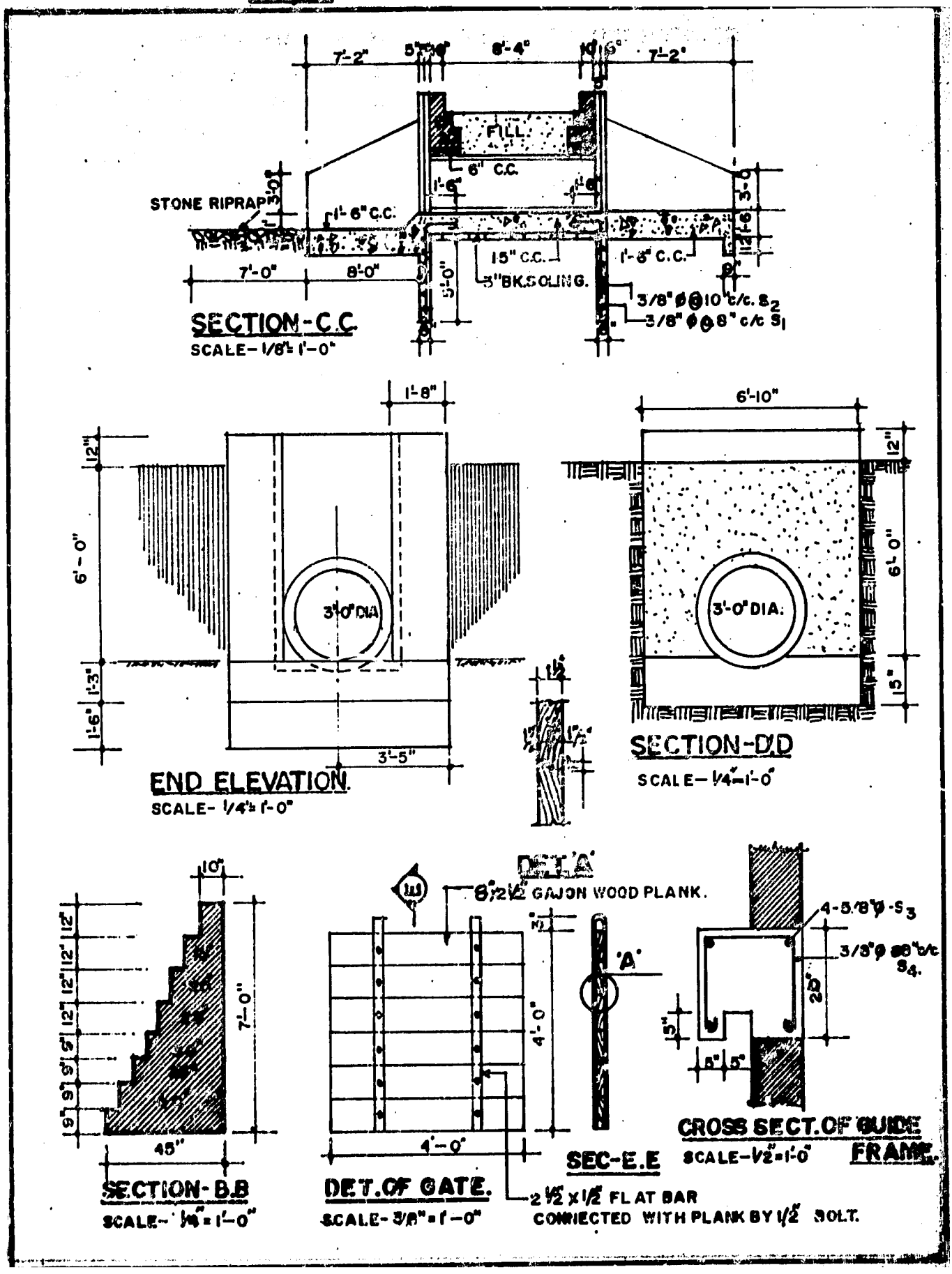


PLAN



SCALE- 1/8" = 1'-0"

DESIGN EXAMPLE S-1



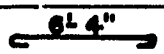
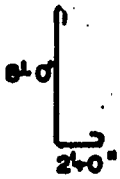
DESIGN EXAMPLE S-1

SPECIFICATIONS	REINFORCED CONCRETE PIPE TYPE. SPAN — 3'-0" LENGTH - 10'-0" SOIL CONDITION. - SATISFACTORY. ● 1ST CLASS BRICKS. ● 1:4 MORTAR MIX FOR BRICKWORK. ● 1:3 MORTAR MIX FOR PLASTERING ALL EXPOSED BRICKWORK. ● 1:1½:3 MIX FOR REINFORCED CONCRETE WORK. ● 1:3:6 MIX FOR CEMENT CONCRETE WORK.

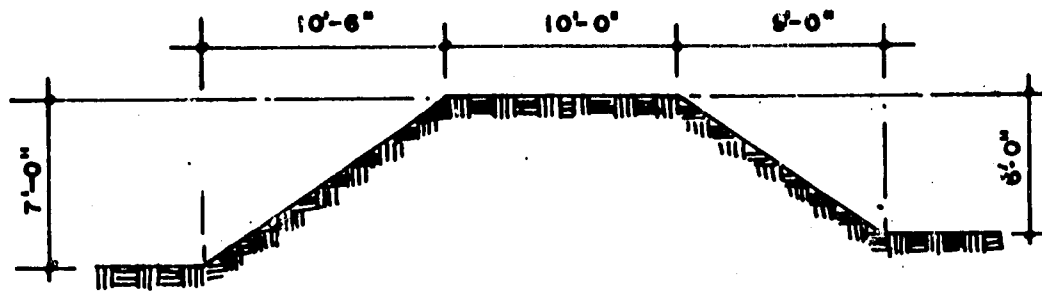
MATERIALS.

BRICK WORK.	CEMENT CONC.	BRICKS	CEMENT	SAND	KHOA.	STONE CHIPS.	WOOD.	PIPE	M.S. ROD.
535 cft.	C.C 290 cft. R.C.C 150 cft.	6170 Nos.	101 Bags.	375 cft.	411 cft.		8"x2"x4' = 2'67 cft.	5' DIA. 4' L. 3 Piece	3/8"ø 218 # 5/8" ø 180 #

ROD BENDING SCHEDULE.

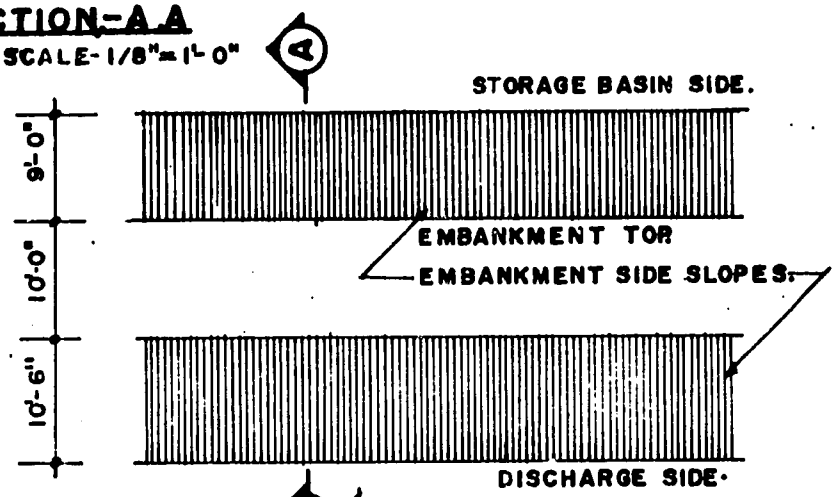
MARK.	DIA	NOS	LENGTH	FINAL SHAPE.
S_1	3/8" ø	11X2	7'-6"	
S_2	3/8" ø	12X12	6'-10"	
S_3	5/8" ø	4X4	10'-10"	
S_4	3/8" ø	12X4	5'-2"	

DESIGN EXAMPLE S - 2 R. C. Box Culvert Type Sluice



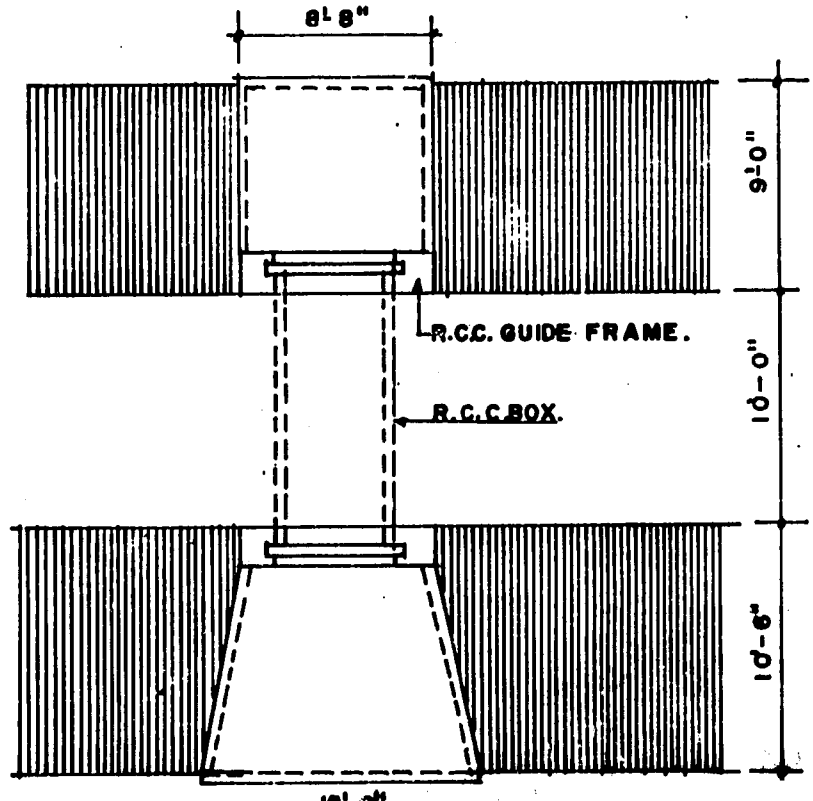
SECTION-A A

SCALE-1/8"=1'-0"



PLAN

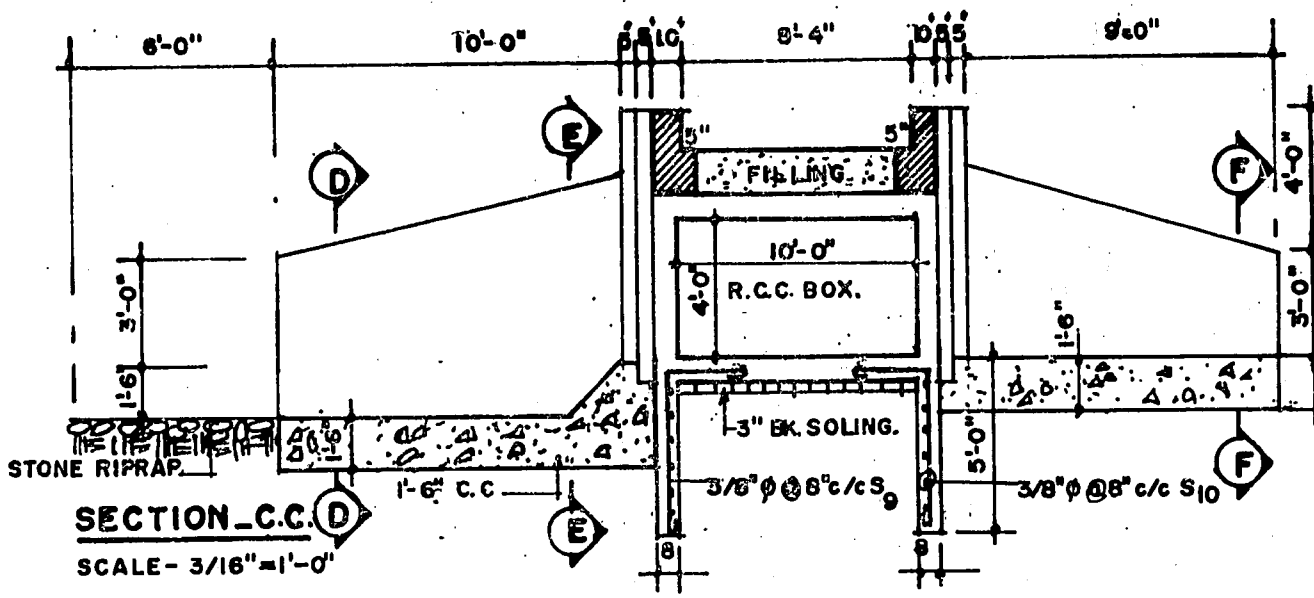
SCALE-1/16"=1'-0"



PLAN

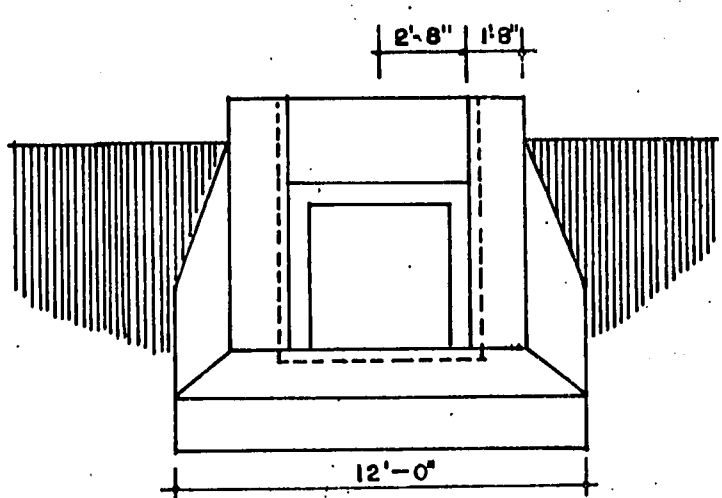
SCALE-1/8"=1'-0"

DESIGN EXAMPLE S - 2



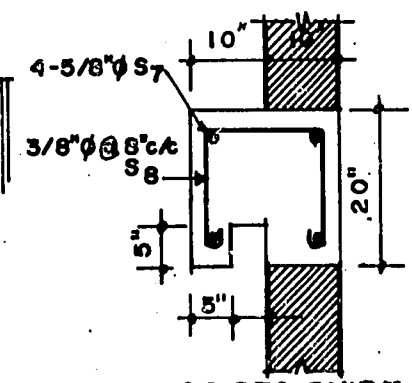
SECTION_C.C.

