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MINISTRY OF WATER RESOURCES

BANGLADESH WATER DEVELOPMENT BOARD

MEGHNA ESTUARY STUDY

TECHNICAL NOTE MES-019

INNOVATIVE BANK PROTECTION MEASURES

August 1998

DHV CONSULTANTS BV

in association with

KAMPSAX INTERNATIONAL
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Technical Note on:

INNOVATIVE BANK PROTECTION MEASURES

Dhaka , June 1998

Project Name	:	Meghna Estuary Study (MES)
Location	:	Meghna Estuary
Key words	:	Screen arrays, Caisson Spurs, Cross Dams Woven Geotextiles, Non-woven Geotextiles Design, Installation, Cost

INNOVATIVE BANK PROTECTION SCHEMES

MES

June 1998

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1. INTRODUCTION

In particular during the monsoon season erosion of the river banks occurs throughout the Meghna Estuary. Protective works have been installed at several locations along the rivers, however these measures have not always proved effective. Feasibility studies carried out showed that protection of the river bank using conventional bank protection methods is, in general, too expensive for protection of agriculture land or even rural villages and townships and therefore not economically viable.

As per Terms of Reference, the Meghna Estuary Study [MES] has to develop advanced techniques for land reclamation and erosion control incorporating the use of local technologies, labour and construction materials. One way to advance technological development is to make use of relatively cheap geotextiles in an innovative manner.

Alternative protection measures have been developed under MES. These measures are relatively cheap and differ from conventional methods by use of geotextile materials and construction methods using prefabricated elements. The following protection measures have been considered:

I. Screen arrays
II. Caisson spurs
III. Cross-dams

Screen arrays

MES has developed a bank protection scheme based on the principle of upright geotextile screens placed on the river bed. The screens are placed with an angle of 45 degrees perpendicular to the river bank. The screens will divert the sediment rich bottom current towards the river bank and will reduce current velocities along the river bank in general. A cluster of such screens is expected to facilitate accretion along the embankment.

A screen is kept upright by floats made of closed PVC pipes attached to the top of the screen. To keep the screen close to the bottom the screen is connected to two concrete weight anchors. The anchors are designed such that they have a large resistance to the current forces applied to the screen. A PVC beam filled with concrete is fixed at the bottom of the screen to keep the screen in horizontal position.

The objective of the screens arrays is to

- divert the sediment rich bottom flow towards the river bank
- obstruct the current in general

The screens can best be applied at locations meeting the following conditions:

- water depths at low water exceeding 5 meter.
- river flow with high sediment content

Caisson spurs

Spurs, or permeable groins, consist of one or several rows of vertical piles placed perpendicular to the riverbank. Conventionally these piles are driven into the river bed with water born equipment. Due to high current velocities in the Megna river this can only be done during slack water, when the current velocity is low. MES developed the concept of spurs made of wooden "box shaped" caissons. The caisson sections can be partly prefabricated on shore. Installation of the caisson can be done in the relatively short time during slack water. The caisson spurs are placed on a geotextile bed protection and initially ballasted with a layer of gunny bags. On top of these gunny bags a layer of concrete blocks is placed. The tip of the spurs is protected by a geotextile mattress to which steel anchors or concrete blocks are attached This mattress will act as a falling apron in case of bed erosion at the tip of the spurs.

The objective of the spurs is to:
- Slow down the current velocity in front of the riverbank causing deposition of sediments
- Create a hard point in the riverbank
- Divert the main current

The caisson spurs as described above can be optimally be applied given the following site conditions:
- Water depths at low water not exceeding 5 m.
- Tidal flow conditions with a considerate period of slack water.

Cross-dam

In case of emerging sand banks in front of an eroding river bank, the bank line can be effectively extended by creating a connection between the river bank and these sand banks. A conventional earthen cross-dam would in general be too expensive. By building a cross-dam using prefabricated wooden caissons as proposed for the caisson spurs described above, a cost effective construction method can be realised. Anticipating erosion at the tip of the cross-dam, sand ballasted geotextile bed protection will be installed around the tip of the cross-dam. This bed protection can be placed on the char land.

The cross-dam configuration as described above can be optimally be applied given the following site conditions:
- Sand banks (chars) located in front of the riverbank , which are constantly emerged
- Water depths at low water not exceeding 5 m.
- Tidal flow conditions with a considerate period of slack water.

The same principle of cross-dam construction can be applied to close tidal channels in order to enhance accretion.

2. SCREEN ARRAYS

2.1 General

River banks erode when the river current velocities along the embankment are such that sediments are picked up and transported away from the embankment. The embankment can be protected by covering the embankment with a layer of materials that has a sufficient resistance to the prevailing current velocities. Such a layer can consist of rock, concrete blocks or asphalt.

Another way to protect the embankment is to introduce structures along the embankment to reduce the current velocities and push the river flow away from the embankment. Traditionally such structures are rubble or concrete covered groins or rows of wooden or steel poles placed perpendicular to the embankment.

However, implementation of such "hard" structures in the lower Meghna river system have in general failed, because the river currents induce such exceptional and continuous rate of erosion at the toe of the construction that the protection measure collapses.

An alternative solution to protect stream banks against erosion is the use of bottom vanes. This system has been successfully applied in the United States. The vanes are placed at the riverbed with a certain angle to the bank. The system causes the flow passing it to attain a circular motion downstream from it. The circulation alters the magnitude and direction of the shear stresses and causes a change in direction of velocity, depth and sediment transport in the area affected by the system. As a result de riverbed aggrades in one portion of the river cross-section and degrades in the other.

MES has further developed the alternative of bottom vanes described above. To divert the river flow, geotextile screens are placed on the river bed with an angle of 45 degrees to the river bank. An array of screens will divert the sediment rich bottom current towards the river bank and will reduce current speeds along the river bank in general (See Figure 2.16).

The upstream part of the scheme needs special care as any tendency for outflanking of the system will start at this point. The upstream part should be located in an area with no - or minimal - bank erosion. As the screens are not attached to the river bank it is possible that part of the flow is diverted between the screens and the river bank. To prevent erosion of the river bank due to this diverted flow, a "hard point" can be created at this location by constructing a more traditional bank protection measure such as a groin or spur.

2.2 Design considerations

At the moment of executing the pilot schemes, the actual dimensions and lay-out of the screens was quite arbitrary. Based on the results of previous tests and the advise of Prof. Odgaard of the university of IOWA, a scheme was devised, which theoretically should induce the required physical phenomena (deflection of the sediment rich bottom flow) and was practical to install.

The screens are 5 meter wide and 4 meter high. The screen is kept upright by floats made of closed PVC pipes attached to the top of the screen. The screens close to the shore will be fitted with 3 floats, the screens in deeper water with 4 floats (See Figure 2.1). To keep the screen close to the bottom the screen is connected to two concrete weight anchors. The anchors are designed such that they have a large resistance to the current forces applied to the screen (See Figure 2.3 and 2.4). A PVC beam filled with concrete is fixed at the bottom of the screen to keep the screen in horizontal position (See Figure 2.2).

Materials	Specifications
Geotextile	Propex 6088
Beam	1 PVC pipe filled with reinforced concrete
Floaters	4 PVC pipes; 8" diameter; 5,2 m long
Anchors	2 Concrete blocks; 0,5 m3 each

During the pilot schemes a screen configuration has been used consisting of pairs of screens, 5 meter apart from each other and 30 to 40 m meter from the shore. The pairs have been placed at intervals of 20 m along 200 m of river bank. However, future research might develop more effective configurations (See Figure 2.16).

2.3 Construction aspects

Construction of the screen arrays consists of the following main activities:
1. Survey of installation site and selection of screen locations
2. Selection and establishment of work site
3. Casting of concrete anchors and beams
4. Attaching PVC floats and beam to geotextile
5. Installation of screens

Survey of installation site and selection of screen locations
A bathemetric and topographic survey will be conducted of the proposed installation site. The final location of the screens will be determined based on these survey results and on water level data. The water depth at the selected location during low water slack should always exceed the height of the screens. Divers should check the river bed for debris such as trees, rubble or old bank protection works. The projection of the screen locations on the shore will be marked with permanent marking points.

Selection and establishment of work-site
A suitable onshore work site will be selected and prepared close to the offshore installation site. The work-site should be accessible by car, truck and launch. Facilities for long-term stay of staff and workers should be available or be constructed. A clear and understanding relationship should be established with the local people, especially with the land-owner and chairman of the area.

Casting of concrete anchors and beams
Casting of the concrete anchors and beams should be started well in advance of the installation date of the first set of screens. Facilities should be available to transport the concrete elements and to lift them on a pontoon.

Attaching PVC floats and beam to geotextile
First, the PVC float elements will be fixed tightly to the geotextile screen. Special yarn will be used and special care will be taken to the sewing to prevent failure of the seam; every 15 cm a fixation knot will be apllied and extra pvc rods will be fixed to the seam to prevent rupture of the textile. Geotextile fixed with PVC floats can still be handled on shore. The concrete beam will be fixed to the geotextile with the same care as the PVC floats. The package of geotextile, PVC floats and concrete beam will be tied together and lowered into the water. In this way it can be easily transported to the installation site.

Installation of screens
A special installation pontoon will be used to install the screens. The pontoon consists of two hulls connected by two lifting frames. The screens will be lifted off a pontoon positioned inside the two hulls and the anchors will be attached to the screens. The installation pontoon will be manoeuvred into the required position by means of a set of mooring anchors. Two of these anchors may be fixed to the shore. The current velocity should be limited during the lowering of the screens to the riverbed. Therefore installation of the screens will take place during high or low water slack. After lowering the first screen, the installation pontoon will be slightly repositioned to install the second. The position of the screens will be marked by marker buoys and the exact location of the anchors will be fixed with a positioning system.

The pilot schemes showed that using one installation pontoon, an average of 4 screens a day could be installed.

Because of the weather constraints it is advisable to start site preparations in the month of October. Placing the screens should preferably be carried out in the months December to March and all activities should be finished before the end of April

Detailed procedures for the installation of screens are presented in Annex A. An overview of labour required to carry out all activities related to the installation of screens is presented in Annex C.

2.4 Costs

The cost estimate for the screen arrays is set-up according to the guidelines described in the "Flood Action Plan; Guidelines for Project Assessment". The guidelines recommend a breakdown of the base costs into materials, equipment and person power. The principles on which the costs have been calculated are described in Annex E

In general, installation of screen arrays will cost about 60,000 Tk per screen

In addition to these costs the following general costs have to be taken into account:

- mobilisation of equipment
- surveying
- site preparation
- overhead
- profit
- physical contingencies
- engineering cost
- maintenance costs.

Detailed calculations of the costs of installing screens is presented in Annex F.

3. CAISSON SPURS

3.1 General

Spurs, or permeable groins, consist of one or several rows of vertical piles placed perpendicular to the riverbank. Conventionally these piles are driven into the river bed with water born equipment. Due to high current velocities in the Megna river this can only be done during slack water, when the current velocity is low. MES developed the concept of spurs made of wooden "box shaped" caissons. Sections of the caisson can be partly prefabricated on shore, after which the caisson can be assembled on the water using a special pontoon. Installation of the caisson can be done in the relatively short time during slack water.

The caisson spurs are placed on a geotextile bed protection and initially ballasted with a layer of gunny bags. On top of these gunny bags a layer of concrete blocks is placed. The tip of the spurs is protected by a geotextile mattress to which concrete blocks are attached. This mattress will act as a falling apron in case of bed erosion at the tip of the spurs.

As the caissons require a minimum water depth to be installed they can not be placed right up to the shore line (See Figure 3.15 and 3.16). The connection between the caissons and the shore can be realised by constructing a connecting dam of gunny bags. This connecting dam will also be placed on a geotextile mattress and covered by concrete blocks. This mattress will be extended a certain distance onto the shore, in anticipation of initial scouring at the sides of the spurs.