SCALE- 3/16"=1'-0"



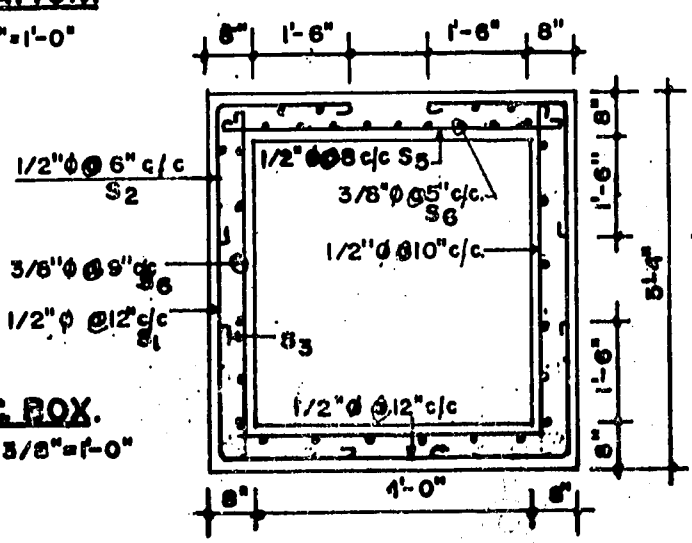
END ELEVATION.

SCALE- 3/16"=1'-0"



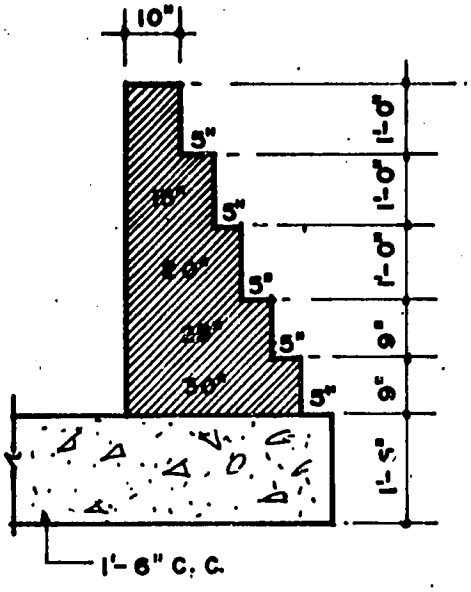
CROSS SEC. GUIDE FRAME

SCALE- 3/16" = 1'-0"



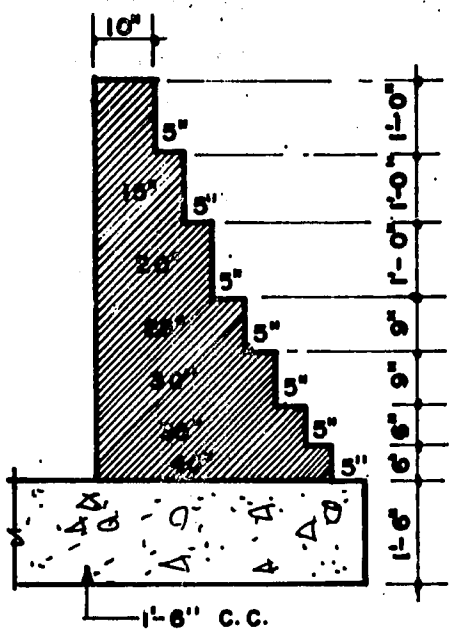
R.C.C. BOX.

SCALE- 3/8"=1'-0"



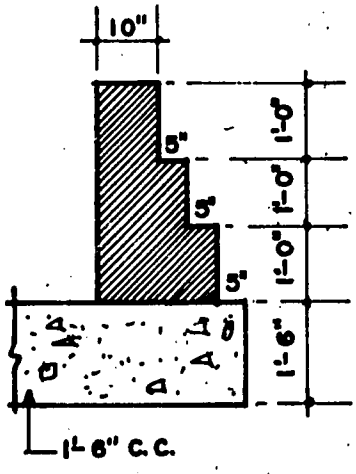
SECTION-D.D

SCALE - 3/8" = 1'-0"



SECTION-E.E

SCALE - 3/8" = 1'-0"



SECTION-F.F

SCALE - 3/8" = 1'-0"

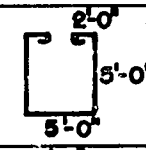
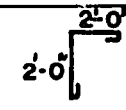
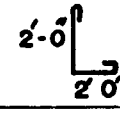
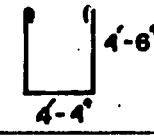
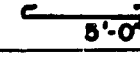
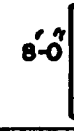
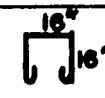
DESIGN EXAMPLE S - 2

SPECIFICATIONS	REINFORCED CONCRETE BOX CULVERT TYP. SPAN. 4'-0" LENGTH - 10'-0" HEIGHT - 7'-0" SOIL CONDITION. SATISFACTORY. ● IST CLASS BRICKS. ● 1:4 MORTAR MIX FOR BRICKWORK. ● 1:3 MORTAR MIX FOR PLASTERING ALL EXPOSED BRICKWORK. ● 1:1½":3 MIX FOR REINFORCED CONCRETE WORK. ● 1:3:6 MIX FOR CEMENT CONCRETE WORK.

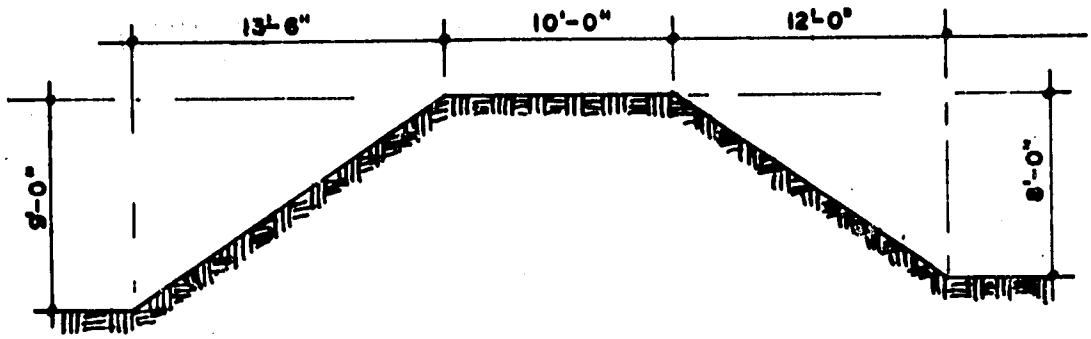
MATERIALS.

BRICK WORK.	CEMENT CONCRETE	BRICKS	CEMENT	SAND	KHOA	GARJON WOOD	M.S. RODS.
347 cft.	C.C. 518 cft RCC 238 cft.	3340 Nos	144 Bags.	508 cft.	703 cft.	2"X8"X8' = 2·7 cft.	3/8" ø 450 # 1/2" ø 462 # 5/8" ø 147. #

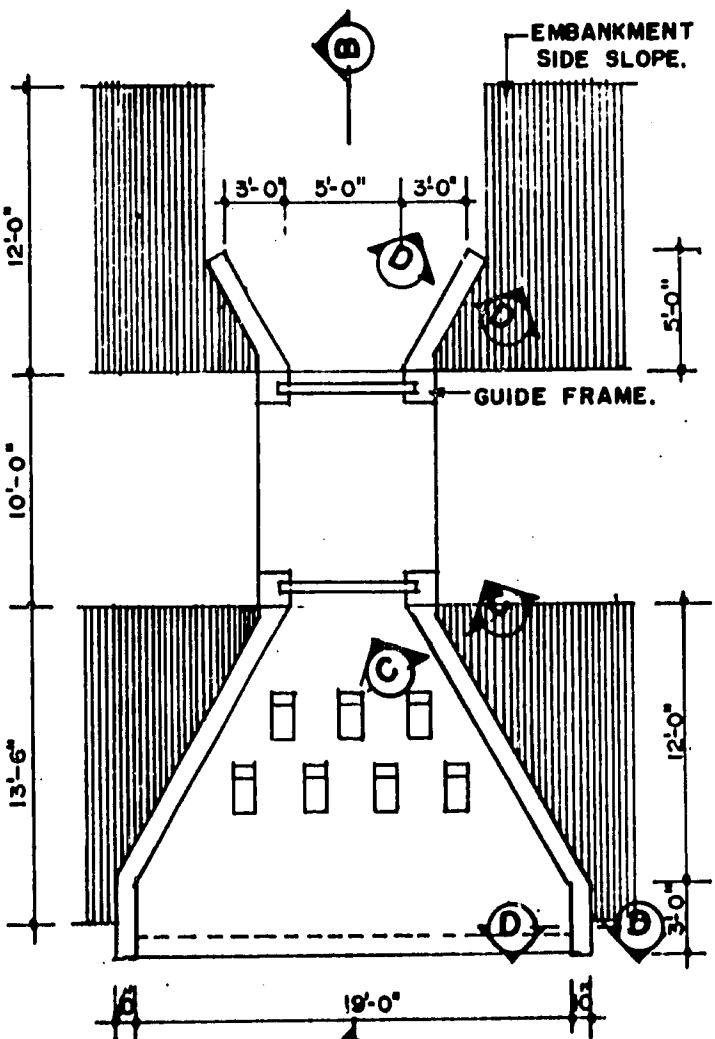
ROD BENDING SCHEDULE

MARK.	DIA	NOS.	LENGTH	FINAL SHAPE.
S_1	1/2" ø	11	19'-8"	
S_2	1/2" ø	2X11	4'-8"	
S_3	1/2" ø	2X11	4'-8"	
S_4	1/2" ø	13	14'-0"	
S_5	1/2" ø	15	5'-10"	
S_6	3/8" ø	40	11'-10"	
S_7	5/8" ø	4X4	8'-10"	
S_8	3/8" ø	60	4'-6"	
S_9	3/8" ø	2X8	7'-8"	
S_{10}	3/8" ø	2X9	11'-10"	

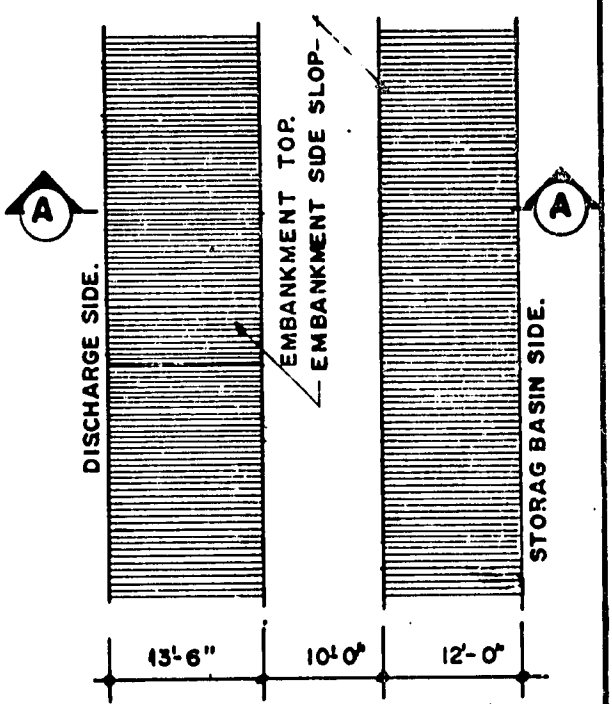
DESIGN EXAMPLE S-3



SECTION A.A.
SCALE – 1/8" = 1'-0"

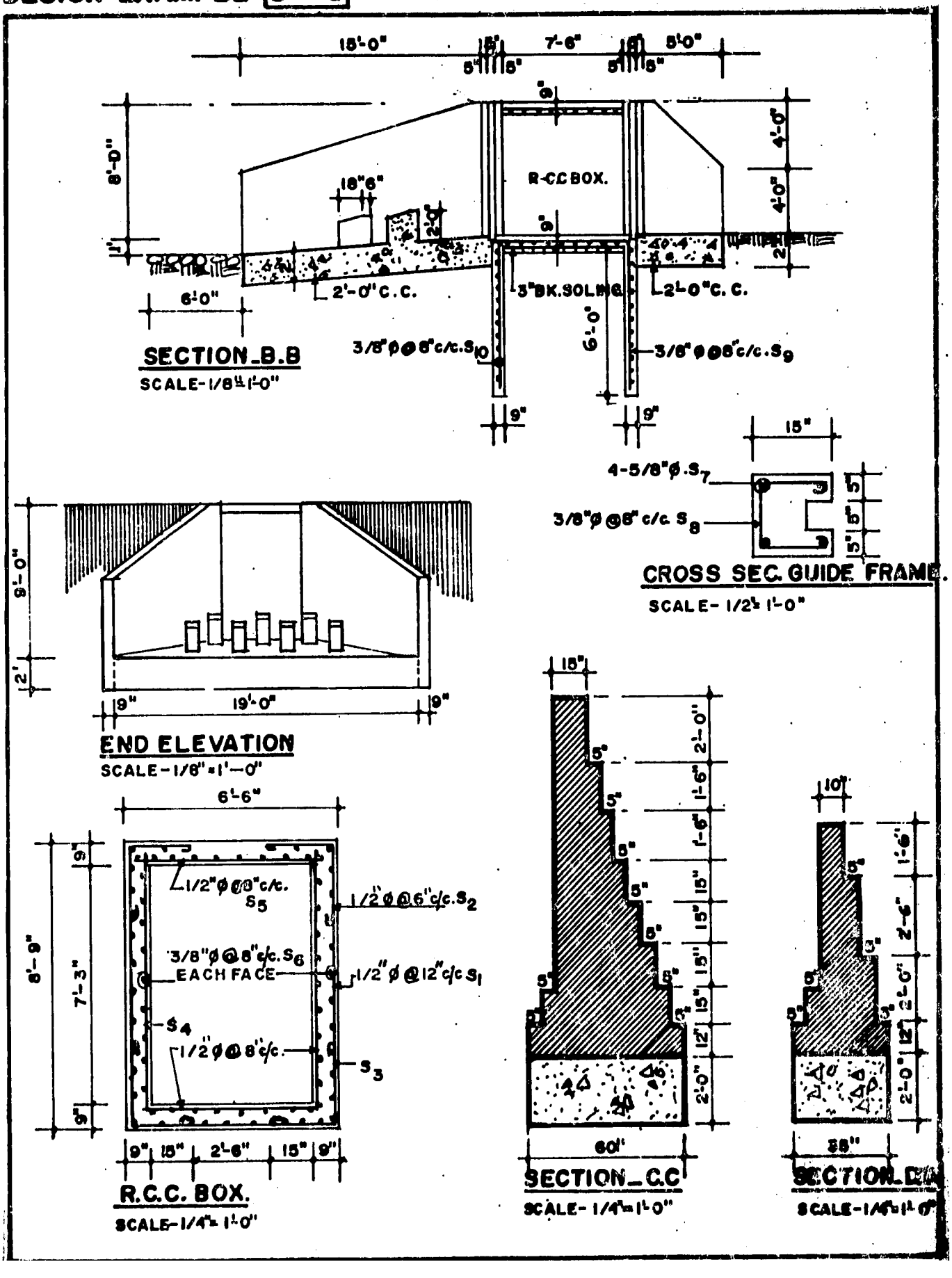


PLAN
SCALE – 1/8" = 1'-0"



PLAN
SCALE – 1/16" = 1'-0"

DESIGN EXAMPLE S - 3



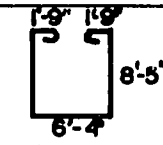
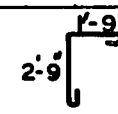
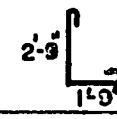
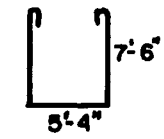
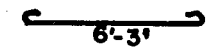
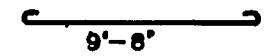
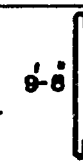
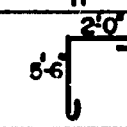
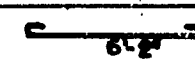
DESIGN EXAMPLE S-3

SPECIFICATIONS	REINFORCED CONCRETE BOX CULVERT TYPE. SPAN_ 5'-0" LENGTH_ 10'-0" HEIGHT_ 8'-0" SOIL CONDITION_SATISFACTORY. ● 1ST CLASS BRICKS. ● 1:4 MORTAR MIX FOR BRICKWORK. ● 1:3 MORTAR MIX FOR PLASTERING ALL EXPOSED BRICKWORK. ● 1:1/2:3 MIX FOR REINFORCED CONCRETE WORK. ● 1:3:6 MIX FOR CEMENT CONCRETE WORK.

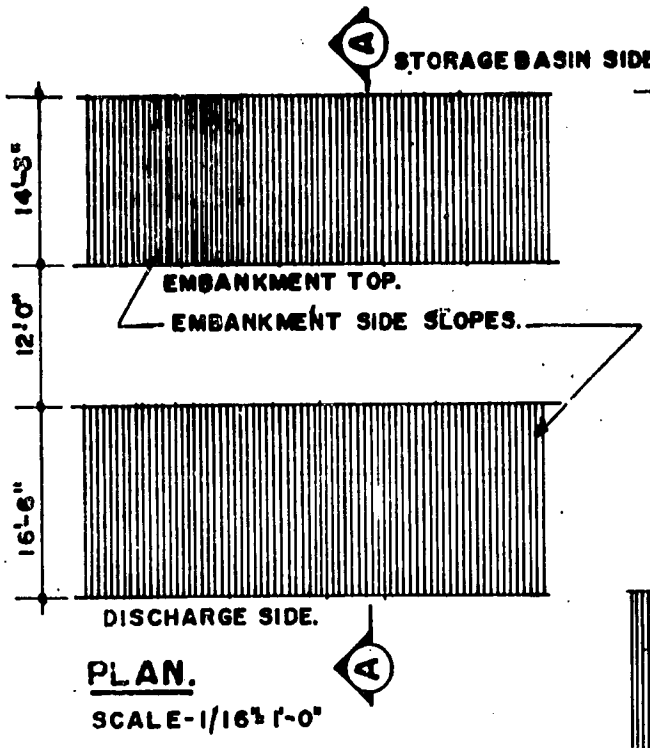
MATERIALS.

BRICK WORK.	CEMENT CONCRETE	BRICKS	CEMENT	SAND	KHOA	M.S. RODS
892 cft.	C.C. 561 cft. R.C.C. 315 cft.	10270 Nos	192 Bags.	695 cft.	630 cft.	3/8" ø 490 # 1/2" ø 505 # 5/8" ø 175 #

ROD BENDING SCHEDULE

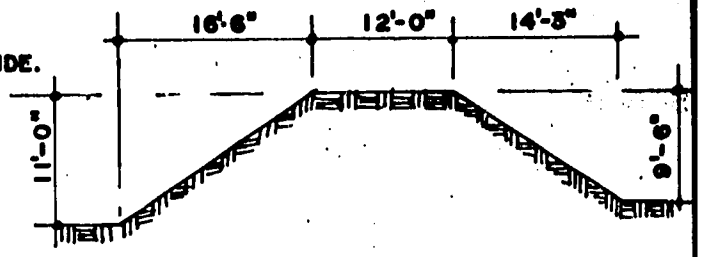
MARK.	DIA.	NOS.	LENGTH.	FINAL SHAPE.
S_1	1/2" ø	9	27'-4"	
S_2.	1/2" ø	9X2	5'-2"	
S_3	1/2" ø	9X2	5'-2"	
S_4	1/2" ø	12	20'-0"	
S_5	1/2" ø	12	6'-11"	
S_6	3/8" ø	78	10'-2"	
S_7	5/8" ø	4X4	10'-6"	
S_8	3/8" ø	15X4	3'-3"	
S_9	3/8" ø	2X11	8'-0"	
S_{10}	3/8" ø	2X10	6'-8"	

DESIGN EXAMPLE S-4



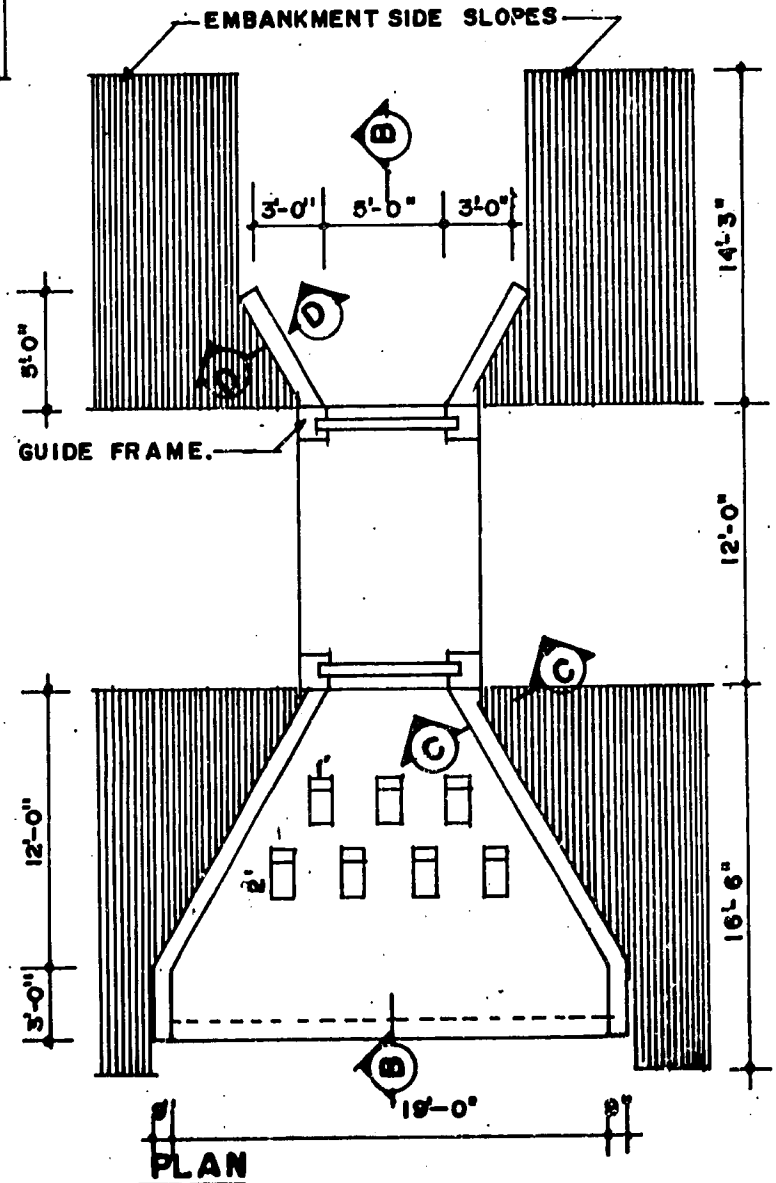
PLAN.

SCALE-1/16" = 1'-0"



SECTION A.A.

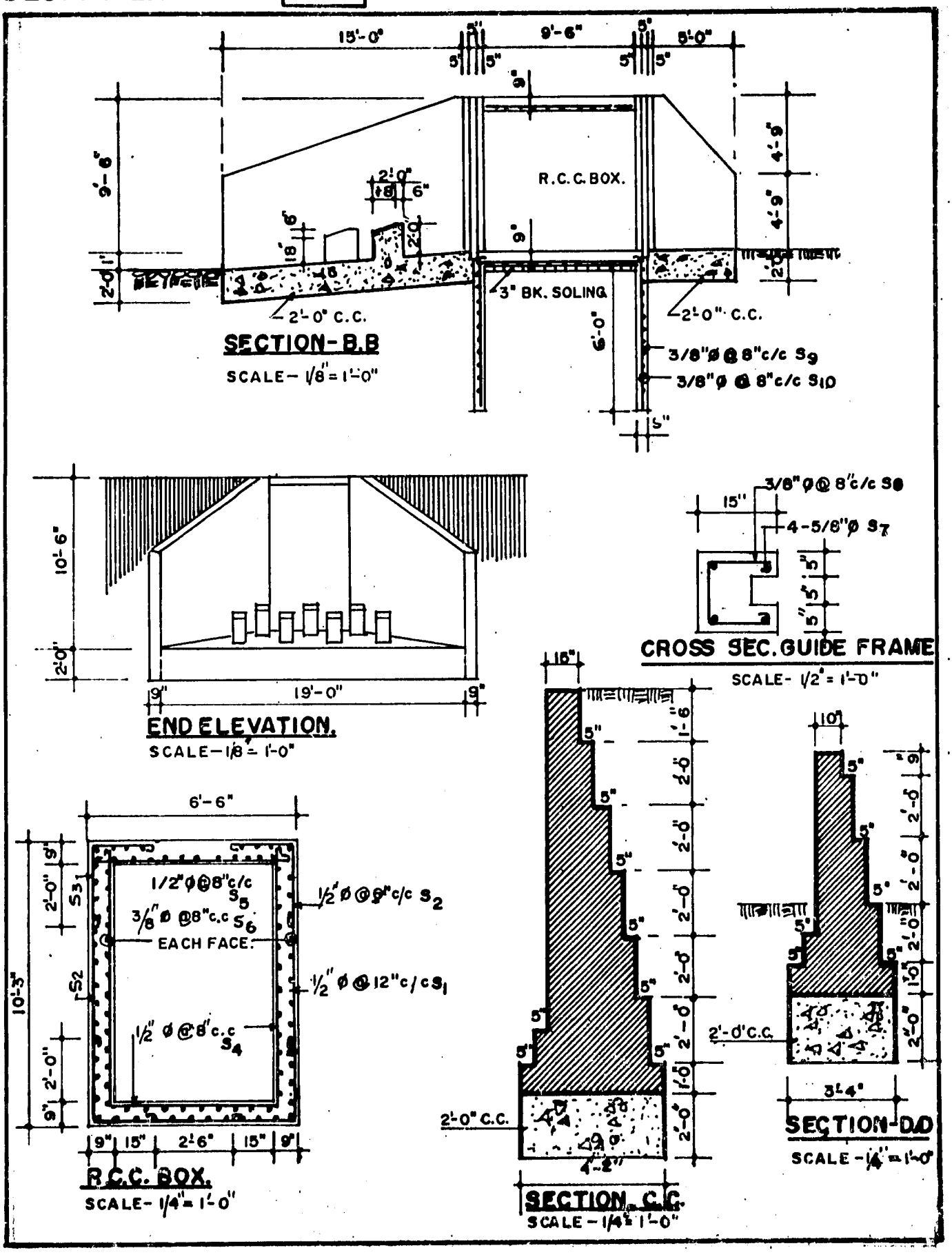
SCALE- 1/16" = 1'-0"



PLAN

SCALE-1/8" = 1'-0"

DESIGN EXAMPLE S- 4



DESIGN EXAMPLE S-4

SPECIFICATIONS

REINFORCED CONCRETE BOX CULVERT TYPE.

SPAN. 5'-0"

LENGTH-12'-0"

HEIGHT-9'-6"

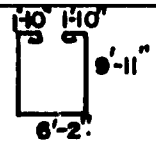
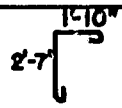
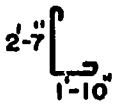
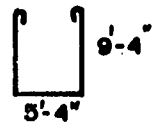
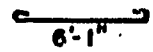
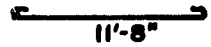
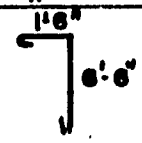
SOIL CONDITION-SATISFACTORY.

- 1ST CLASS BRICKS.
- 1:4 MORTAR MIX FOR BRICKWORK.
- 1:3 MORTAR MIX FOR PLASTERING ALL EXPOSED BRICKWORK.
- 1:1½:3 MIX FOR REINFORCED CONCRETE WORK.
- 1:3:6 MIX FOR CEMENT CONCRETE WORK.

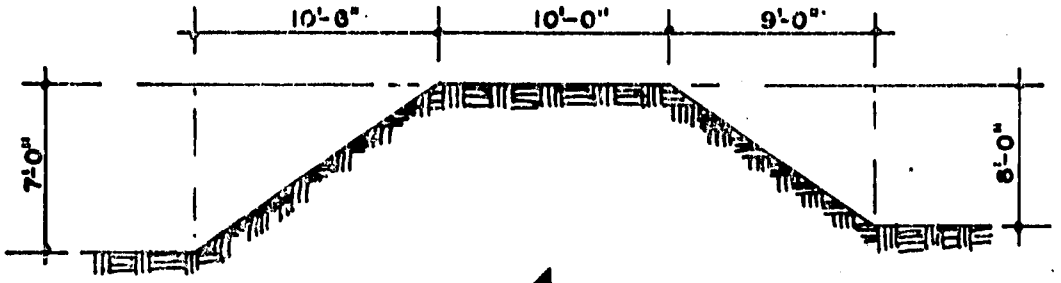
MATERIALS

BRICK WORK.	CEMENT CONCRETE	BRICKS	CEMENT	SAND	KHOA	GARJON WOOD	M.S. RODS
894 cft.	C.C.777cft. R.C.C.292 cft.	10,280 Nos.	209 Bags	768 cft.	982 cft.	2"X8"X6' =10'7cft	3/8" ϕ 629 # 1/2" ϕ 712 # 5/8" ϕ 214 #

ROD BENDING SCHEDULE.