3.2 Design considerations

The dimensions of a caisson spur will eventually be determined by local conditions at the location to be protected. The spurs tested by MES, however can be considered representative for many locations along the Megna river.

The standard dimensions of a caissons used during the pilot schemes are 12 meter long, 4 meter wide and 5.7 meter high. The caisson is build up by bullah pole frames placed at 2 meter distance. The frames consist of diagonal crosses to ensure stability of the structure. Bamboo poles are placed in between the bullah frames with an interval of 25 cm.

The geotextile mattress is 20 m wide and 15 m long. The mattress is 3 meters longer than the caisson to allow for an overlap. Steel anchors or concrete blocks with hooks are used to fix the edges of the mattress to the riverbed and to ascertain that the mattress will follow the decline of the river bed in case of erosion at the edges.

Depended on the required length of the spur, several caissons can be placed in line with each other. During the pilot schemes at Haim Char and Khorki spurs were installed with a length of 18 meter (1.5 caisson). The half caisson was placed at the river side of the spur and the protruding 12 meter length of geotextile mattress will serve as a bed protection at the tip of the spur.

Materials	Specifications
Bullah	15 cm diameter
Bamboo	7,5 cm diameter
Geotextile	Propex 6088
Concrete blocks	40x40x30 cm3 with steel hook
Geo bags	Propex 6082 with non-woven innerbag
Gunny bags	New bags; 50 kg capacity
Earth	Borrow pit at site

3.3 Construction aspects

Construction of the spurs consists of the following main activities:
1. Survey of installation site and selection of the spur locations
2. Selection and establishment of the work-site
3. Construction of the side panels of the caissons
4. Preparation of geotextile mattresses.
5. Positioning of installation pontoon
6. Assembling and installation of caissons
7. Installation of shore mattress
8. Construction of connection dam
9. Placing of ProFix bank protection

Survey of installation site and selection of spur locations
A bathymetric and topographic survey will be conducted of the proposed installation site. The final location of the spurs will be determined based on these survey results and on water level data. The water depth at the selected location during low water slack should preferably not exceed the height of the caissons. Divers should check the river bed for debris such as trees, rubble or old bank protection works. The projection of the spur locations on the shore will be marked with permanent marking points.

Selection and establishment of work-site
A suitable onshore work site will be selected and prepared close to the offshore installation site. The work-site should be accessible by car, truck and launch. Facilities for long-term stay of staff and workers should be available or be constructed. A clear and understanding relationship should be established with the local people, especially with the land-owner and chairman of the area.

Construction of the side panels of the caissons
The side panels of the caissons can be constructed on the shore at the work site. The bulah poles will be connected to each other by steel bolts and the bamboo is connected by steel wire and nylon rope. The panels can be pulled into the water by manpower en floated to the installation site.

Preparation of geotextile mattresses
The geotextile mattresses will have to be sown together at the work site. Bamboo poles will be fixed to the mattress by nylon rope. When ready, the mattress can be folded and rolled up into a compact package. This package can be rolled into the water and floated to the installation site.

Positioning of installation pontoon
The caissons will be placed perpendicular to the shore using a custom made installation pontoon (See Figure 3.6). The same pontoon will be used to assemble the caissons. The pontoon will be positioned at the required location using a small tugboat and anchor wires fixed to the shore as well as to anchors.

Assembling and installation of caissons
The sequence of assembling and installation the caissons is as follows:
1. floating side panels under pontoon
2. lifting side panels with lifting frame
3. floating folded geotextile under pontoon
4. inter-connecting side panels with cross-beams and diagonals
5. connecting side panels to bottom frame on geotextile
6. pre-ballasting caisson with gunny bags
7. lowering caisson to channel bed
8. placing steel anchors or concrete anchor blocks
9. connecting geotextile to anchor blocks
10. spreading out geotextile
11. dumping ballast bags on geotextile

Installation of shore mattress
The geotextile mattress between the caissons and the shore can be installed manually. The floating mattress package is unpacked and positioned in alignment of the shore end of the caisson. Divers fix the end of the mattress to the bottom of the caisson and the mattress is spread out onto the shore with manpower. Gunny bags are dumped onto the mattress starting from the caisson towards the shore.

Construction of connection dam
The connection between the caisson and the shore is established by constructing a 4 meter wide dam consisting of a core gunny bags. To protect the gunny bag core from wave action this core can be either covered by geotextile sheets or concrete blocks or both.

Placing of ProFix bank protection
Before placing the ProFix on the bank, the bank profile has to be adjusted. The ProFix is filled with coarse sand with the assistance of sawn off PVC pipe and a water pump.

The pilot schemes showed that a spur with a length of 18 m (1.5 caisson) can be placed in approx. 3 days.

Because of the weather constraints it is advisable to start site preparations in the month of October. All activities should be finished before the end of April.

Detailed procedures for the installation of spurs are presented in Annex B. An overview of labour required to carry out all activities related to assembling and installing spurs is presented in Annex D.

3.4 Costs

The cost estimate for the caisson spurs is set-up according to the guidelines described in the "Flood Action Plan; Guidelines for Project Assessment". The guidelines recommend a breakdown of the base costs into materials, equipment and person power. The principles on which the costs have been calculated are described in Annex E.

In general, installation of a spur with a length of 18 meter (1.5 caisson) will costs about 1,700,000 Tk per spur.

In addition to these costs the following general costs have to be taken into account:
- mobilisation of equipment
- surveying
- site preparation
- overhead
- profit
- physical contingencies
- engineering cost
- maintenance costs.

Detailed calculations of the costs of installing spurs is presented in Annex G.

4. CROSS-DAM

4.1 General

Cross-dams can be build to connect main land with developing chars at it foreshore. Closure of the channel in between will not only stop erosion of the mainland , but will also enhance accretion in the channel, effectively connecting the char to the mainland. Traditionally, in Bangladesh, cross-dams consist of a large volume of gunny bags, dumped by local labour.

The side slope of the cross-dam mainly determines the volume of the cross-dam. If steeper slopes can be applied the volume of the dam will decrease dramatically. Using filled gunny bags as construction material, the maximum slope considered to be safe is 1:1,5. A more gentle slope would be required for a dam build up of loose soil.

If, however, the gunny bags are to be placed in a box-type framework, a practically vertical slope could be obtained. To ensure the stability of the structure the height of the "box" will be restricted. The frame work can be made of bamboo and bullah poles.

Due to waves, wind and currents the working conditions at cross-dam location can be very unfavourable. To minimise working time at the actual dam location, a construction method has been adopted using wooden caissons. The caissons consist of pre-fabricated wooden frame elements which will be assembled at a sheltered location. The geotextile bed protection will also be pre-fabricated and fixed to the caisson before installation. The connection with the channel bank will be established by a gunny bag dam section.

The principle of using caissons to install a cross-dam is basically the same as the principle described for construction of caisson spurs.

4.2 Design considerations

Main design aspects of a cross-dam are the following:

- Core material
- Crest level
- Crest width
- Side slope
- Wave protection
- Bed-protection
- Alignment

Core material

As "hard" materials are rare in Bangladesh and good quality sand is also not available, the core of the cross-dam will consist of gunny gags filled with earth. The earth can be supplied from local borrow pits in the vicinity of the cross-dam. Using earth filled gunny bags to construct a cross-dam is common practise in Bangladesh.

Crest level

A logical crest level of the cross-dam would be the level of the adjoining. However, higher water levels can occur during extreme spring tides, particularly in the monsoon season (say June to September/October). Once the cross-dam has been completed, and also during the construction phase, differential water levels will occur on both sides of the cross-dam. To prevent a substantial flow of water over the cross-dam, its crest should be raised above the level of adjacent land.

Crest width

During construction the crest will be used to transport construction material along the alignment of the dam. A crest width of 4 m is deemed desirable to facilitate smooth two way traffic along the crest. This width will also allow sufficient area to elevate the crest level with approx. 1 m in a later stage if required.

Side slope
Because the cross-dam is made out of box-type caissons, the sides of the cross-dam are vertical.

Bed protection
A geotextile layer is placed between existing bed level and the gunny bag filled caissons. The geotextile extends 8 m meter from the base of the dam to prevent erosion of the existing bed during the construction period. The geotextile is fixed to the river bed by anchor blocks at its edges. Furthermore, a layer of gunny bags is placed on top of the geotextile. The textile also serves as soil stabilisation, preventing excessive differential settling of the cross-dam.

Alignment
The cross-dam alignment is determined based on bathymetric data and hydro-morphological analysis. The bathymetric data will allow for a most economic alternative with reference to the volume and length of the cross-dam; the hydro-morphological analysis will determine which location will induce the most effect with reference to diversion of flow and land accretion.

4.3 Construction aspects

Construction of the cross-dam consists of the following main activities:
1. Selection and establishment of the work-site
2. Construction of the side panels of the caissons
3. Preparation of geotextile mattresses.
4. Positioning of installation pontoon
5. Assembling and installation of caissons
6. Filling of caissons with gunny bags
7. Installation of shore mattress
8. Construction of connection dam

Selection and establishment of work-site
A suitable onshore work site will be selected and prepared close to the offshore installation site. The work-site should be accessible by car, truck and launch. Facilities for long-term stay of staff and workers should be available or be constructed. A clear and understanding relationship should be established with the local people, especially with the land-owner and chairman of the area.

Construction of the side panels of the caissons
The side panels of the caissons can be constructed on the shore at the work site. The dimensions of the panels depends on the bed profile where they will be installed. The bulah poles will be connected to each other by steel bolts and the bamboo is connected by steel wire and nylon rope. The panels can be pulled into the water by manpower en floated to the installation site.

Preparation of geotextile mattresses
The geotextile mattresses will have to be sown together at the work site. Bamboo poles will be fixed to the mattress by nylon rope. When ready, the mattress can be folded and rolled up into a compact package. This package can be rolled into the water and floated to the installation site.

Positioning of installation pontoon
The caisson cross-dam sections will be placed along the alignment of the cross-dam using a custom made installation pontoon (See Figure 3.6). The same pontoon will be used to assemble the caissons. The pontoon will be positioned at the required location using a small tugboat and anchors.

Assembling and installation of caissons

The sequence of assembling and installation the caissons is the same as for the caisson spurs:

1. floating side panels under pontoon
2. lifting side panels with lifting frame
3. floating folded geotextile under pontoon
4. inter-connecting side panels with cross-beams and diagonals
5. connecting side panels to bottom frame on geotextile
6. pre-ballasting caisson with gunny bags
7. lowering caisson to channel bed
8. placing steel anchors or concrete anchor blocks
9. connecting geotextile to anchor blocks
10. spreading out geotextile
11. dumping ballast bags on geotextile

Filling of caissons with gunny bags

The proposed construction strategy is the following:

1. install the wooden caissons along the whole length of the cross-dam
2. fill the caissons with gunny bags up to low water level along the whole length of the cross-dam
3. finalise the construction of the cross-dam core up to the crest level of the dam except for approx. 100 m (the actual closure gap)
4. close the closure gap at neap low water tide

Assuming a (temporary) closure profile with a width of 100 m, a crest width of 4 m and a difference between low water neap and high water neap of 3 meter, the volume of earth filled gunny bags required to close the gap is approximately 1.200 m^3 (say 50.000 bags*). If these bags have been prepared in advance and stockpiled at both sides of the cross-dam, a labour force of maximal 1.000 should be sufficient to close the gap between a low and high water period, ideally during the tide with the lowest predicted range.

* Theoretically one m^3 can be made up of 32 filled gunny bags (50 kg of fill each). In practice, at least as experienced in the construction of the Feni closure dam (where also a very large number of gunny bags was use) at least 40 bags are required to "arrive" at one m^3.