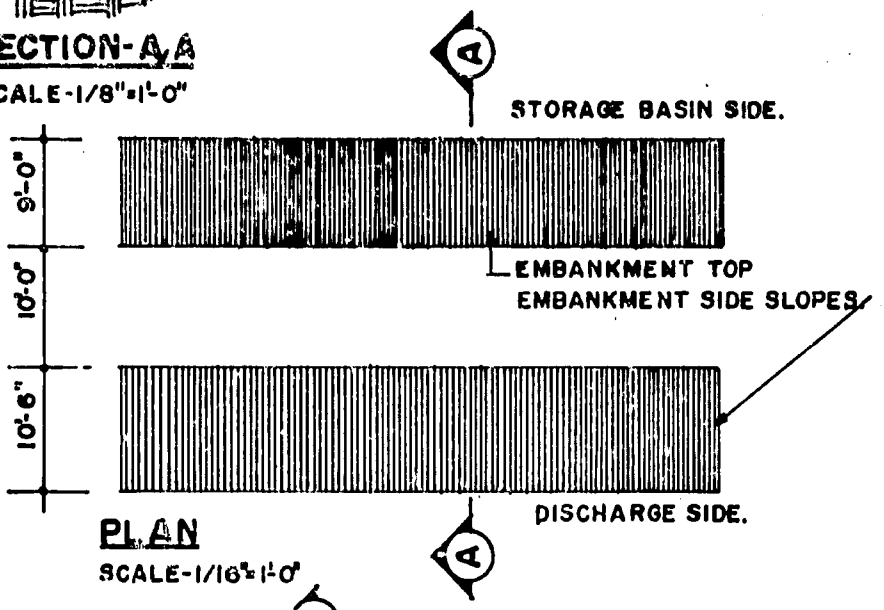
MARK	DIA	NOS	LENGTH	FINAL SHAPE.
S_1	1/2" ϕ	11	30'-4."	
S_2	1/2" ϕ	11X2	5'-3"	
S_3	1/2" ϕ	11X2	5'-3"	
S_4	1/2" ϕ	16	24'-8"	
S_5	1/2" ϕ	16	6'-9"	
S	3/8"	77	12'-2"	
S	5/8" ϕ	4X4	12'-10"	
S_7	3/8" ϕ	15X4	3'-3"	
S_8	3/8" ϕ	2X16	8'-6"	
S	3/8" ϕ	2X10	12'-2"	

DESIGN EXAMPLE **S-5** Multiple vent R.C.Pipe Type Sluice



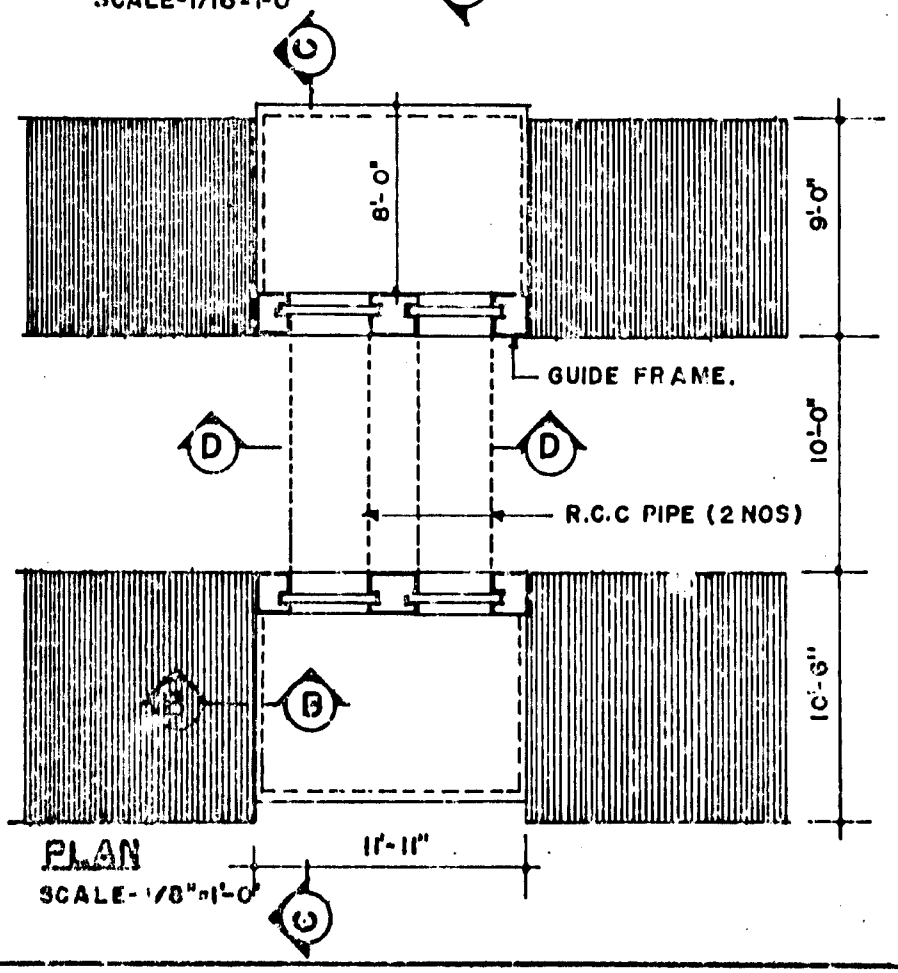
SECTION-A/A

SCALE-1/8"=1'-0"



PLAN

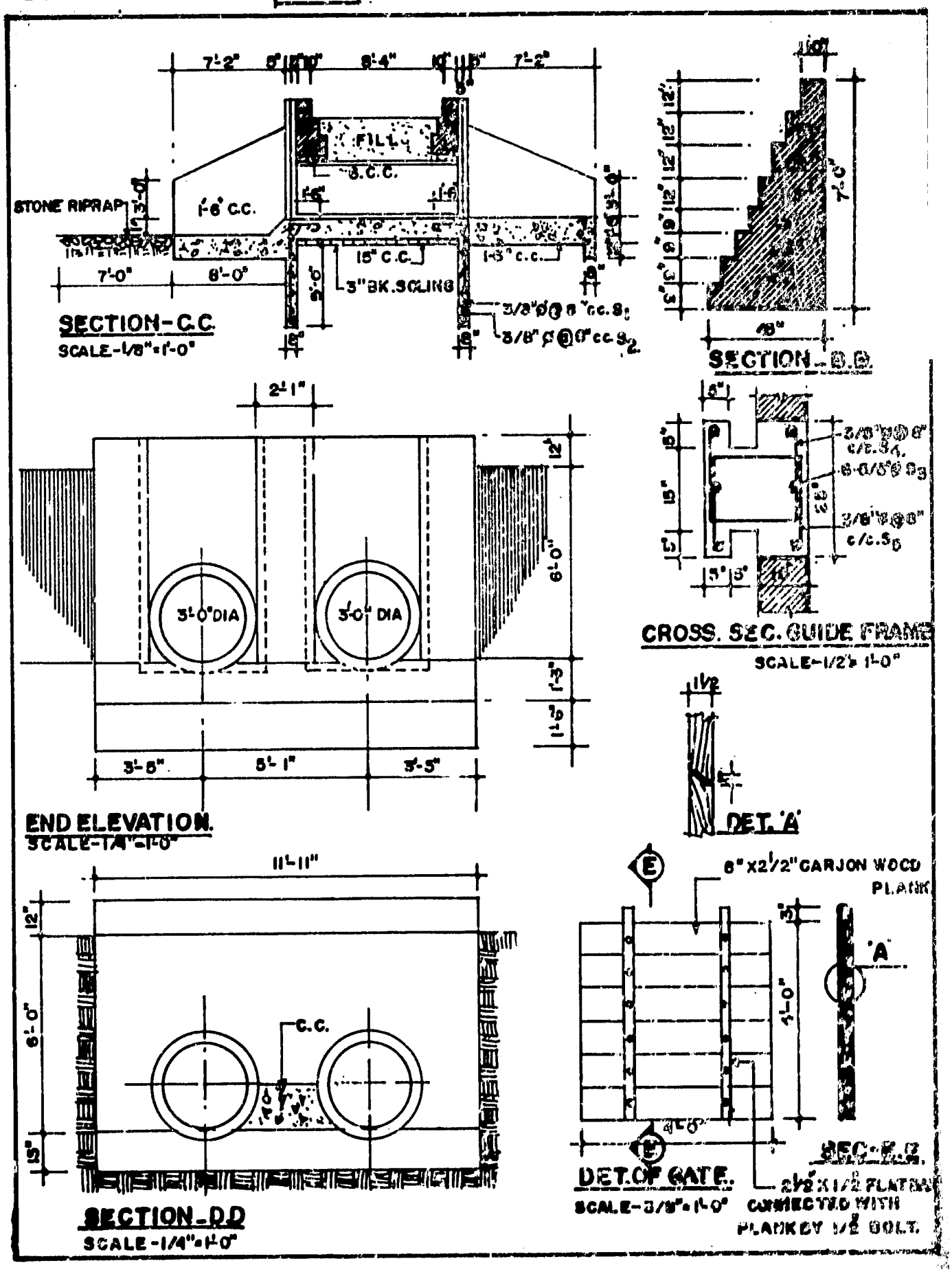
SCALE-1/16"=1'-0"



PLAN

SCALE-1/8"=1'-0"

DESIGN EXAMPLE S_5



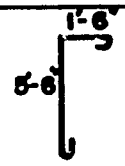
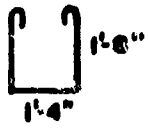
DESIGN EXAMPLE S-5

SPECIFICATIONS	REINFORCED CONCRETE MULTIPLE VENT PIPE TYPE. PIPE DIA — 3'-0" LENGTH — 10'-0" SOIL CONDITION. SATISFACTORY. (1) 1ST CLASS BRICKS. (2) 1:4 MORTAR MIX. FOR BRICKWORK. (3) 1:3: MORTAR MIX FOR PLASTERING ALL EXPOSED BRICKWORK. (4) 1:1½:3 MIX FOR REINFORCED CONCRETE WORK. (5) 1:3:6 MIX FOR CEMENT CONCRETE WORK.

MATERIALS.

BRICK WORK	CEMENT CONCRETE	BRICKS.	CEMENT	SAND	KHOA	BARJON WOOD	M.S. RODS.
573 cft.	C.C. 463 cft. R.C.C. 216 cft.	8464 No	146 Bag"	482 cft.	610 cft.	5·34 cft	3/8" ø 382 # 5/8" ø 309 #
						R.C.C. PIPE 3'-0" DIA 6 Nos.	

ROD BENDING SCHEDULE

MARK	DIA	NOS.	LENGTH.	FINAL SHAPE.
S_1	3/8" ø	17X2	7'-6"	
S_2	3/8" ø	11X2	12'-0"	
S_3	5/8" ø	6X2 4X4.	10'-10"	
S4.	3/8" ø	12X2	5'-2"	
S_5	3/8" ø	12X6	5'-2"	

SECTION VI

PREPARATION OF THE CONTRACT DOCUMENTS AND PROCEDURES FOR CONTRACT NEGOTIATIONS, JOB AWARDING AND CONSTRUCTION SUPERVISION

1. Preparation of the contract documents

For an engineering construction work, contract documents usually consist of the following :

(i) Tender notice

(ii) General rules and directions for use of the contractors.

(iii) Form and conditions of contract.

(iv) Specifications and bill of quantities.

(v) Project drawings.

(i) **Tender notice** :-Tender notice is usually given in daily news papers for publication for a specified number of days. A tender notice should contain the following information :

(a) Name of the inviting authority, nature of tho work and its location.

(b) Mode of submitting tender - sealed cover should be mentioned to maintain secrecy.

(c) Form in which tender is to be submitted - it is convenient if all the quatations are obtained in the same form.

(d) Estimated cost of the work and the time limit within which the work is to be completed.

(e) Information regarding the time and place and at what cost drawings, specifications and blank tender forms etc. may be obtained.

(f) The earnest money required and the last date, place and time of receipt of sealed bids.

(g) The date, time, place and procedure of opening of tenders.

A Specimen tender notice can be as follows :

NOTICE INVITING TENDER

OFFICE OF THE.....

1. Tenders in sealed covers are hereby invited in the form no. ( ) from bonafide contractors for the under mentioned work and will be received by the undersigned upto ( ) and will be opened on the same day at.....Hours !

2. Name of the work :.....

3. The amount of the estimate of work put to tender Tk.....

4. Each tender to be accompained by Tk.....in crossed cheque, Bank Draft, Govt. securities or Postal certificates in favour of the undersigned as earnest money.

5. The rates should be quoted both in words and figures and should be inclusive of all taxes now in force.

6. Time allowed for completion of the work from the date of issue of work order.....

7. The tender form together with the schedule of items, specifications, terms and conditions plans etc. can be obtained from the office of the undersigned during office hours on payment of usual charges.

8. The undersigned is not bound to accept the lowest tender and reserves the right to reject any or all tenders received without assigning any reason.

9. This tender notice along with the special terms and conditions will form a part of the contract and will be binding upon the contractor.

Supervisor of work

(ii) **General rules and directions for use of the contractor :-**

It is necessary to insert general instructions to the competing contractors at the Beginning of the contract documents which include clauses like issue rate (rate at which cost of materials will be deducted from the contractor's bill if materials are supplied by the authority) and use of materials supplied by the authority, correction of tender, withdrawal of tender etc.

(iii) **Form and condition of contract :** Form 2911 of the Public Works Department of the Government of Bangladesh is a standard form for contract and should be used. It is rather an elaborate form. A specimen Memorandum of contract with headings for conditions of contract can be as follows :

Memorandum

(a) General description
(b) Estimated cost.....Tk.
(c) Earnest money.....Tk.
(d) Security deposit including earnest money _____Tk.
(e) Percentage if any to be deducted from bills_____Tk.
(f) Time allowed for the work from the date of written order to commence the work (in months)

Item	Description	Quantity	Unit	Unit rate	Amount

Direction :

1. We undertake, if our tender is accepted, to commence the work within.....days of the employer's written order to commence and to complete the whole work comprised in the contract within.....days.

2. We solemnly declare that we have noted the conditions of contract to the effect that there shall be no change whatsoever in the item rate entered in the bill of quantities under the contract.

3. We understand that the authority is not bound to accept the lowest or any tender you may receive,

4. We are sumbittieg herewith the earnest mony of Tk.....as required by the notice inviting tender.

5. We are submitting herewith the complete set of Tender Documents, all duely filled in and signed,

Signature of Tenderer with Seal.

The usual sections of conditions of contracts are

1. Award and execution of contract
2. Scope of work
3. Control of work
4. Control of Material
5. Legal relations and Responsibility to the Public
6. Prosecution and Progress
7. Measurement and Payment.

(vi) **Specifications and bill of quantities :** Specifications are written instructions distinguishing or limiting and describing in detail the various 'trade sections' of the construction work proposed to be undertaken. In the following paragraphs, sample specifications for a few items are given as an illustration. It should be noted that these examples are subject to variation according to actual circumstances.

Earth work

This item shall consist of the necessary excavation for foundations of the structure/structures under the project.

Excavation shall include rsmoval of all materials from within the excavation limits as shown on the drawings, all clearing and grubbing of the site of the proposed work, the construction and subsequent removal of all necessary bracing, shoring, sheetings all pumping, bailing, draining and back filling and disposal of surplus or unsuitable material and the necessary excavation of the stream channel as may be directed by the job supervisor.

All foundations shall be constructed by open excavation and the foundation opening shall be shored, braced in accordance with approved methods.

Pumping or bailing of water from the interior of any foundation enclosure shall be done in such a manner as to preclude the posibility of any portion of the construction materials being carriedaway.

Foundation pits shall be excavated to permit the placing of the full widths and lengths of footings shown on drawings with horizontal beds. Rounded or undercut corners and edges of footings will not be permitted.

The elevation of the bottom of footings, as shown on the drawings, shall be considered as approximate only and the supervisor may order, in writing, such changes in dimensions or elevations of footings as may be necessary to secure a satisfactory foundation.

After such exacavation is completed, the contractor shall notify the supervisor and no masonry shall be placed until the supervisor has approved the depth of the excavation and the character of foundation materials and has given premission to proceed.

All materials used for backfill shall be of a quality acceptable to the supervisor and shall be free from organic materials. All backfill shall be placed in 6 (six) inches layers and thorouhly compacted by approved methods. The top surface of the backfill shall be neatly graded.

Adequate provision shall be made for thorough drainage of all backfilling by the provision of weepholes or other approved methods.

All excavated materials not used for backfilling shall be disposed of as directed by the supervisor.

Unless otherwise specified, no excavation shall be made outside of the specified limit of foundation and the natural streambed adjacent to the structure shall not be disturbed unless shown on the drainage or permitted by the supervisor.

The vertical limits for excavation shall include all excavation made between the existing ground surface and the elevation of the bottom of footing as shown on drawings. The measurement shall be based on the actual volume of earthwork done in conformity with the specification and true to drawing.

Brickwork

All bricks shall be of first class quality. Brickwork shall be built plumb, curved or battered as shown in the drawings or as may be required by the supervisor. Brick shall be cleaned and if necessary, they shall be scrubbed. Bricks shall be soaked in water for at least 8 hours in a reservoir before work, at the contractor's cost. No brick works shall be acceptable unless the bricks are properly soaked.

Vertical joints in alternate courses shall come directly over one another. Joint thickness shall be ½". The height of four courses including 4 bed joints shall rise 12". The masonry shall be cured for atleast 7 days.

Plastering:

Plastering shall be done with cement plaster of specified proportions, applied to clean rough surfaces in a single coat of specified thickness and thoroughly smoothed. All plaster shall be kept moist throughout the progress of the work and for atleast 10 days thereafter.

Concrete

This item shall consist of concreate composed of cousse aggregate, fine aggregate, portland cement and water proportioned and mixed as provided in the specifications and as per aproval of the supervisor.

The coarse aggregate shall be from 1st class picked jhama broken into ¾ inch down graded screened, washed, cleaned, up to the satisfaction of the supervisor. The fine aggregate shall be of Sylhet sand, screened, cleaned and washed. The cement to be used on the job shall be of the brand approved by the supervisor. The supervisor may ask the contractor if the deems it necessary for the performances of any test to the determine suitability of different meterials at contractor's own cost. The ultimate strength of concrete to be used on the job shall be between 2000 to 2500 p.s.i. The proportion of the mix shall in no case be less then 1 : 2 : 4.

The form work shall be substantial, rigid, unyielding and watertight. The maximum deflection 'd' in inches in the longitudinal formwork members shall not be more than that given by the formula (but not exeeding ½") :

$$d = \frac{S + 100}{1000}$$

where 'S' is the distance in inches between bents or supports.

In all cases the formwork for the girders, slabs etc. shall be supported on ballah piling driven to sufficient penetration to carry the superimposed loads. The supervisor may ask the contractor for performing load tests on the shuttering to determine the adequacy of the shuttering at the contractor's cost.

After all these specifications are met and written approval is taken from the supervisor, the contractor will go ahead with reinforcement arrangement. The reinforcement being checked and approved by the supervisor, the contractor will start concreting operation as per approved programme and method. The concrete shall be mixed in approved methods ensuring specified slump. Curing shall be done with care. All surfaces not covered by forms shall be protected with wetted gunny bags or any other approved means and kept wet by sprinkling water for a period of not less than 28 days.

Reinforcement steel

Reinforcing steel shall be of plain bars and shall meet the requirements of ASTM Designation A-15-65 Intermediate or Hard Grades, unless otherwise called for in the drawings.

When placed in concrete, all reinforcing steel shall be clean and free from all scales and injurious rusts. Steel shall be placed in position as per drawings and kept in position while the concrete is being placed. Reinforcement shall be placed in position before concrete is deposited. In no case shall reinforcing steel be driven or forced into the concrete after it has taken its initial set.

All hooks, bends and splicing shall be standard unless otherwise indicated on the drawings.

Reinforcement steel shall be in place and approved by the supervisor before any concrete is placed.

Salballah Piling

This item shall consist of furnishing, driving upto the specified depth and levelling the top at the required position as per the drawings.

The materials shall consist of Salballah, straight of diameter as specified in the schedule of items. The length of Salballah shall be atleast two feet greater than that shown in the drawings. The bellah shall be creosoted to atleast 15 lb retension as per standard specifications of BFIDC.

The bellah shall be driven by monkey cap and guiding posts as per approval of the supervisor. The weight of the monkey shall not be less than the weight of the pile. If the pile does not penetrate to the required depth, it shall be reported to the supervisor who will exercise his judgement as to the adjustibility of the length of the piles, after driving the pile the top level of the pile shall be levelled off.

Bituminous Surface Treatment

This item shall consist of a bituminous surface treatment composed of bituminous material and aggregate constructed on prepared base course. It shall be constructed in accordance with the typical cross-section shown on the drawings and with lines and grades established by the supervisor.

Aggregates for bituminous surface treatment shall consist of hard, strong, Sylhet shingles of specified size, free from adherent coatings and excess of flat, elongated, thinly laminated, soft or disintegrated pieces.

Bituminous materials shall be uniform in character, appearance and viscosity and its measurement shall be taken when the material is of a uniform temperature and free from air bubbles.

Bituminous material shall not be applied until the basecourse is clean, dry, compacted and bonded to the satisfaction of the supervisor and conforms to the typical cross-section shown on the drawings, and the lines and grades established by the supervisor. Bituminous material shall be applied uniformly for the full width to be treated. When the bituminous material is applied for less than the full width of the treatment, a suitable joint shall be provided by overlapping the application approximately 3 inches to ensure complete coverage.

For application, bituminous material shall be heated to 350-375°F and applied to the road surface when the temperature is not less than 350°F. The bitumen shall be applied at the rate of 45 lbs per 100 sq. feet of surface.

Immediately after the application of the bitumen, Sylhets shingles (passing through ¾" square mesh and retained on ⅜" square mesh) in perfectly clean and dry condition shall be applied uniformly at the rate of 6 cft per 100 square feet over the whole surface in which the bitumen is applied.

As soon as the stone chips have been spread over the whole area, it shall be rolled by a heavy roller. The rolling shall be done in longitudinal direction beginning at the outer edges of the treatment and working towards the centre. Each strip of the roller shall overlap the prior one by one half width of roller.

(v) **Project Drawings :** Drawings for supplying to the bidders and also for carrying out the construction work have to be prepared in proper scales with the help of a competent draftsman. The drawings for the different design examples included in the Manual may be redrawn on tracing paper sheets of 20" x 30" / 40" standard dimensions at an appropriate enlarged scale with all the dimensions and notes given therein. The draftsman shall sign the drawings and these shall be counter signed by a technically competent person after thorough checking The drawings can then be reproduced in the required number of copies by ammonia printing process.

2. Contract negotiations and awarding the job.

For construction purposes. the usual types of contracts are as follows :

1. Lump sum contract.
2. Item rate or unit price contract.
3. Cost plus fee contract.
4. Labour contract.

Lump sum Contract : In a lump sum contract the contractor agrees to carry out the entire work as shown in drawings and described in specifications. supplying labour and materials, all complete for a specified lump sum.

In some cases provisions may be made for the cost of extra work changes and omissions. Payments are made to the contractor after a completion certificate is obtained from the Supervisor. Usually no part payment is made to the Contractor but provisions for part payment may also be made.

This type of contract is less complecated for the executing authority and less supervisory staff is necessary. The authortiy may also know the exact sum of money needed for the project. However all the details involving cost of the project have to be found out before hand which may be difficult. Projects having uncertainities and for which a complete set of contract ducumens thave not been prepared are never given as lump sum contract.

Item rate or Unit Price contract : This is the most widely used type of contract. In this contract the contractor agrees to carry out the work as per drawings, bill of quantities and specicifications in consideration of a payment to be made entirely on measurements taken as the work proceeds, and at the unit prices tendered by the contractor in the bill of quantities.

The work may be tendered before all the details have been worked out;uncertainities are taken care of. The agreement is very fair to both the parties.

Both owner and the contractor must do a lot of computation and book keeping. As the quantities are likely to vary it is possible for the contractor to submit an unbalanced tender on the basis of shrewd anticipation or perhaps outside information. The "extra item" or "non tendered items" often causes a lot of trouble and in most cases the owner has to pay slightly higher rates than he would have payed if these were included in the begining.

So contracts of this nature needs careful scrunity by the Supervisor before being entered into.

Cost plus fee contract : In this the owner agrees to pay to the contractor the actual cost of the work plus an agrued fee. The fee may be fixed, fluctuating or a percentage of the cost.

This type of contract is suitable only for specialized work when exceptional quality of work is required and when the contractor is very reliable. In public works this is not done except in emergencies.

Labour Contract : In this type of contract the owner agrees to supply all the requisite materials to the contractor and the contractor agrees to supply all the labour and workmanship necessary for completion of work according to drawings and specifications.

This form is suitable for those cases where materials are obtained free or at a subsidised rate.

Limited or Selective tender : In this method the owner invites tenders from a few contrators who are known to have specialised in the special type of work or who have been previously pre-qualified or enlisted. This is also adopted when there is such an urgency that time for elaborate advertisements and notices is not available. Spot tenders, where tenders are published in a few spots only may also be included in this group. In public works limited or selective tenders are not adopted in usual circumstances.

Open tender : In this method tenders are invited through public advertisement. This is in the usual practice for public works : Advertising is usually done through newspapers under the heading "Tender Notice". Advertisements should appear 2 to 3 weeks in advance of the expected quotation.
Lowest tender may be rejected on following grounds.
(i) Improper offer (ii) Inadequate finances (iii) lack of experience in the particular type of works (iv) unsatisfactory reputation (v) Inadequate staff and equipment.

All tenders received may be rejected, if—

(i) There exists a well grounded suspicion of collusion between Tenderers or some other form of fraud.

(ii) The lowest tenderer has quoted a figure which is higher than the funds available.

(iii) The number of tenders are too low to ensure proper competition.

3. Construction Scheduling, job supervision and Record Keeping.

For successful performance of a construction project, the work should be carefully planned and scheduled. Factors which contribute to good planning are :

(i) Understanding the job to be done.

(ii) Understanding the plans and specifications.

(iii) Acquainting onself with the local condition the worksite, labour, materials, transportation, etc.

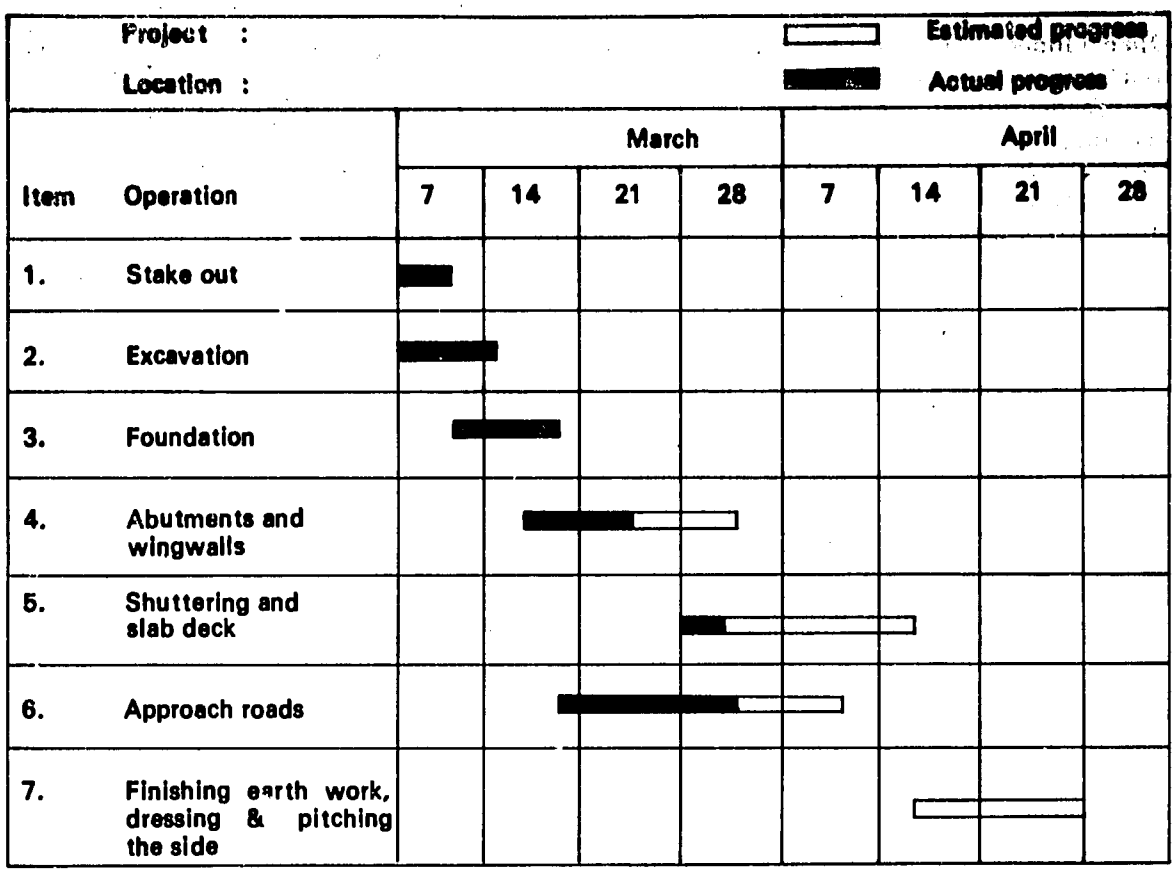
(iv) Ability to plan ahead for coming construction operations.