Construction of connection dam

The geotextile mattress between the caissons and the shore can be installed manually. The floating mattress package is unpacked and positioned in alignment of the shore end of the caisson. Divers fix the end of the mattress to the bottom of the caisson and the mattress is spread out onto the shore manpower. Gunny bags are dumped onto the mattress starting from the caisson towards the shore, hence lowering the mattress to the river bed. The connection dams between the end caissons and the shore are established by constructing gunny bag dam with the same crest level as the caisson and a side slope of 1:2. To protect the gunny bags from wave action this dam can be either covered by geotextile sheets or concrete blocks or both.

Based on the experience with pilot schemes it is estimated one cross-dam section of 12 meter (1 caisson) can be installed every day.

During part of the year weather and sea conditions are not suitable for off-shore construction activities. It is advisable to carry out main construction activities from November to March. The optimum period to carry out the actual closure of the dam is in the months January/February.

Detailed procedures for the installation of caissons are presented in Annex B.

4.4 Costs

The cost estimate for the cross-dam is set-up according to the guidelines described in the "Flood Action Plan; Guidelines for Project Assessment". The guidelines recommend a breakdown of the base costs into materials, equipment and person power. The principles on which the costs have been calculated are described in Annex E

In general, installation of a cross-dam section with a length of 12 meter (1 caisson) and a height of 6 meter will costs about 860,000 Tk per section.

In addition to these costs the following general costs have to be taken into account:

- mobilisation of equipment
- surveying
- site preparation
- overhead
- profit
- physical contingencies
- engineering cost
- maintenance costs.

Detailed calculations of the costs of installing cross-dams is presented in Annex H.

FIGURES

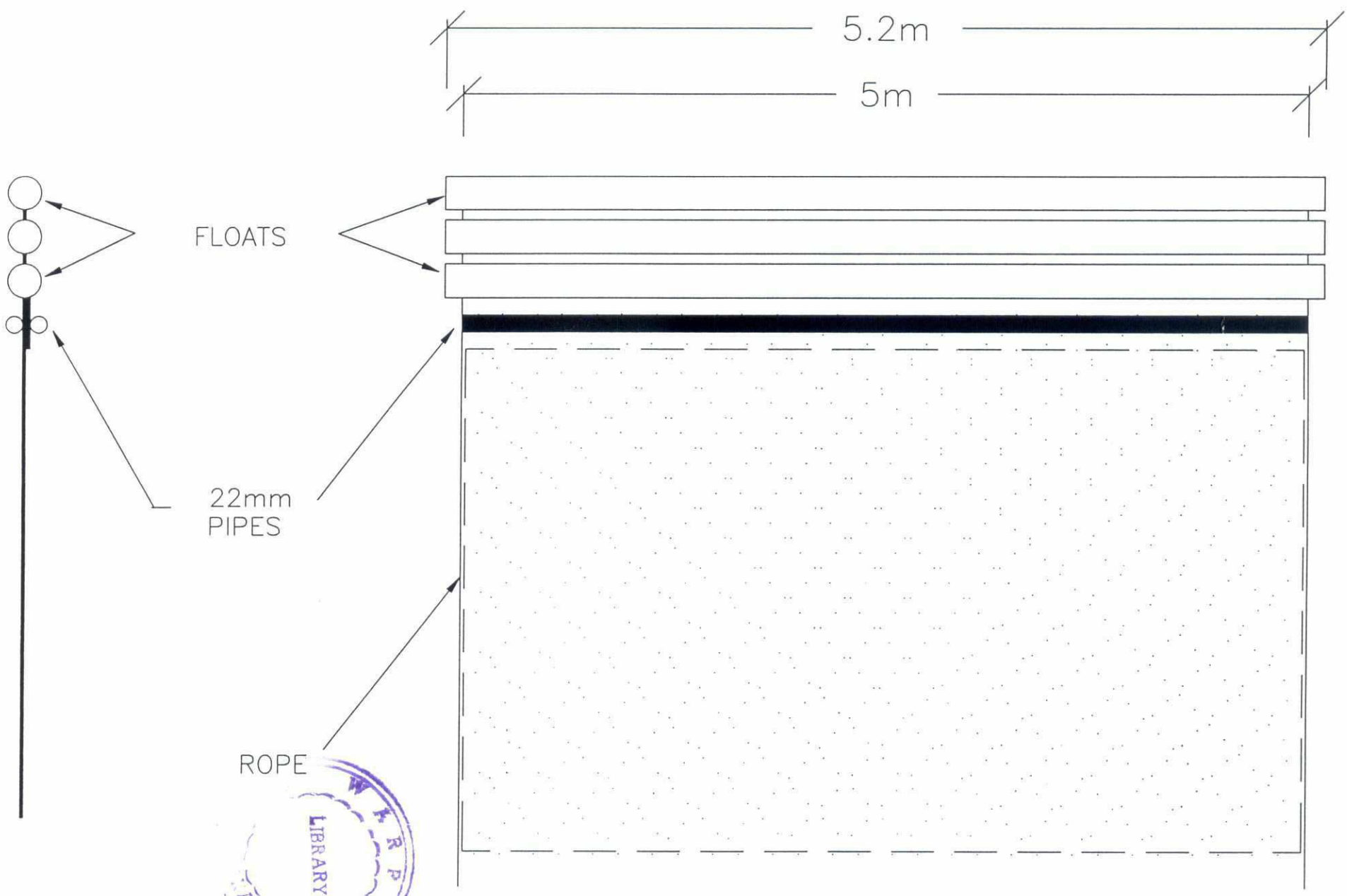

Figure 2.1: Fixing floats to geotextile

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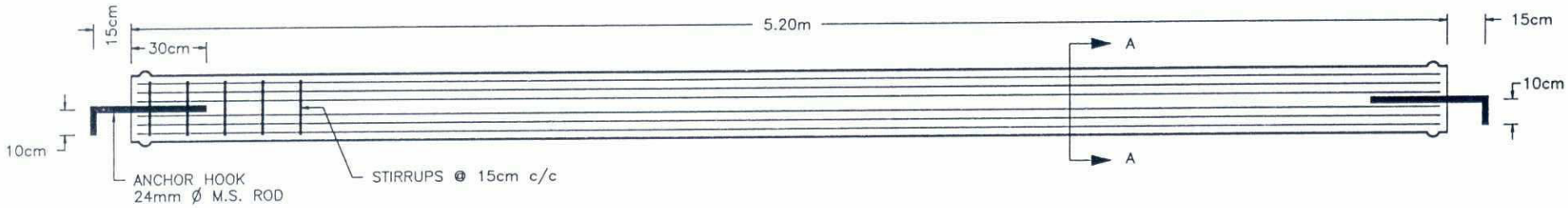
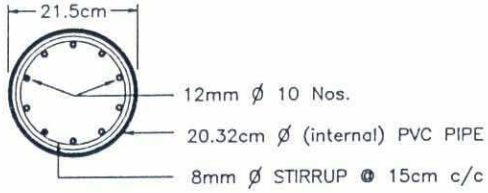
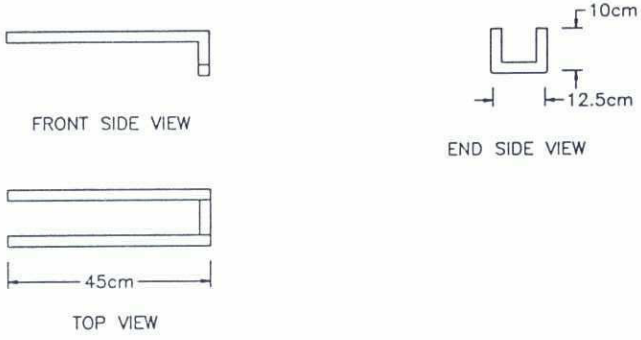
DRAWING OF R.C.C BEAM





SECTION A–A



DETAIL OF ANCHOR HOOK

Figure 2.2: Dimensions of R.C.C. beam

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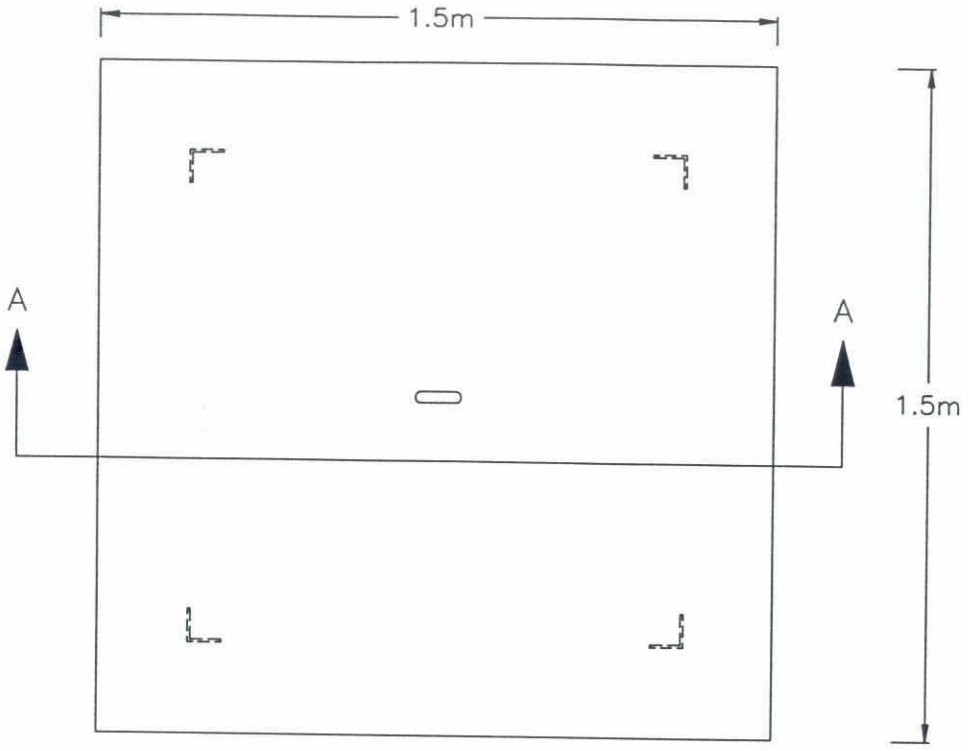
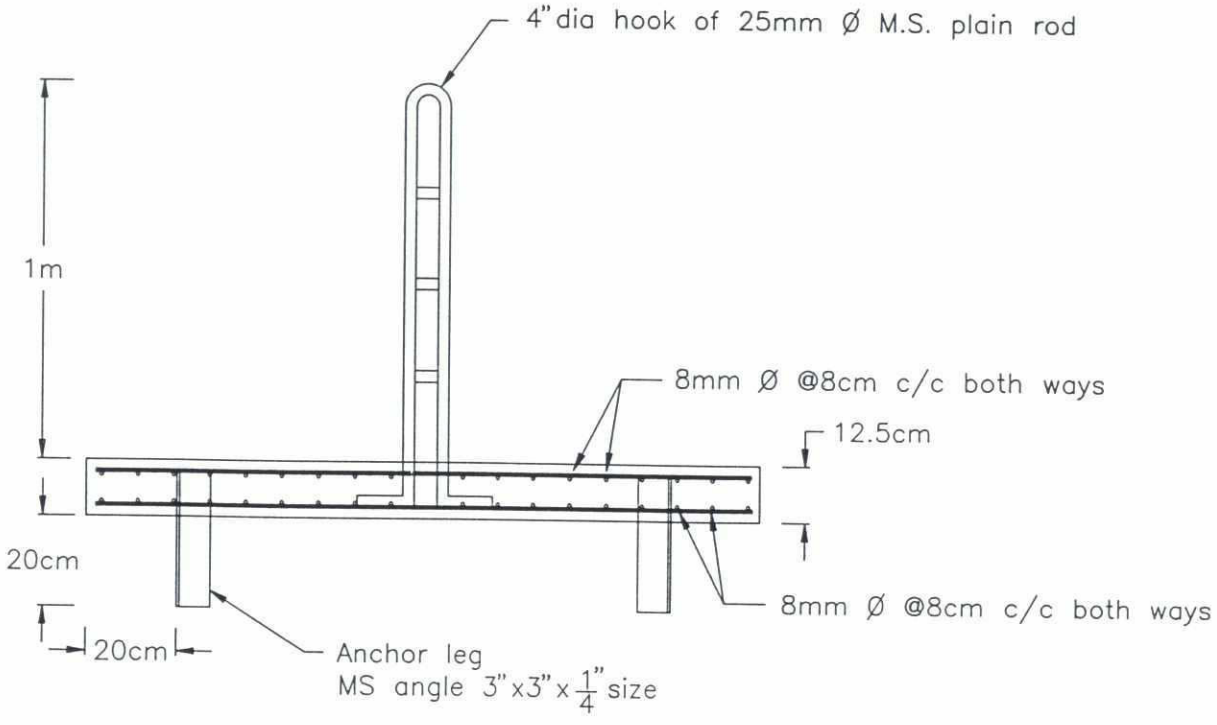