(v) Purchasing, transporting and properly storing materials ahead of time for use on the project.

(vi) Obtaining the supervisory staff to properly execute the work.

(vii) Obtaining and maintaining a good labour force.

It is a common practice to setup a chart of construction schedule by breaking down the project into appropriate divisions and activities and assigning appropriate time period for the completion of each of these. On the same chart, the actual progress of the work can also be recorded giving a clear visual picture of the progress of the work. An illustrative example of a construction schedule for a cultvert is given.



Before and during construction, materials must be brought to the site. A constant check should be made on the quality of materials at the site so that they may be ordered well in advance to avoid work delays. A check list for materials can be prepared as follows :

Example

Project :		Date	
Location :			
Materials	Required	Ordered	On hand.
1. Bricks,	43000	13,000	30,000
2. Cement	137 bags	57 bags	80 bags
3. Sand	343 cft	143 cft	200 cft
4. Khoa.	650 cft	150 cft	500 cft
5. Stone Chips	35 cft	35 cft	—
6. M. S. Rods	35 cwt	24 cwt	10 cwt

Job supervision will be done as per the project documents (contracts) and in accordance with the common and good practices discussed in the Section III of the manual.

It is a good practice for the supervisor to keep a 'Tour Diary' (day to day record). In it should be recorded in rough and compact form, all the information he needs to makeup the weekly and/or monthly progress report/reports. In addition, he should record any disputes, verbal instructions, personal comments on workers, weather, work progress and so on.

This diary is a personal record and not an official document. But it may be of great importance as a reference or as a defence for the supervisor if a project dispute or failure arises. A sample page from a 'tour diary' can be as follows ;

March 1, 1978

Weather : Clear, hot visited Gazipur Culvert site.
Excavation for foundation complete, footings for abutment and wingwalls to be laid. Told the contractor to order more bricks. Excavation work done well.

March 2, 1978

Weather : Clear, hot. Checked placement of reinforcement in footings. Instructed head mistri to ensure tying of the bars firmly with wire. Concreting can begin tomorrow.

March 3, 1978

Weather : Clear, hot dry. Concreting of foundation sterted after a final check of the reinforcements. Remained on site whole day. Concreting completed just before sun set. No undue problems.

For any sizable construction job, a 'project log' must be kept at the job site by the Project Committee. The project log is the official record of the daily progress on the site. Each entry in it should be signed by one of the Committee members.

When visiting a worksite, the Supervisor (Circle Officer, Overseer, Union Council Chairman, Project Supervisor) should always consult the Project log to determine what progress has been made and to note the work being done, materials on hand, labourers on hand and their jobs and to note any suggestions made as to different work methods and quality control. A sample project log can be as follows :

GAZIPUR CULVERT SITE

Date	Weather	No. of Men	Progress	Materials on Hand	Remarks	Singture
March 1, 1978	Clear, Hot	2 Mistris 6 Masons 3 Mixers 10 Labourers	Abutment and wing walls foundation excavation completed, rod bending in progress.	Bricks-short	Told contractor to order more bricks.	
March 3, 1978	Clear, Hot	2 Mistries 6 Masons 3 Mixers 10 Labourers	Concreting of footing com-lete.		Told rod mistri to start rod bending for slab deck.	
March 8, 1978	Cloudy. Hot	3 Mistries 8 Masons 3 Mixers 10 Labourers	Abutments and wing walls progressing as per schedule	Sufficient.	Bricks arrived	

4. Measurement of Works, Preparation of Bills and Payments.

Earthwork shall be measured in cubic feet (cft) based on the actual volume of earthwork done in conformity with the specification and true to drawings. Rate is given in Taka per 1000 cft.

Brickwork is measured in two-ways. For 5", 10" or 15" walls, work is measured in square feet and rate is given in Taka per 100 sft. For Mass masonry work, brickwork is measured in cubic feet and the rate is given in Taka per 100 cft.

Plastering is measured in square feet and the rate is given in taka per 100 sft.

Concretework is measured in cubic feet and the rate is given in taka per cft. Rates for R.C.C. is about 30% higher than the rate for plain mass concrete wall.

Piling is measured on the basis of actual footage of pile driven in conformity with the specification and true to drawings and the rate is given in taka per foot.

Bituminous surface treatment is measured in square feet of surface treated as per specification and true to drawings and the rate is given in taka per 100 sft.

The contractor has to take measurements of the work carried-out and submit the bill periodically, generally every month. The Supervisor accompanies the Contractor or his representativte where measurements are being taken. If the Supervisor is satisfied, he recommends the bill for payment. The amount recommended by the Supervisor is the the cost of the work less the retention money (security, deduction of part of mobilization fee etc.) and the cost of materials supplied to the contractor by the authority which has been used on the work during the period under consideration.

If any item occurs during execution of the work which is not included in the bill of quantities, it is usually possible to construct that item by a combination of other items already in the bill ; otherwise it is paid for as an 'extra' item at a specially analysed rate.

A completion certificate from the Supervisor and a no claim certificate from the contractor is necessary before final bills are paid.

Security monery is paid back to the contractor after a stipulated period of time as mentioned in the contract.

SECTION VII

POST CONSTRUCTION INSPECTION AND MAINTENANCE OF THE STRUCTURES.

1. General Inspections :

General inspection of the structure should form a regular practice after the completion of the project for proper maintenance. The inspection should include some or all of the following points depending on the type and description of the structure :

(i) An examination of roadway surface for signs of excessive scaling or unevenness in the surface.

(ii) An examination of the approaches to the structure for erosion of the sides of the embankment.

(iii) An examination of the masonry work for cracked, disintegrated, spalled or honeycombed areas which may expose the reinforcing steel ; growth of vines or brush in the cracks and joints.

(iv) An examination of the face of abutmeni for moisture in dry weather which will be an indication of accomulation of water behind the abutment which can seriously affect the structure over a period of time.

(v) An examination of the foundation of abutments and piers for indication of scour or undercutting.

2. Testing for Deflection.

Deflection is elastic deformation. It depends on the length of the span, loading on the structure and the properties of the materials. The strength of the structure is given by the load corresponding to the allowable deflection.

Deflection can be measured by a deflectometer mounted on a platform erected on a timber trestle, constructed centrally at mid-span. Adjacent to this, on an entirely independent trestle, and observer's platform is erected. This is to avoid any effect on the instrument trestle through vibration.

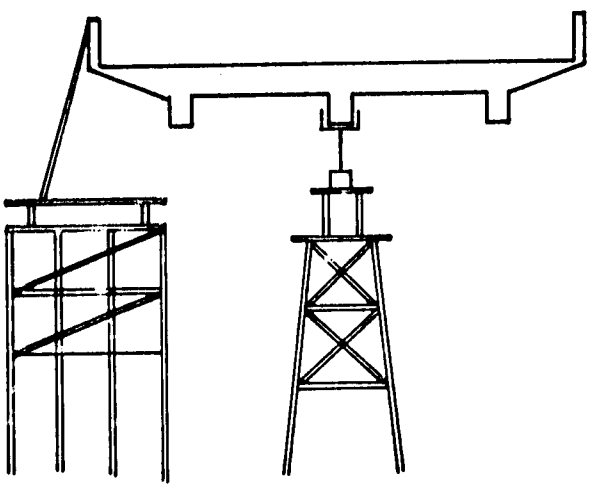


Fig. VII-1 : Measuring Deflection of a Bridge

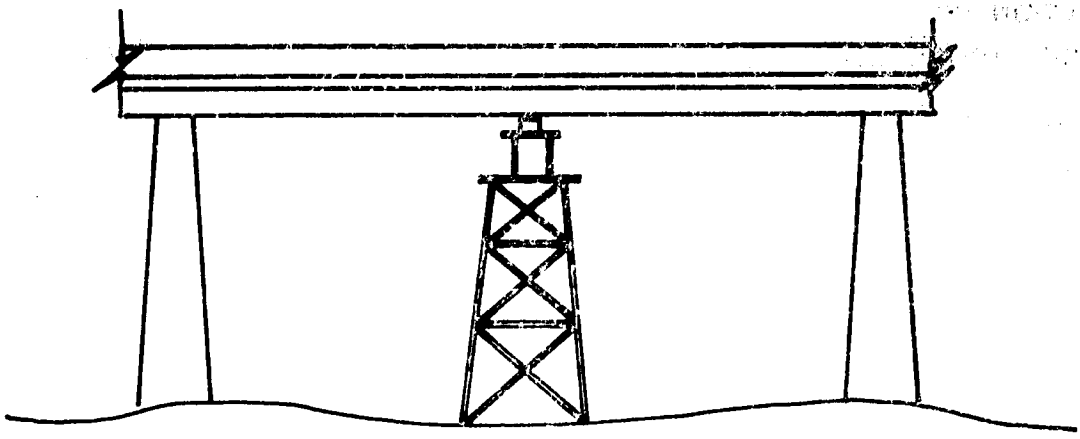


Fig. VII—1 : Measuring Deflection of a Bridge.

The measured deflection is to be compared with the maximum allowable deflection under loading.

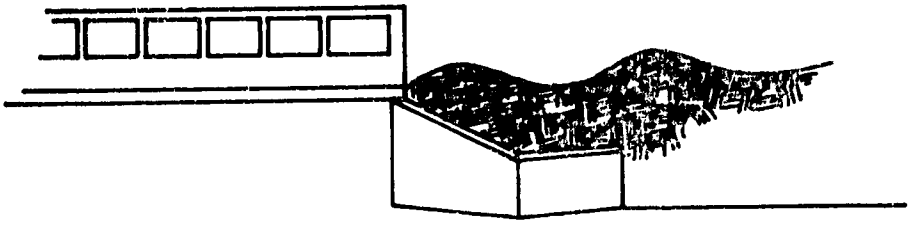
3. Road Surfaces :—If a crack in a concrete surface is to be repaired, the area should be roughened to give the new concrete a holding surface. The loose particles should be brushed out to make the area clean, then grouted with a neat cement grout against which the new concrete shall be placed before the grout has attained its initial set. If a hole is to be repaired, it should be chiseled out to a square or rectangular shape with vertical sides to make an uniform patch. Before adding the concrete, all loose particles should be brushed out and the area watered down. Sand should be placed in the hole and tamped, if necessary. Then the concrete is added, tamped and cured.

Fig. VII-2 : Incorrectly and Correctly Installed patches

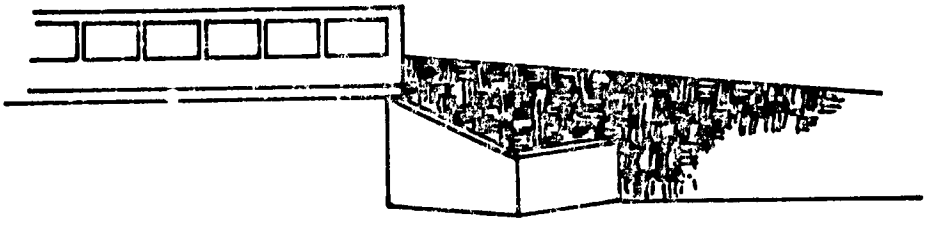
For brick surfaced roads, the most common form of repair is replacement of broken bricks. When replacing broken bricks in a road, the bad bricks should be removed and the materials beneath and the bricks removed down to the earth below. Next sand should be added to serve as a base for the new bricks. If soling is to be added, it should now be placed and levelled. Then the top layer of bricks should be added and sand placed between the bricks.

For bituminous or asphalt surfaced roads, wearing, cracks and holes are the most commonly found faults. The easiest and probably the most economical way of making these repairs is to apply a sealcoat which is a thin mixture of bituminous or asphalt compound heated to a liquid and applied with sand. The area should be thoroughly cleaned before applying the seal coat. For repairing big holes, excavation should be made at least one foot outside of the edge of the faulty area in order to tie the patch to solid materials all around. In excavating materials from the area to be repaired, the faces should be vertical. The hole should be filled with sand and compacted in layers, if neccessary. After spreading a primer, the new surface should be applied.

4. **Approaches to the Structure** :—Approaches to the culverts and bridges should be maintained with proper slope avoiding too steep and dangerously uneven surfaces and exposure of the end of the slab or abutment making it difficult for vehicles to pass. The slope should be repaired by dressing, filling and surfacing to a gradual slope.



Faulty approach.

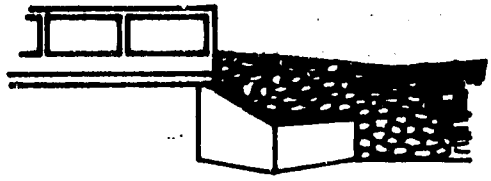


Properly maintained approach

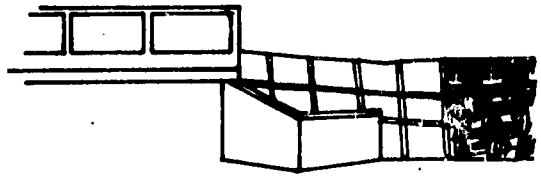
Fig. VII-3 : Approaches to structures.

The maintenance of the embankment and road sideslopes against erosion can be done by riprap, turfing or seeding as follows :

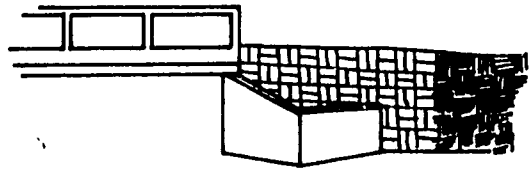
Riprap is stones, concrete blocks or bricks placed on the sideslope of an embankment or roadway. It is used to stabilize embankments that are subjected to high velocities of water flow. It is also used to reinforce the embankments around bridge wingwalls to protect against scouring.