PLAN



SECTION A–A (for Khorki, bottom slab)

Figure 2.3: Dimensions of anchor base

File D:\Peter\Report\Screen3.dwg

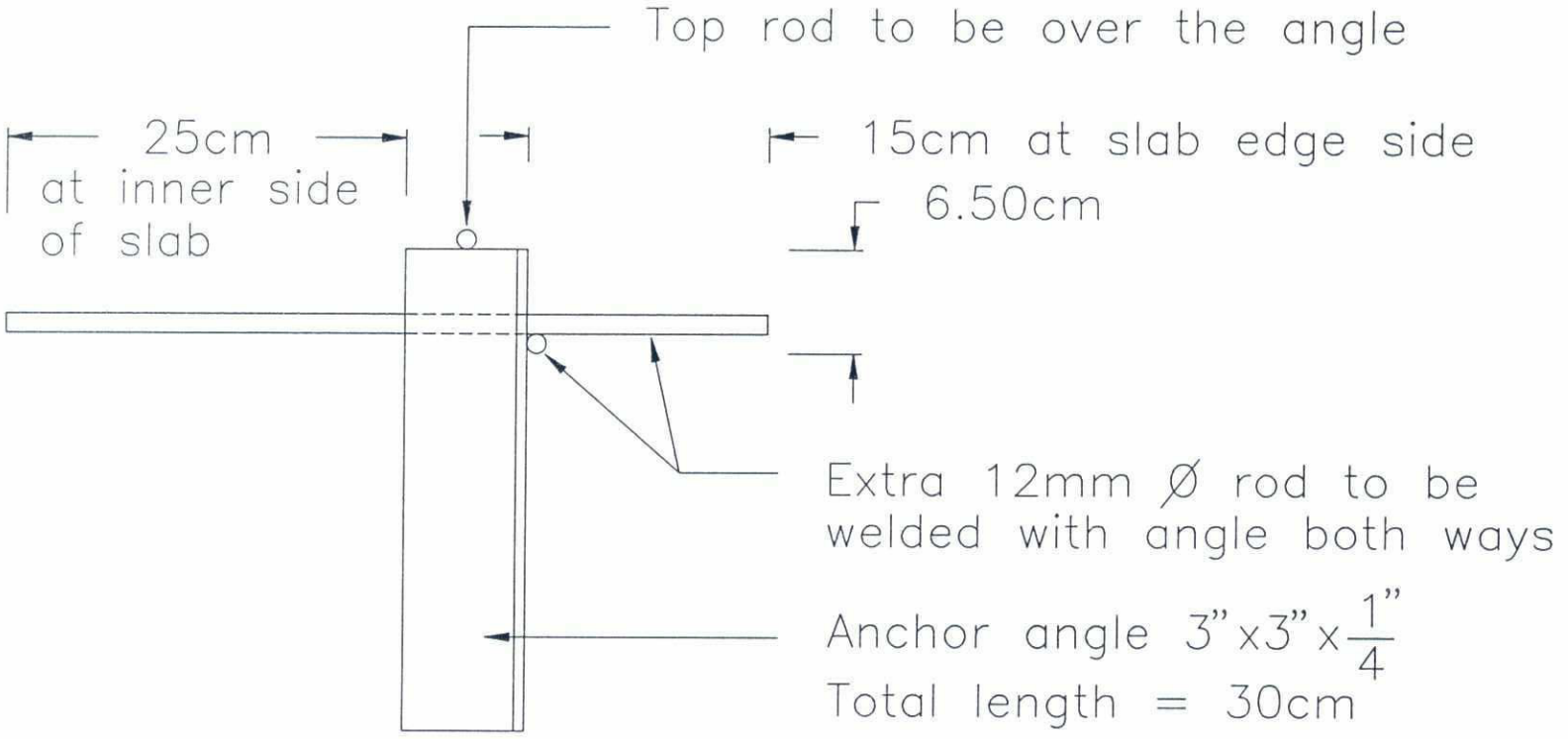
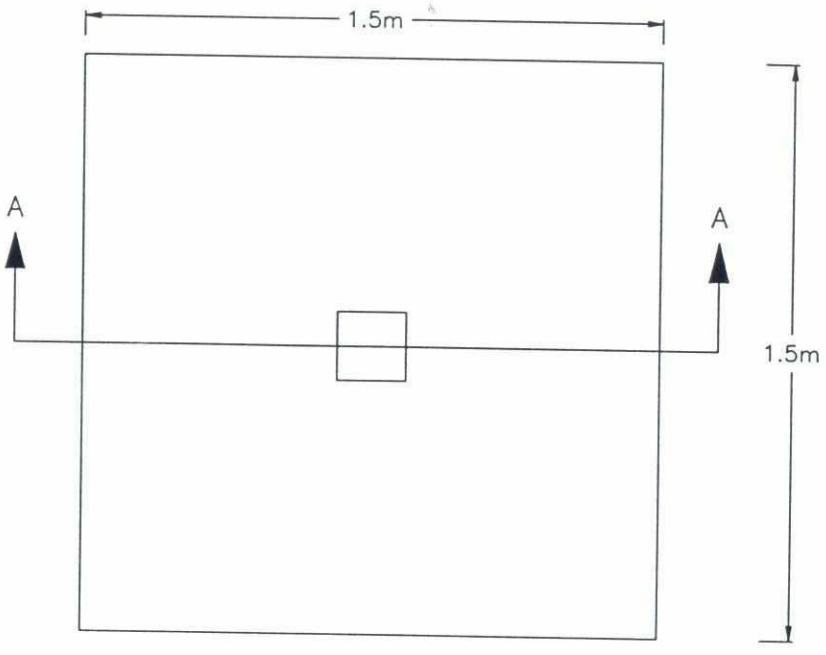
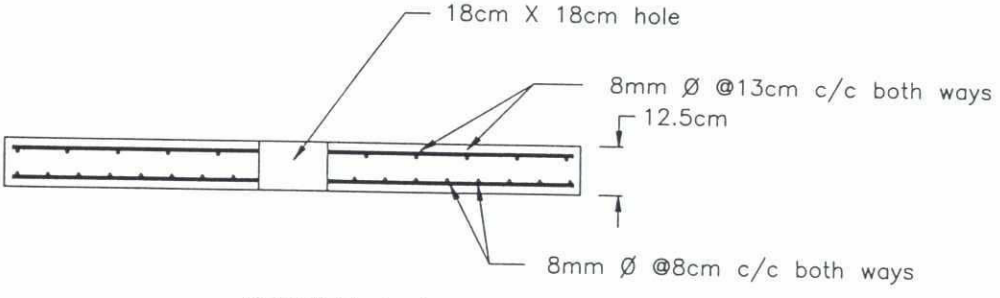


Figure 2.4: Detail of anchor leg

File D:\Peter\Report\Screen4.dwg



PLAN



SECTION A–A

Figure 2.5: Dimensions of anchor slab

File D:\Peter\Report\Screen5.dwg

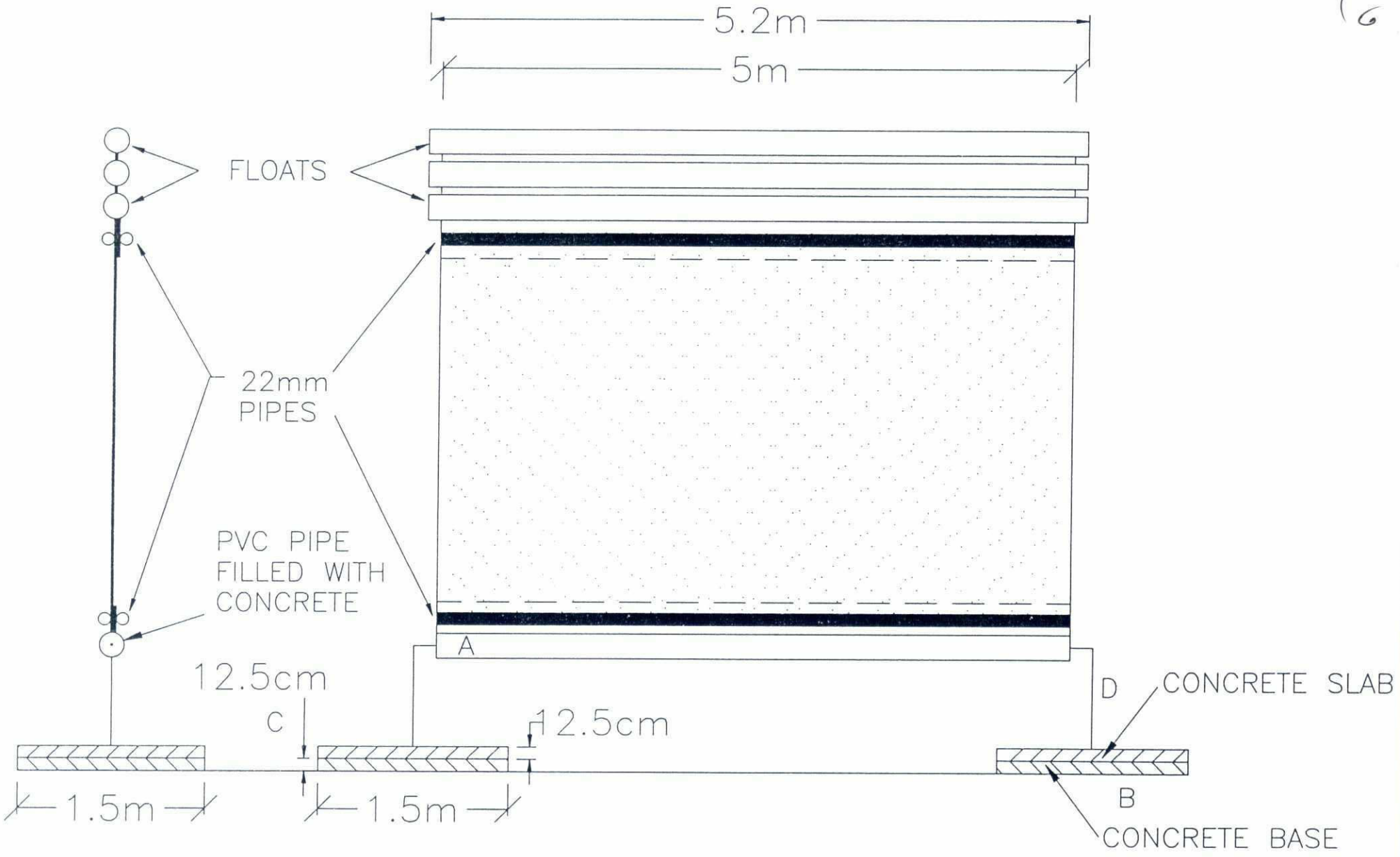


Figure 2.6: Assembling of geotextile screen

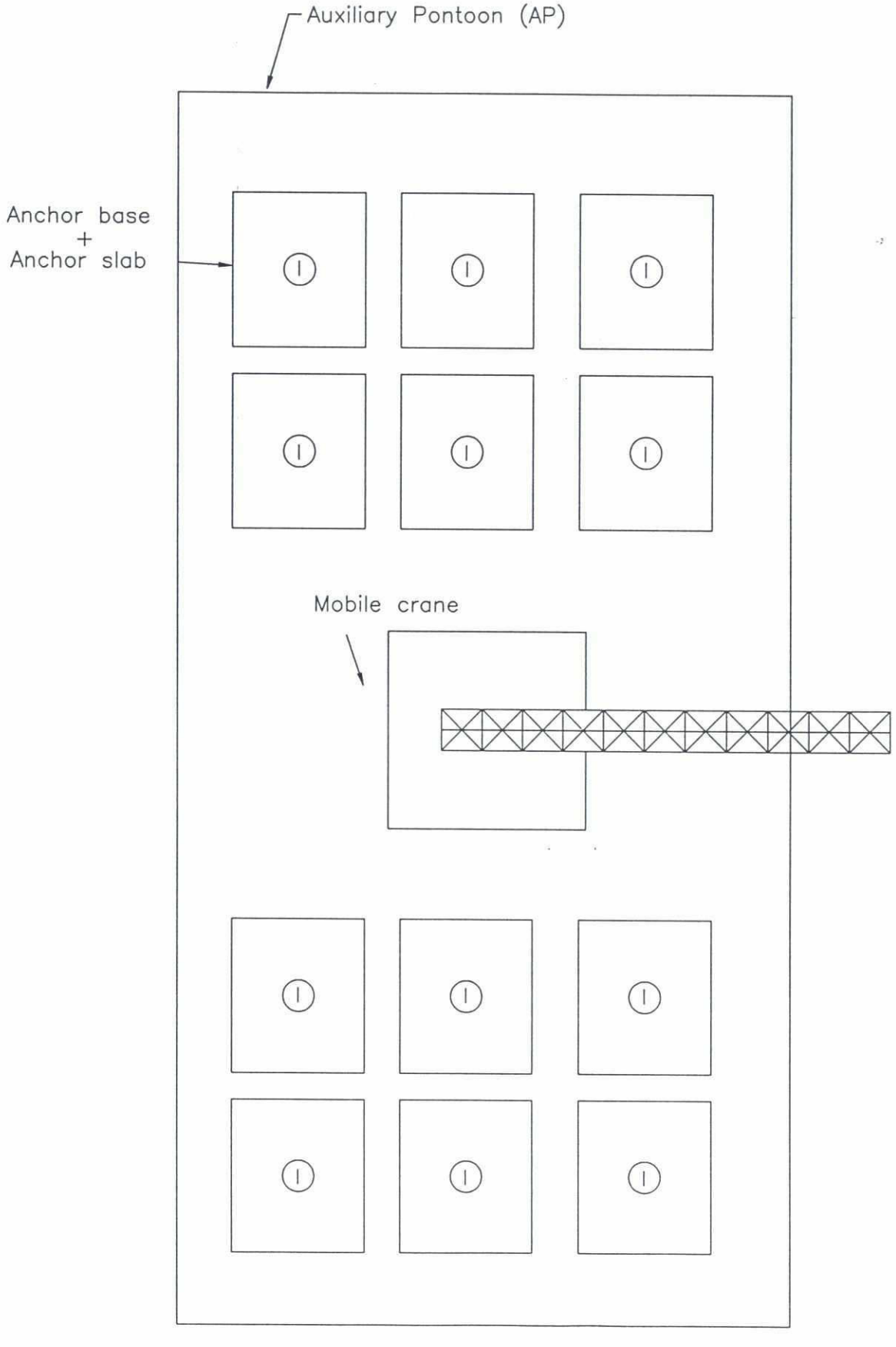


Figure 2.7: Screen anchors loaded on auxiliary pontoon

D:\PETER\SCREENS\FIG7

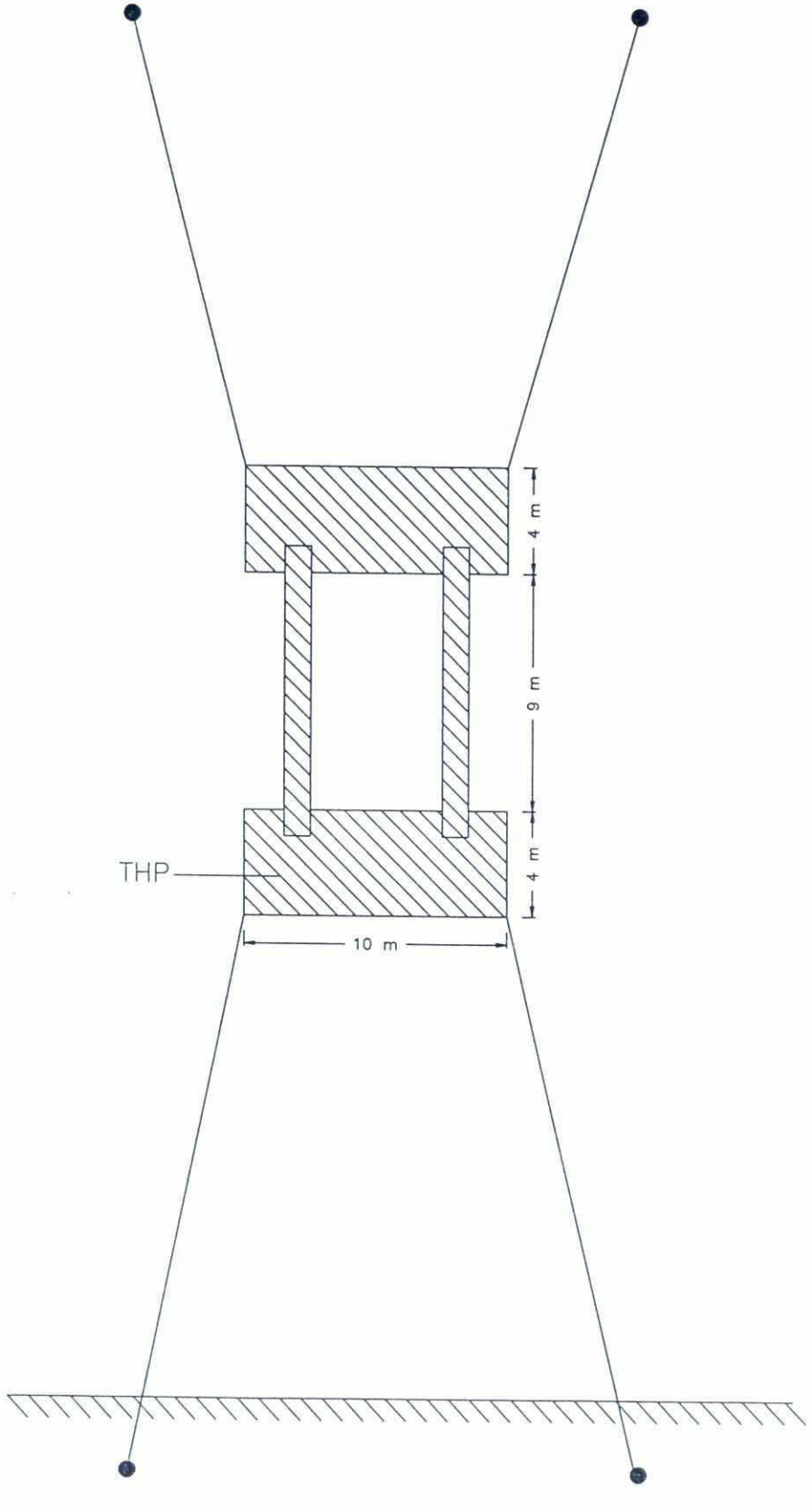


Figure 2.8: Positioning of THP

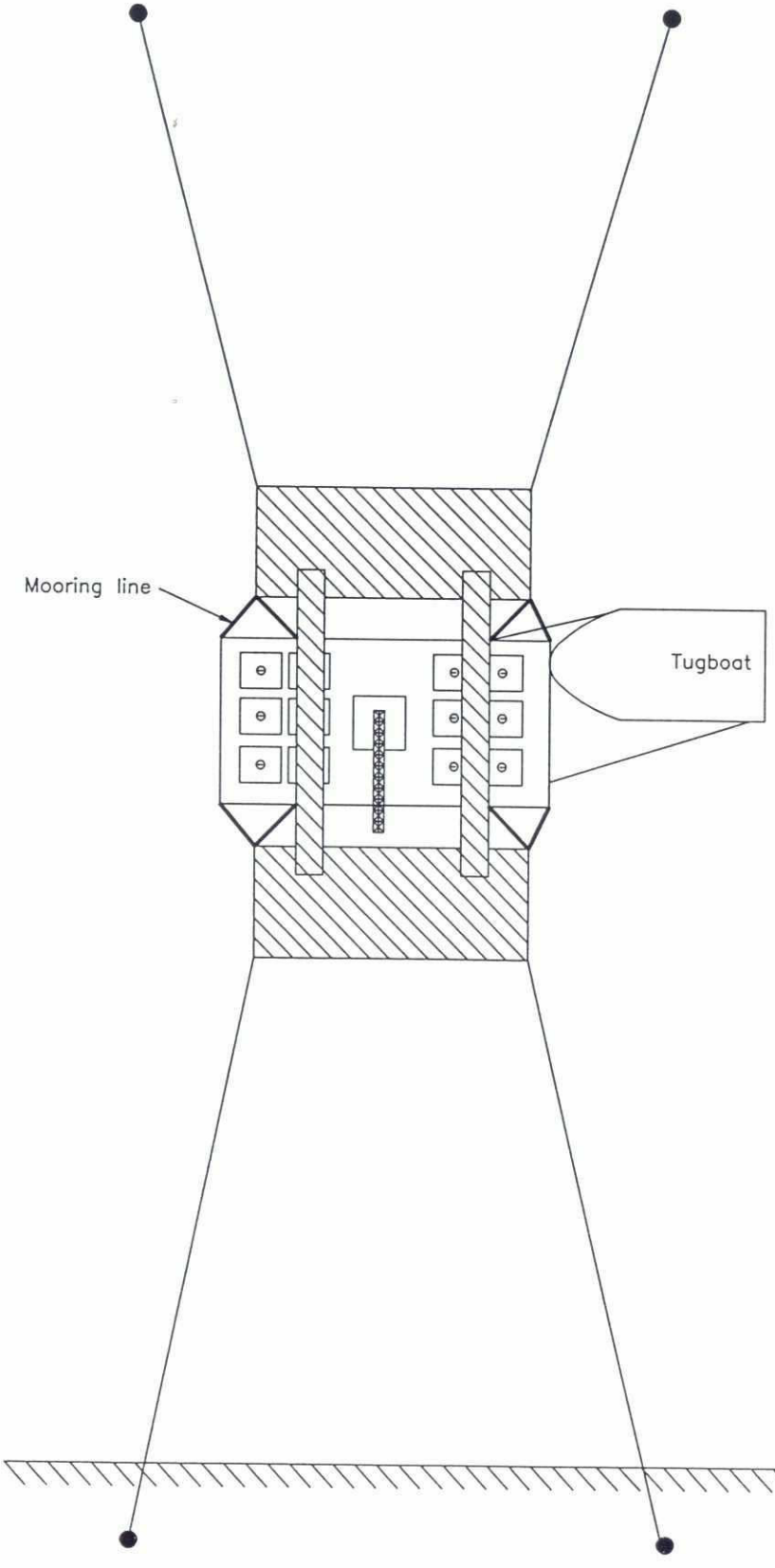
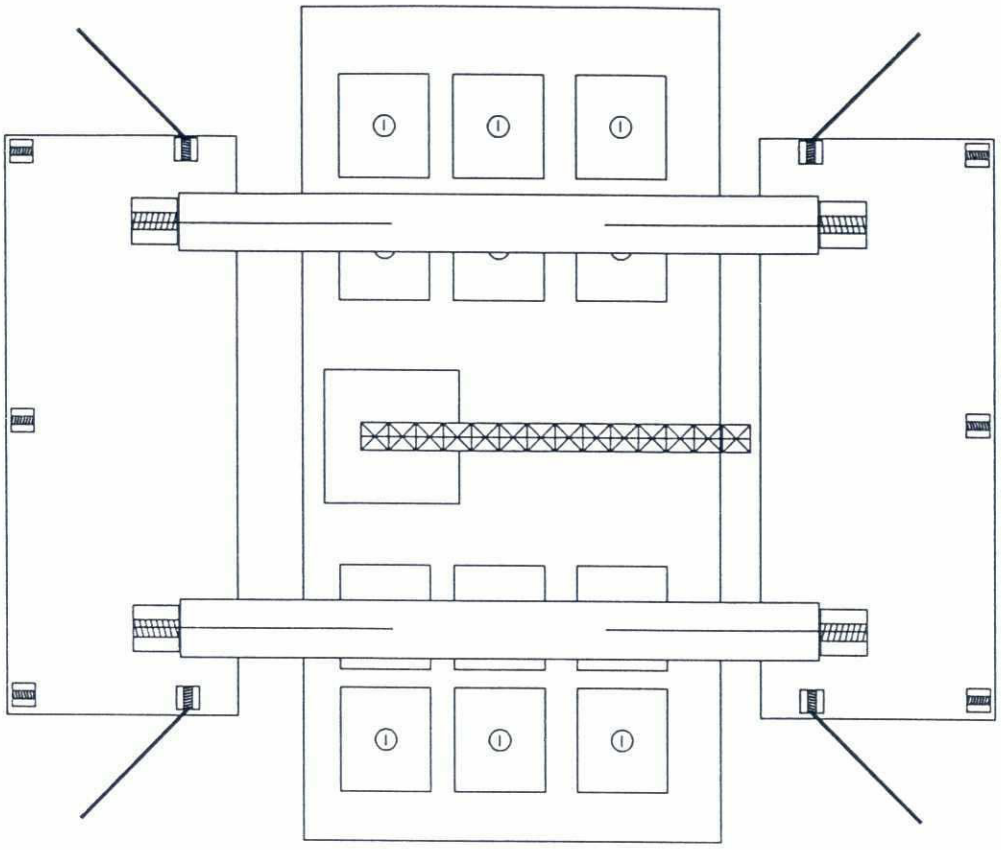