Stone riprap, minimum size of stones 6" to 7". The stones should be carefully placed to fill all spaces.



Concrete block riprap. Conc. blocks should be 12"x12"x4" and made of 1:3:6 or 1:4:8 concrete mix. The blocks should be placed in neat columns and held together with wires.



Brick riprap. Bricks should be placed flat on the slopes in a consistant pattern as shown filling all the gaps and held together by wire mesh placed on top and anchored to the ground with spikes.

Fig. VII 4 : Riprap on the embankment slopes.

5. Turfing and Seeding are two of the most economical methods of protecting a slope. If a slope has become eroded and is to be turfed or seeded, it should be first scraped to a depth of about 3". The soil should then be compacted after which new top soil consisting of good soil and sand which will promote growth of grass is added. The new top should also be compacted and then scarified (scratched). The seed or turf should then be added and compacted lightly. If seed is used, jute sacks or dead grass and vegetation should be placed over the seeded area and anchored with bamboo stakes for protection during germination.

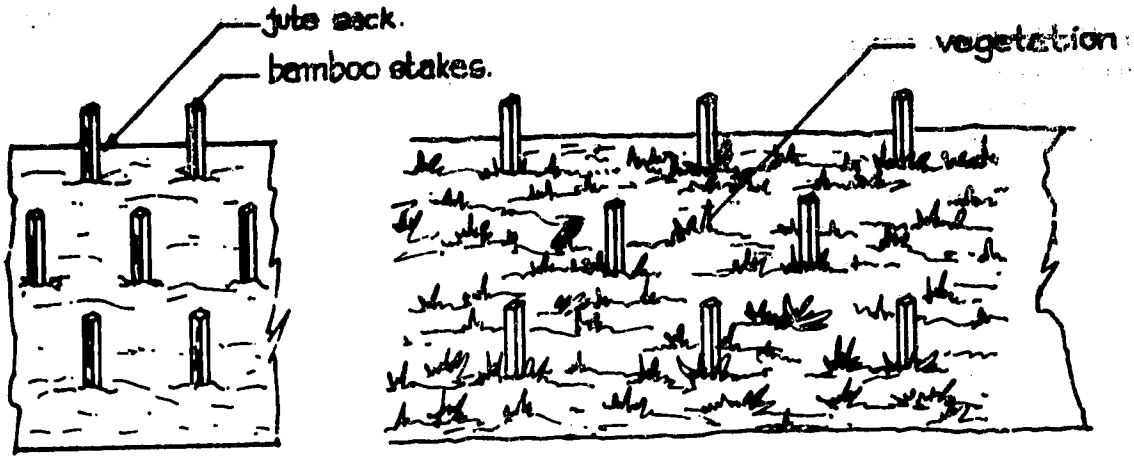


Fig. VII 5 : Protection of Newly Seeded ground.

When turf is to be used, the joints should be staggered. The turf should then be tamped and achored to the slope with bamboo stakes.

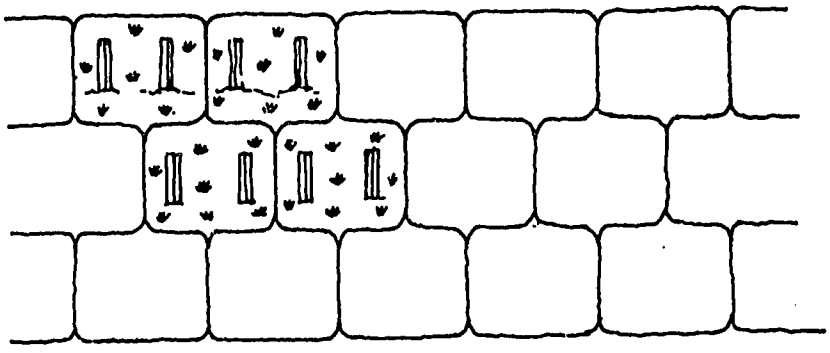


Fig. VII-6 : Staggered placement of Turf with Anchoring

6. Masonry Work :-If a crack is to be repaired, it should be roughened cleaned and wetted before sealing it with a rich mortar. Disintegreted, spalled or honey combed concrete surfaces should similarly be roughened, cleaned, wetted and patched with rich cement-sand mortar. Any growth of vines or brush should be immediately cleaned on detection and the cracks repaired otherwise these will tend to enlarge the cracks to a point of breakage.

If the old masonry in the substructure shows signs of disintegration, it should be protected by removing all loose materials all around the structure and thoroughly cleaning the masonry to find out the defects. If there are any large cavities, they should be filled with good cement concrete after which a wire netting should be stretched around the entire masonry and fastened thereto with spikes. A final coating of cement morter is then to be applied.

7. Moist Abutment :-If there is some sign that water has accumulated at the back of the abutment, it must be drained out otherwise, over a period of time, it may result in disintegration to the extent that the abutment may be materially damaged. In such a case, provision should be made to provide an outlet for this accumulated water, either by providing a proper drain around the back of the abutment or by drilling weep holes through the abutment.

8. Foundaton Scouring or Erosion :-If the action of the water current has under scoured the footings of piers or abutments, repair works must be carried out immediately on detection. But it may be necessary first to divert water from the pier or abutment which can be done by building a dyke as shown in the figure below :

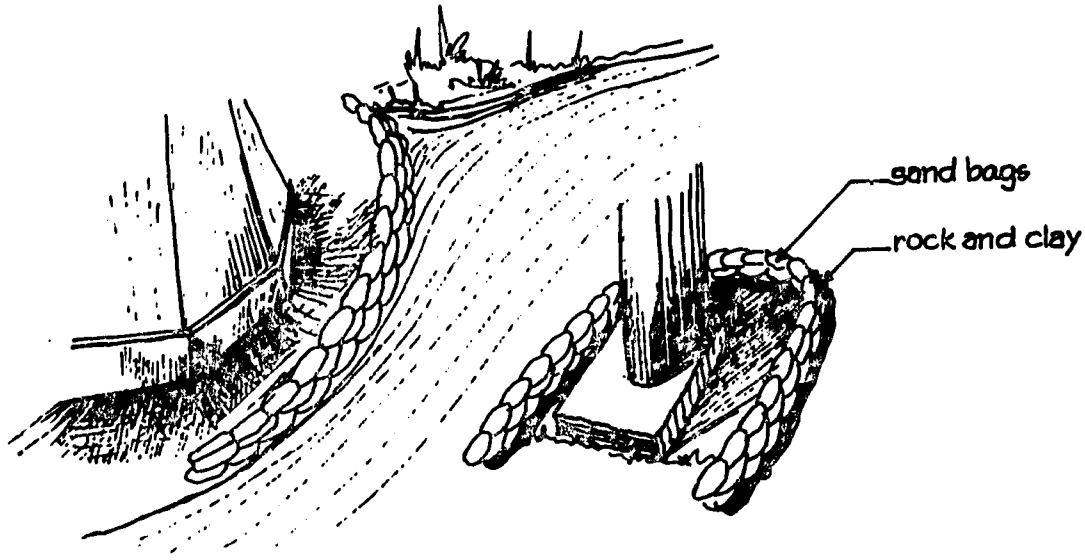
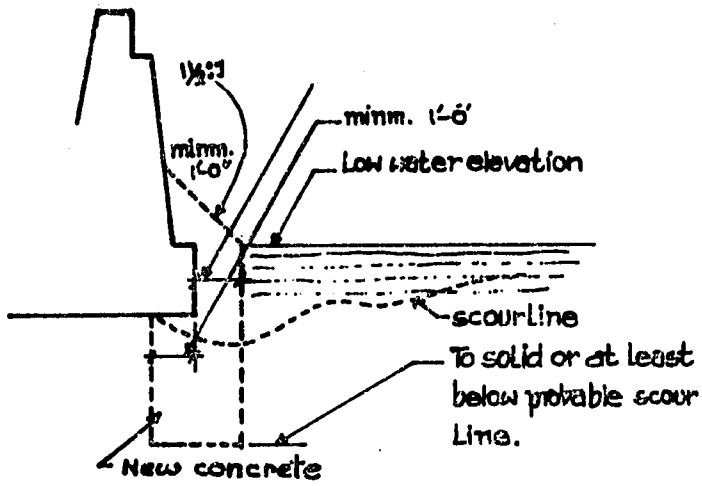
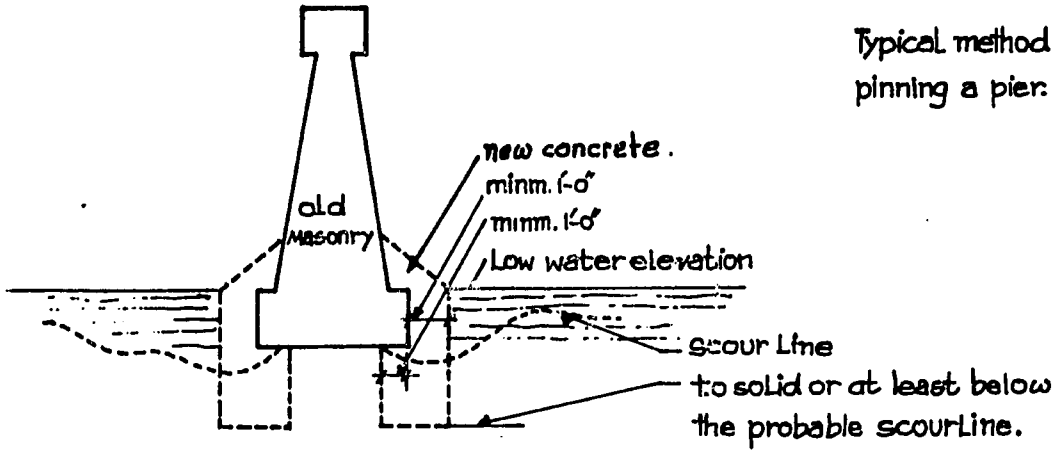


Fig VIII-7 : Dykes for Diverting Water Flow.

On diverting the water, remedial measures as illustrated below may be used to correct the effect of the underscouring and thereby preserve the usefulness of the piers or abutments.



Typical method of under pinning an abutment.



Typical method of under pinning a pier.

Fig. VII-8 : Typical Methods of Underpinning Abutments and Piers.

SECTION VIII

TABLES OF INFORMATION

1. Weight and Measures

(a) Weights :

Table VIII-1

5.00	tolas	= 1	Chatteck
4.00	Chattacks	= 1	poa
16.00	Chattacks	= 1	seer
4.00	Poa	= 1	seer
40.00	seer	= 1	maund
27.20	maunds	= 1	long ton
2.06	pounds	= 1	seer
82.28	pounds	= 1	maund
2000.00	pounds	= 1	short ton
2240.00	pounds	= 1	long ton
112.00	pounds	= 1	cwt (hondar)
20.00	cwt	= 1	long ton

(b) Linear Measure :

Table VIII-2

12.00	inches	= 1	foot
3.00	feet	= 1	yard
5.00	yards	= 1	rod
5.00	yards	= 1	pole
4.00	rods	= 1	chain
10.00	chains	= 1	furlong
8.00	furlongs	= 1	mile
7.92	inches	= 1	link
100.00	links	= 1	chain
80.00	chains	= 1	mile
5280.00	feet	= 1	mile
1760.00	yards	= 1	mile
2.54	centimeters	= 1	inch
30.48	centimeters	= 1	foot
0.91	meter	= 1	yard
1.61	kilometers	= 1	mile
100.00	centimeters	= 1	meter
1000.00	meters	= 1	kilometer

(c) **Square and Land Measure :** **Table VIII-3**

144.00	square inches	=	1 square foot
9.00	square feet	=	1 square yard
30.25	square yard	=	1 square rod
160.00	square rods	=	1 acre
4840.00	square yards	=	1 acre
43560.00	square feet	=	1 acre
640.00	acres	=	1 square mile
484.00	square yards	=	1 square chain
16.00	square rods	=	1 square chain
10.00	square chains	=	1 acre
720.00	square feet	=	1 cottah
80.00	square yards	=	1 cottah
20.00	cottahs	=	1 bigha
3.05	bighas	=	1 acre
1936.00	bighas	=	1 square mile

(d) **Liquid Measure/Volume Measure :** **Table VIII-4**

4.00	gills	=	1 pint
2.00	pints	=	1 quart
4.00	quarts	=	1 gallon (U. S.)
7.48	gallons (U. S.)	=	1 cubic foot
1728.00	cubic inches	=	1 cubic foot
27.00	cubic feet	=	1 cubic yard
1.06	quarts	=	1 liter
3.80	liters	=	1 gallon (U. S.)
4.54	liters	=	1 gallon (Imperial)
1.20	gallons (U.S.)	=	1 gallon (Imperial)

(e) **Unit weights of materials :**

Table VIII-5

Materials	Unit	Weight
Cement	cubic foot	90.00 pounds
Sand	cubic foot	110-120.00 pounds
Clay	cubic foot	115-130.00 pounds
Lime	cubic foot	40.00 pounds
Surki	cubic foot	80.00 pounds
Asphalt	cubic foot	90.00 pounds
Tar	cubic foot	60.00 pounds
Brick work	cubic foot	120.00 pounds
Lime concrete	cubic foot	115-135.00 pounds
Cement concrete	cubic foot	140.00 pounds
R. C. concrete	cubic feot	150.00 pounds
Shingles	cubic foot	90.00 pounds
Brick ballast	cubic foot	60-70.00 pounds
Cast iron	cubic foot	450.00 pounds
Steel	cubic foot	490.00 pounds
C. I. Sheet	square foot	1.8-3.50 pounds
Asbestos sheet	square foot	3.00 pounds
Sal wood	cubic foot	60-65.00 pounds
Teak wood	cubic foot	50-55.00 pounds
Water	cubic foot	62.50 pounds

(f) Measures for reinforcing round bars :

Table VIII-6

Dia. in inches.	Area in sq. inches.	Perimeter in inches.	Weight in pounds per foot.	Length in feet making 1 cwt approximately
1/4	0.049	0.785	0.168	672
5/16	0.077	0.982	0.261	238
3/8	0.110	1.178	0.376	168
7/16	0.150	1.375	0.511	107
1/2	0.196	1.570	0.668	75
5/8	0.307	1.960	1.043	55
3/4	0.442	2.360	1.502	42
7/8	0.601	2.750	2.040	33
1	0.785	3.140	2.670	27
1 1/8	0.994	3.530	3.380	22