Figure 2.9: Mooring auxiliary pontoon inside THP.



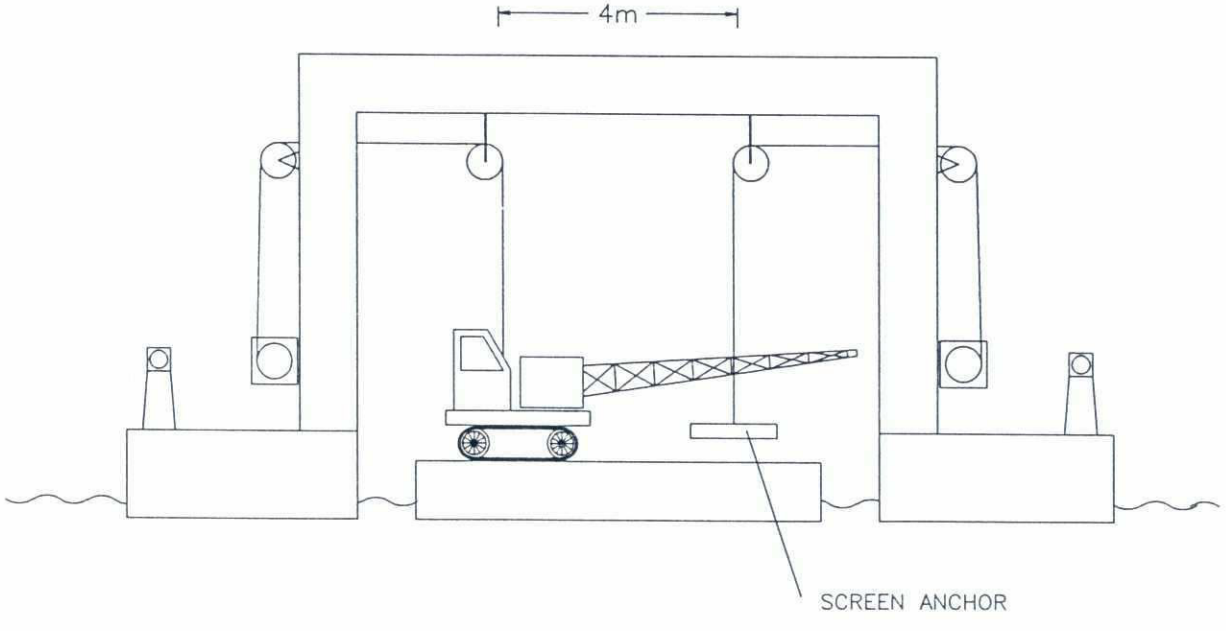
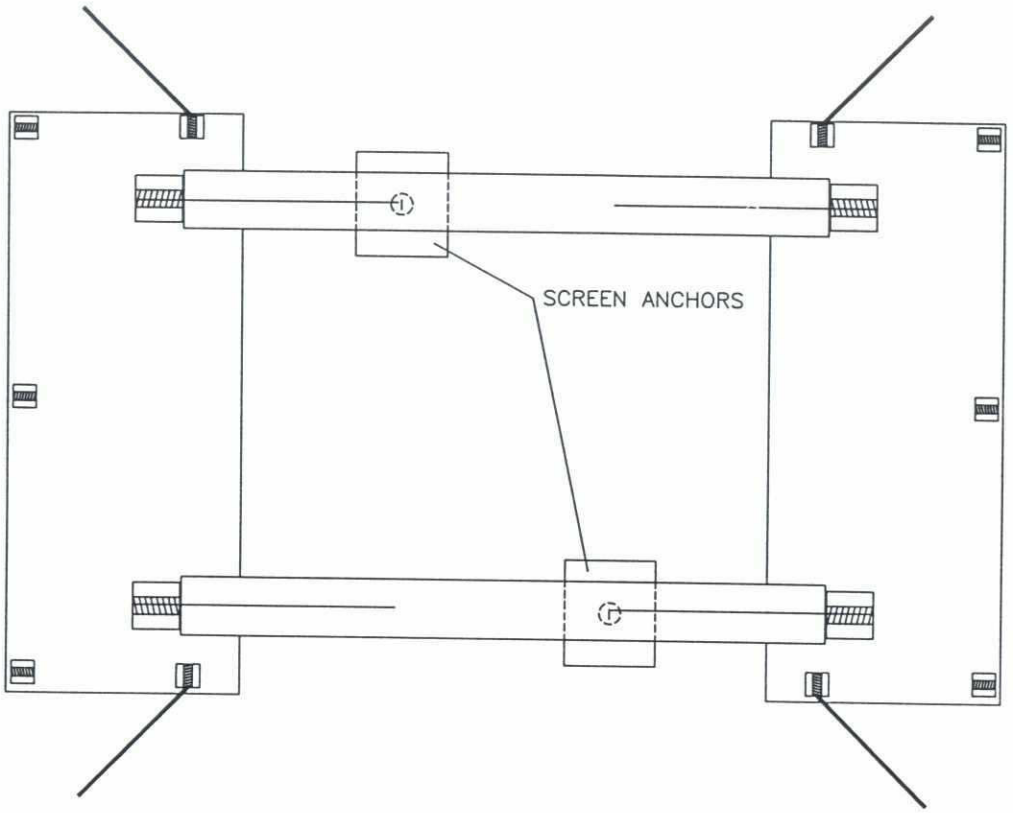


Figure 2.10: Lifting of screen anchors



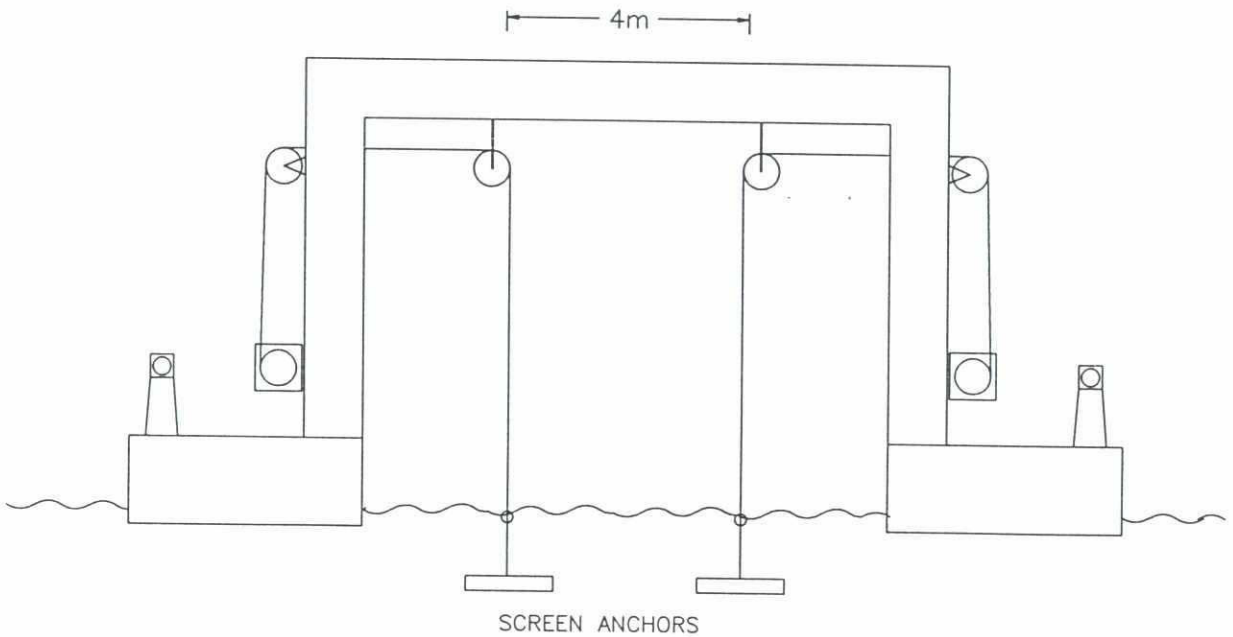
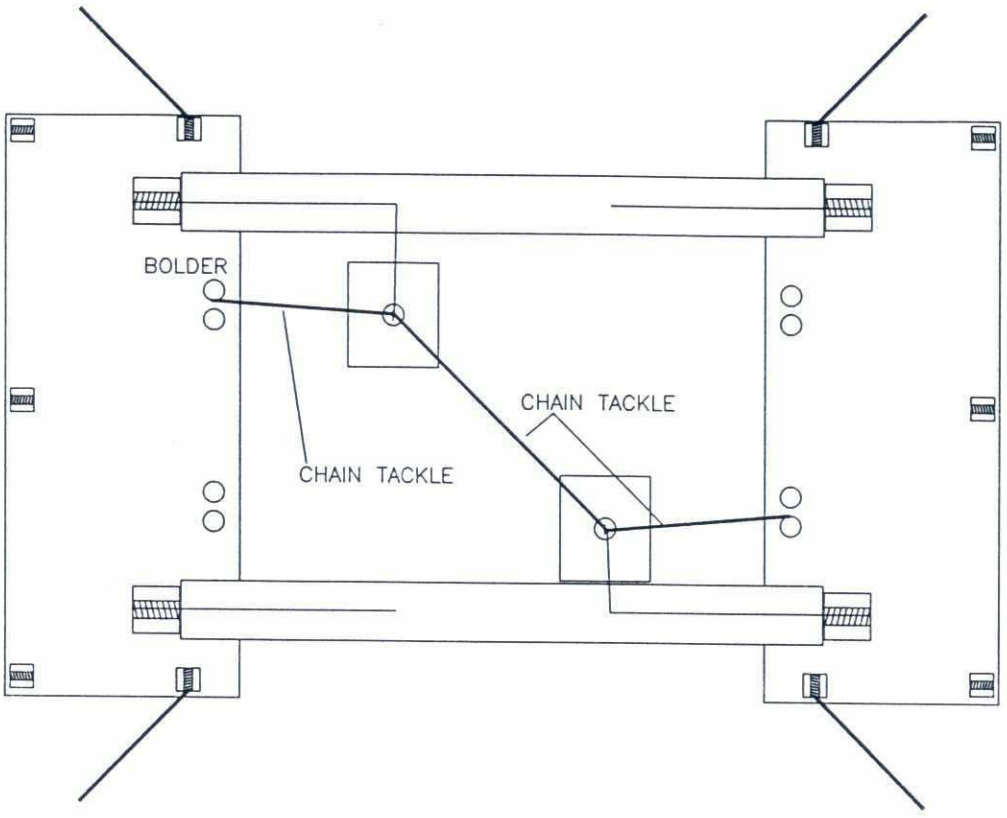


Figure 2.11: Lowering of screen anchors



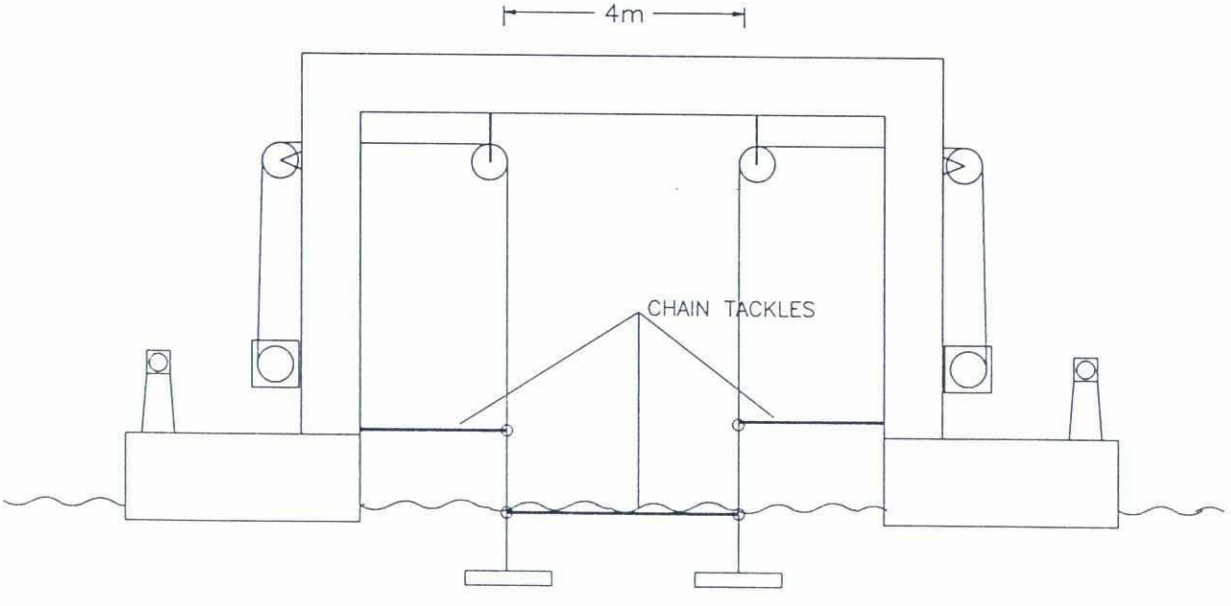
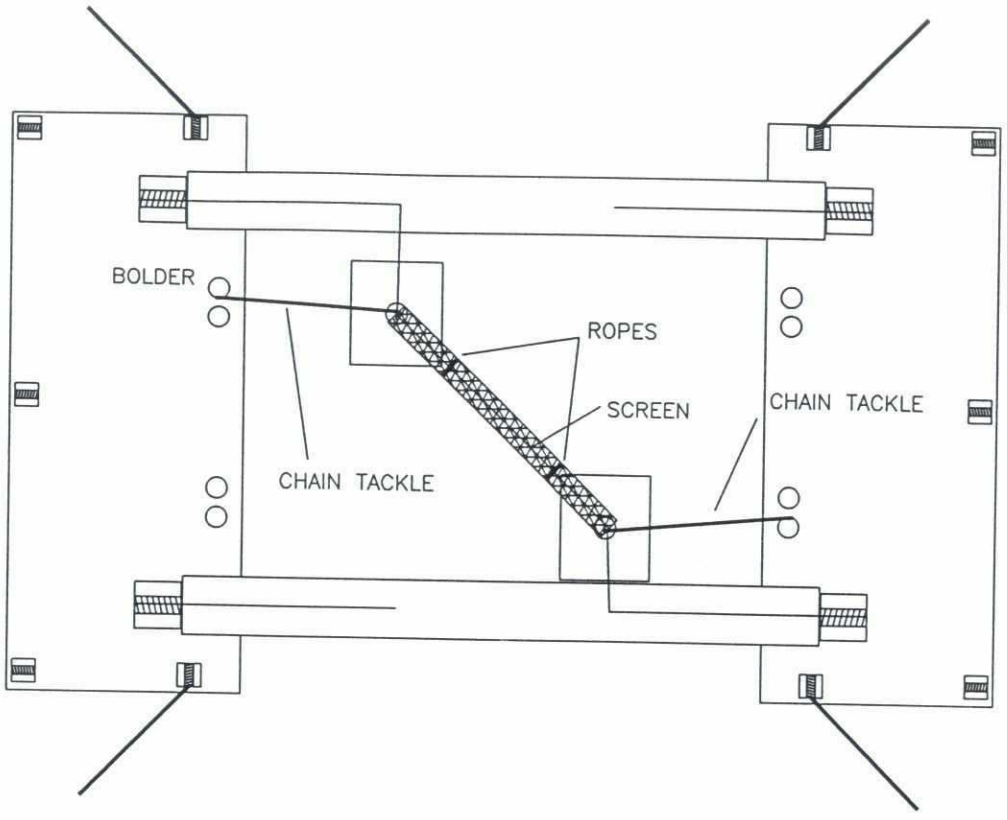


Figure 2.12: Attaching of chain tackles



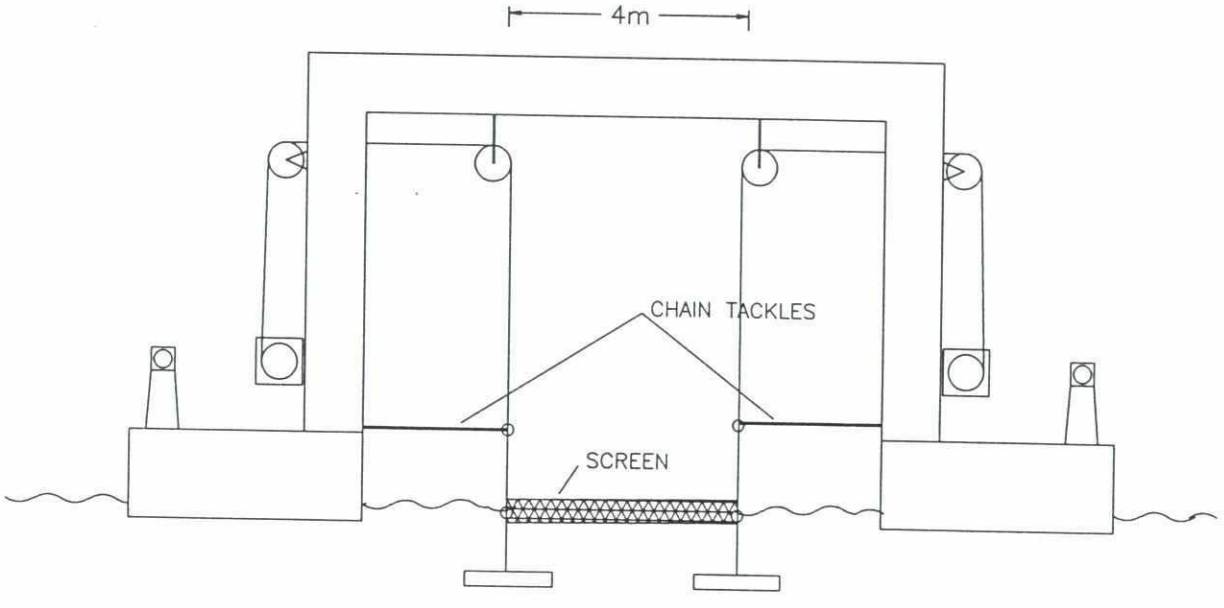
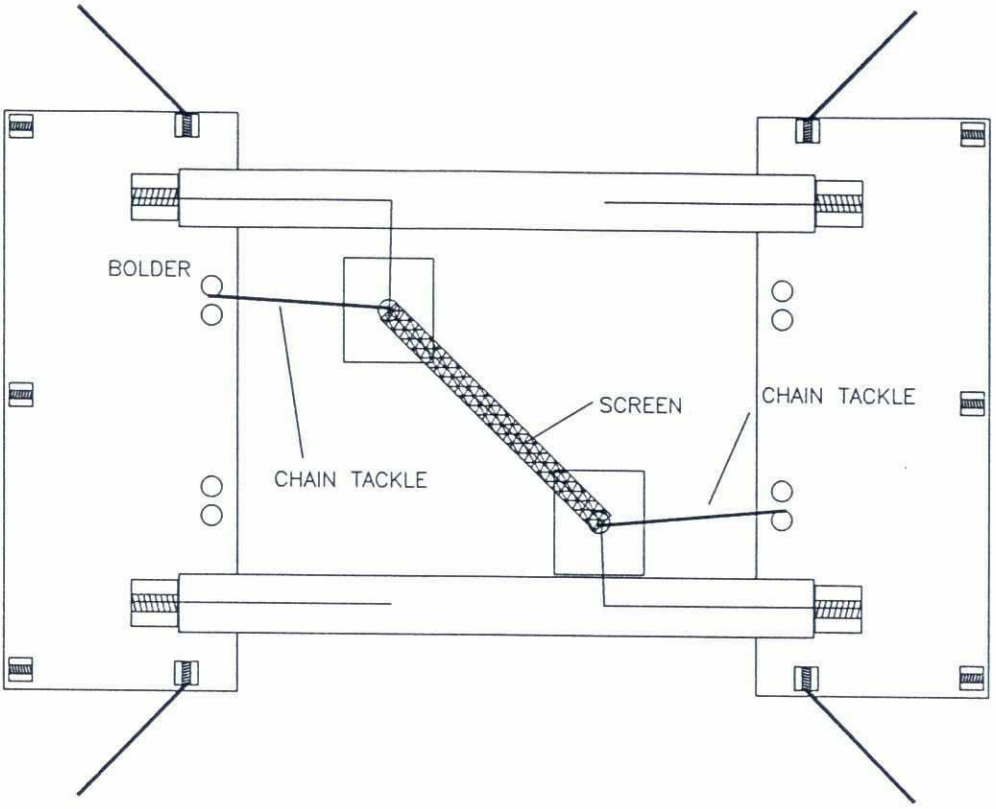