(g) Standard Dimensions and Weight of M. S. Rod :

Table VIII-7

Numerals	Diameters, in.	Cross-section, sq. in.	Weight, lb/ft.
2	$\frac{1}{4}$	0.05	0.167
3	$\frac{3}{8}$	0.11	0.367
4	$\frac{1}{2}$	0.20	0.666
5	$\frac{5}{8}$	0.31	1.043
6	$\frac{3}{4}$	0.44	1.502
7	$\frac{7}{8}$	0.60	2.044
8	1	0.79	2.670
9	$1\frac{1}{8}$	1.00	3.400
10	$1\frac{1}{4}$	1.27	4.303

(h) Quantities of Materials Required for Concrete Mix of 1 : 1½ : 3

Table VIII-8

Conc. cft.	Cement		Sand cft.	Khoa/ st. chip cft.	Conc. cft.	Cement		Sand cft.	Khoa/ st. chip cft.
	cfts.	Bags.				cft.	Bags		
1.	.27	.22	.22	.84	29.	7.97	6.38	12.18	24.36
2.	.55	.44	.84	1.68	30.	8.25	6.60	12.60	25.20
3.	.82	.66	1.26	2.52	31.	8.52	6.82	13.02	26.04
4.	1.10	.88	1.68	3.36	32.	8.80	7.04	13.44	26.88
5.	1.37	1.10	2.10	4.20	33.	9.07	7.26	13.86	27.72
6.	1.65	1.32	2.52	5.04	34.	9.35	7.48	14.28	28.56
7.	1.92	1.54	2.94	5.88	35.	9.62	7.7	14.70	29.40
8.	2.20	1.76	3.36	6.72	36.	9.9	7.92	15.12	30.24
9.	2.47	1.98	3.78	7.56	37.	10.17	8.14	15.54	31.08
10.	2.75	2.20	4.20	8.40	38.	10.45	8.36	15.96	31.92
11.	3.02	2.42	4.62	9.24	39.	10.72	8.48	16.38	32.76
12.	3.30	2.64	5.04	10.08	40.	11.00	8.80	16.80	33.60
13.	3.57	2.86	5.46	10.92	41.	11.27	9.02	17.22	34.44
14.	3.85	3.08	5.88	11.76	42.	11.55	9.24	17.64	35.28
15.	4.12	3.30	5.30	12.60	43.	11.82	9.46	17.06	36.12
16.	4.40	3.52	6.62	13.44	44.	12.10	9.68	18.48	36.96
17.	4.67	3.74	7.14	14.28	45.	12.37	9.90	18.90	37.80
18.	4.95	3.96	7.56	15.12	46.	12.65	10.12	19.32	38.64
19.	5.22	4.18	7.98	15.96	47.	12.92	10.34	19.74	39.48
20.	5.50	4.40	8.40	16.80	48.	13.2	10.56	20.16	40.32
21.	5.77	4.62	8.82	17.64	49.	13.47	10.78	20.58	41.16
22.	6.05	4.84	9.24	18.48	50.	13.75	11.00	21.00	42.00
23.	6.32	5.06	9.66	19.32	51.	14.02	11.22	21.42	42.84
24.	6.60	5.28	10.08	20.16	52.	14.30	11.44	21.84	43.68
25.	6.87	5.50	10.50	21.00	53.	14.57	11.66	22.26	44.52
26.	7.15	5.72	10.92	21.84	54.	14.85	11.88	22.68	45.36
27.	7.42	5.94	11.34	22.68	55.	15.12	12.10	23.10	46.20
28.	7.70	6.16	11.76	23.52	56.	15.40	12.32	23.52	47.04

Table VII-8 (Contd)

Conc. cft.	Cement		Sand cft.	Khoa/st. chip cft.	Conc. cft.	Cement		Sand cft.	Khoa/st. chip cft.
	cft.	Bags				cft.	Bags		
57.	15.67	12.54	23.94	47.88	85.	23.37	18.70	35.70	71.40
58.	15.95	12.76	24.36	48.72	86.	23.65	18.92	36.12	72.24
59.	16.22	12.98	24.78	49.56	87.	23.92	19.14	36.54	73.08
60.	16.50	13.20	25.20	50.40	88.	24.20	19.36	36.96	73.38
61.	16.77	13.42	25.62	51.24	89.	24.47	19.58	37.38	74.76
62.	17.05	13.64	26.04	52.08	90.	24.75	19.08	37 80	75.60
63.	17.32	13.86	26.46	52.92	91.	25.02	20.02	38.22	76.44
64.	17.60	14.08	26.88	53.76	92.	25.30	20.24	33.64	77.28
65.	17.87	14.30	26.30	54.60	93.	25.57	20.46	39.06	78.12
66.	18.15	14.52	27.72	55.55	94.	25.85	20.68	39.48	78.96
67.	18.42	14.74	27.14	56.28	95.	26.12	20.90	39.90	79.80
68.	18.70	14.96	28.56	57.12	96.	26.40	21.12	40.32	80.64
69.	18.97	15.18	28.98	57.96	97.	26.67	21.34	40.74	81.48
70.	19.25	15.40	29.40	58.80	98.	26.95	21.56	41.16	82.32
71.	19.25	15.40	29.40	58.80	99.	27.22	21.78	41.58	83.16
72.	19.08	15.84	30.24	60.48	100.	27.50	22.00	42.00	84.00
73.	20.75	16.06	30.66	61.32	200.	55	44	84	168
74.	20.35	16.28	31.08	62.16	300.	82.5	66	126	252
75.	20.62	16.50	31.50	63.00	400.	110	88	168	336
76.	20.90	16.72	31.92	63.84	500.	137.5	110	210	420
77.	21.17	16.94	32.34	64.68	600.	165	132	252	404
78.	21.45	17.16	32.76	65.52	700.	192.5	154	294	588
79.	21.72	17.38	33.18	66.36	800.	220	176	336	672
80.	22.00	17.60	33.60	67.20	900.	247.5	198	378	756
81.	22.27	17.82	34.02	68.04	1000.	275	220	420	840
82.	22.55	18.04	34.44	68.88					
83.	22.82	18.26	34.86	69.72					
84.	23.10	18.48	35.28	70.56					

(i) Quantities of Materials Required for Concrete Mix of 1:2:4

Table VIII-9

Conc. cft.	Cement		Sand cft.	Khoa/ st. chip cft.	Conc. cft.	Cement		Sand cft.	Khoa/st. chip cft.
	cft.	Bags				cft.	Bags.		
1.	.225	.180	.45	.90	29.	6.53	5.22	13.05	26.1
2.	·450	.360	.90	1.80	30.	6.70	5.36	13.50	27.00
3.	.675	.540	1.35	2.70	31.	6.98	5.58	13.95	27.9
4.	.90	.720	1.80	3.60	32.	7.20	5.76	14.40	28.8
5.	1.13	.900	2.25	4.5	33.	7.43	5.94	14.85	29.7
6.	1.35	1.08	2.70	5.40	34.	7.65	6.12	15.30	30.6
7.	1.68	1.26	3.15	6.30	35.	7.88	6.30	15.75	31.5
8.	1.8	1.44	3.60	7.20	36.	8.10	6.48	16.20	32.4
9.	2.03	1.62	4.05	8.10	37.	8.33	6.66	16.65	33.3
10.	2.25	1.80	4.50	9.00	38.	8.55	6.84	17.10	34.2
11.	2.48	1.98	4.95	9.90	39.	8.78	7.02	17.55	35.1
12.	2.70	2.16	5.40	10.80	40.	9.00	7.2	18.00	36.00
13.	2.93	2.34	5.84	11.70	41.	9.23	7.38	18.45	36.9
14.	3.15	2.52	6.30	12.60	42.	9.46	7.56	18.90	37.8
15.	3.38	2.70	6.75	13.50	43.	9.68	7.74	19.35	38.7
16.	3.60	2.88	7.20	14.40	44.	9.91	7.92	19.8	39.6
17.	3.83	3 06	7.65	15.30	45.	10.18	8.10	20.25	40.5
18.	4.05	3.24	8.10	16.20	46.	10.36	8.28	20.70	41.4
19.	4.28	3.42	8.55	17.10	47.	10.58	8.46	21.15	42.3
20.	4.50	3.60	9.00	18.00	48.	10.81	8.64	21.60	43.2
21.	4.73	3.78	9.45	18.90	49.	11.04	8.82	22.05	44.1
22.	4.95	3.96	9.9	19.80	50.	11.25	9.00	22.50	45.00
23.	5.17	4.14	10.35	20.70	51.	11.48	9.18	22.95	45.90
24.	5.40	4.32	10.80	21.60	52.	11.70	9.36	23.40	46.80
25.	5.63	4.50	11.25	22.50	53.	11.93	9.54	23.85	47.70
26.	5.85	4.68	11.70	23.40	54.	12.15	9.72	24.30	48.6
27.	6.08	4.86	12.15	24.30	55.	12.38	9.9	24.75	49.50
28.	6.30	5.04	12.60	25.2	56.	12.61	10.08	25.20	50.40

Table VIII-9 (Contd.)

Conc. cft.	Cement		Sand cft.	Khoa/ st. chip cft.	Conc. cft.	Cement		Sand cft.	Khoa/ st. chip cft.
	cfts.	Bags.				cft.	Bags		
57.	12.83	10.26	25.65	51.30	85.	19.14	13.30	38.25	76.50
58.	13.06	10.44	26.10	52.20	86.	19.37	15.50	38.70	77.40
59.	13.28	10.62	26.55	53.10	87.	19.60	15.70	39.20	78.30
60.	13.51	10.80	27.00	54.00	88.	19.81	15.80	39.65	79.20
61.	13.73	10.98	27.45	54.90	89.	20.00	16.00	40.00	80.00
62.	13.96	11.16	27.90	55.80	90.	20.30	16.20	40.45	80.90
63.	14.18	11.34	28.35	56.70	91.	20.50	16.40	40.90	81.80
64.	14.40	11.52	28.80	57.60	92.	20.70	16.60	41.35	82.70
65.	14.63	11.70	29.25	58.5	93.	20.90	16.70	41.80	83.60
66.	14.86	11.58	29.70	59.40	94.	21.10	16.90	42.25	84.50
67.	15.08	12.06	30.15	60.30	95.	21.40	17.10	42.70	85.40
68.	15.31	12.24	30.60	61.20	96.	21.60	17.30	43.15	86.30
69.	15.53	12.42	31.05	62.10	97.	21.80	17.40	42.60	87.20
70.	15.76	12.60	31.50	63.00	98.	22.00	17.60	44.05	88.10
71.	15.99	12.78	31.95	63.90	99.	22.30	17.80	44.5	89.00
72.	16.21	12.96	32.40	64.80	100.	22.50	18.00	45.00	90.00
73.	16.44	13.14	32.85	65.70	200.	45.00	36.00	90.00	180.00
74.	16.66	13.32	33.30	66.60	300.	67.50	54.00	135.00	270.00
75.	16.89	13.50	33.75	67.50	400.	90.00	72.00	180.00	360.00
76.	17.11	13.68	34.20	68.40	500.	112.5	90.00	225.00	450.00
77.	17.34	13.86	34.65	69.30	600.	135.0	108.	270	540
78.	17.56	14.04	35.10	70.20	700.	157.5	126	315	630
79.	17.79	14.22	35.55	71.10	800.	180.0	144	360	720
80.	18.01	14.40	36.00	72.00	900.	202.5	162	405	810
81.	18.24	14.60	36.45	72.90	1000.	225	180	450	900
82.	18.46	14.80	36.90	73.80					
83.	18.69	14.90	37.35	74.70					
84.	18.91	15.10	37.80	75.60					

(i) Quantities of Materials Required for Concrete Mix of 1:3:6

Table VIII-10

Conc. cft.	Cement		Sand cft.	Khoa/ st. chip cft.	Conc. cft.	Cement		Sand cft.	Khoa/st. chip cft.
	cft.	Bags				cft.	Bags.		
1.	0.15	0.12	0.45	0.90	29.	4.35	3.48	13.05	26.10
2.	0.30	0.24	0.90	1.80	30.	4.50	3.60	13.50	27.00
3.	0.45	0.36	1.35	2.70	31.	4.65	3.72	13.95	27.90
4.	0.60	0.48	1.80	3.60	32.	4.80	3.84	14.40	28.80
5.	0.75	0.60	2.25	4.50	33.	4.95	3.96	14.85	29.70
6.	0.90	0.72	2.70	5.40	34.	5.10	4.08	15.30	30.60
7.	1.05	0.84	3.15	6.30	35.	6.25	4.20	15.75	31.50
8.	1.20	0.90	3.60	7.20	36.	6.40	4.32	16.20	32.40
9.	1.35	1.08	4.05	8.1	37.	5.55	4.44	16.65	33.30
10.	1.50	1.20	4.50	9.00	38.	6.70	4.56	17.10	34.20
11.	1.65	1.32	4.95	9.90	39.	5.85	4.68	17.55	35.10
12.	1.80	1.44	5.40	10.80	40.	6.00	4.80	18.00	36.00
13.	1.95	1.56	5.85	11.70	41.	6.15	4 92	18.45	36.90
14.	2.10	1.68	6.30	12.60	42.	6.30	5.04	18.90	37.80
15.	2.25	1.80	6.75	13.50	43.	6.45	5.16	19.35	38.70
16.	2.40	1.92	7.20	14.40	44.	6.60	5.28	19.80	39.60
17.	2.55	2 04	7.65	15.30	45.	6.75	5.40	20.25	40.50
18.	2.70	2.16	8.10	16.20	46.	6.90	5.52	20.70	41.40
19.	2.85	2.28	8.55	17.10	47.	6.05	5.64	21.15	42.30
20.	3.00	2.40	9.00	18.00	48.	6.30	5.76	21.60	43.20
21.	3.15	2.52	9.45	18.90	49.	6.45	5.88	22.05	44.10
22.	3.30	2.64	9.90	19.80	50.	7.50	6.00	22.50	45.00
23.	3.45	2.76	10.35	20.70	51.	7.65	6.12	22.95	45.90
24.	3.60	2.88	10.80	21.60	52.	7.10	6.24	23.40	46.80
25.	3.75	3.00	11.25	22.50	53.	7.95	7.36	23.85	47.70
26.	3.90	3.12	11.70	23.40	54.	8.10	6.48	24.30	48.60
27.	4.05	3.24	12.15	24.30	55.	8.25	6.60	24.75	49.50
28.	4.20	3.36	12.60	25.20	56.	8.40	6.72	25.20	50.40