Figure 2.13: Attaching of screen, removing ropes



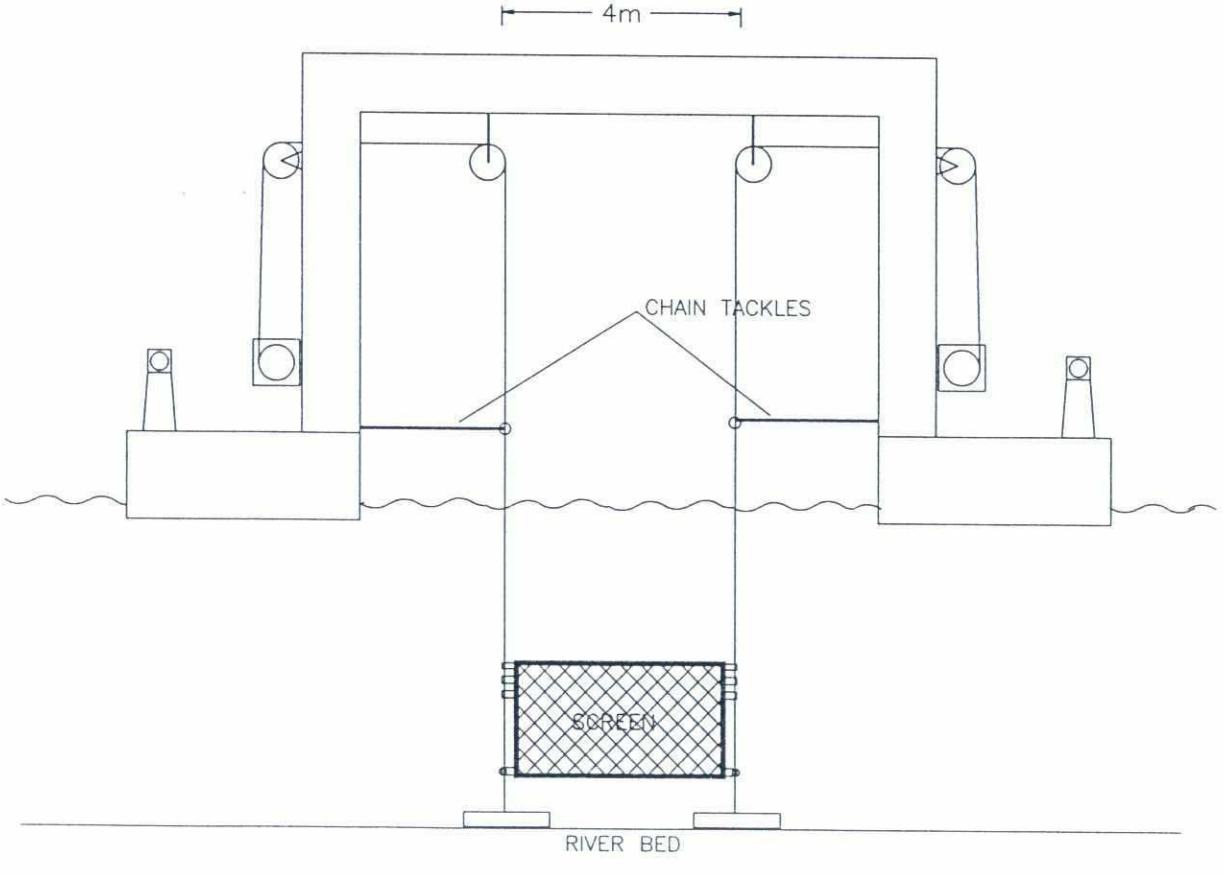


Figure 2.14: Installation of screen

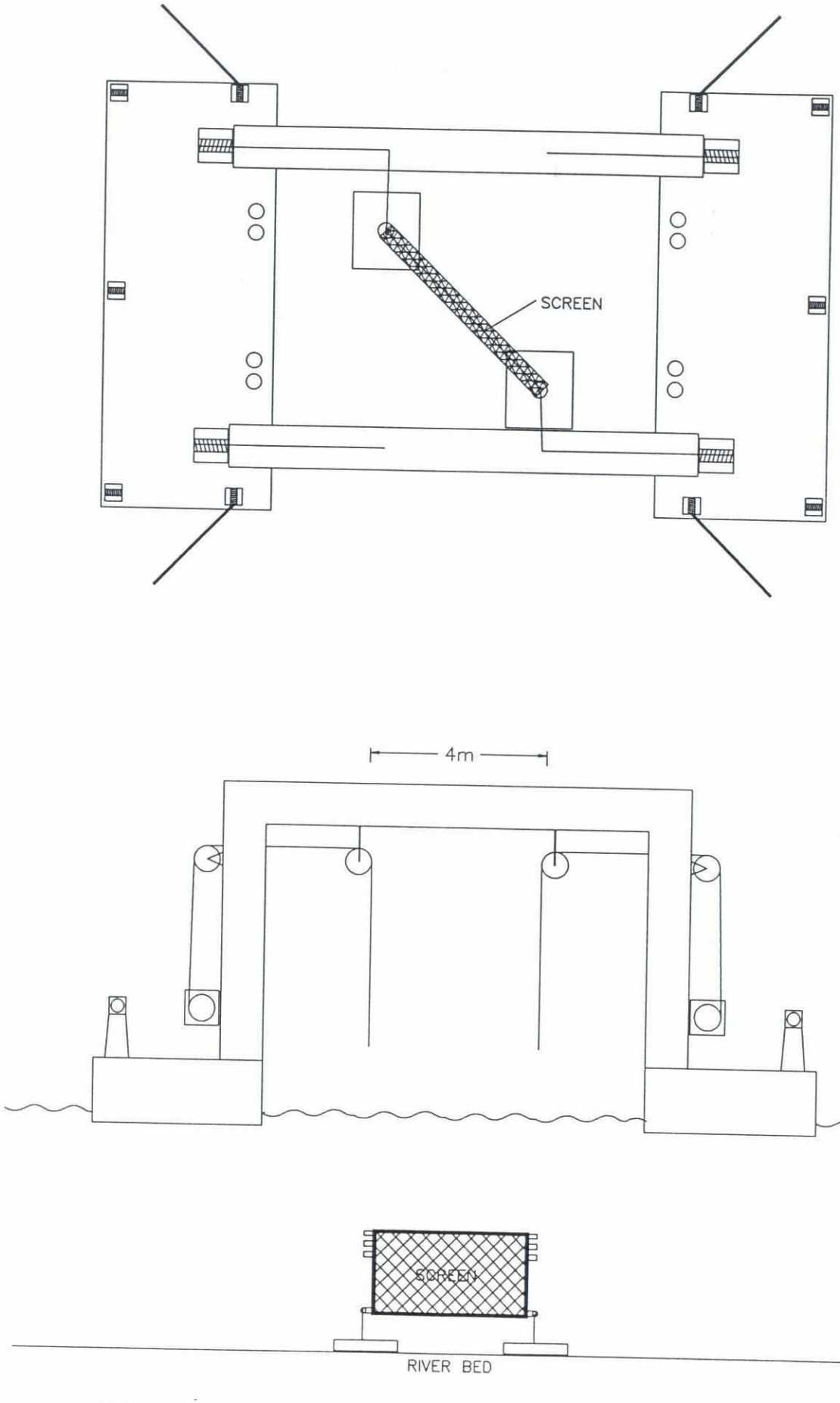


Figure 2.15: Detaching screen and chain tackles

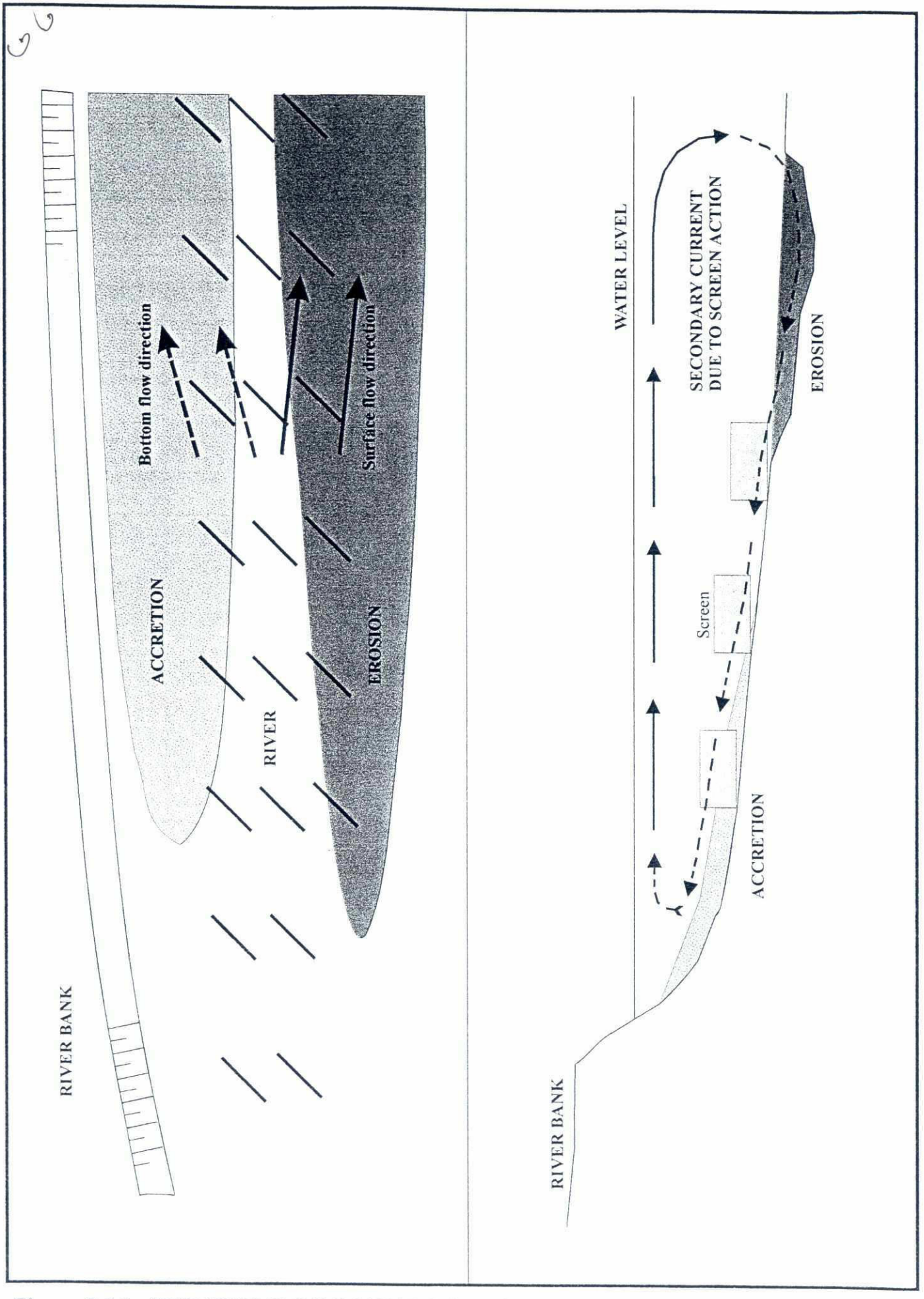
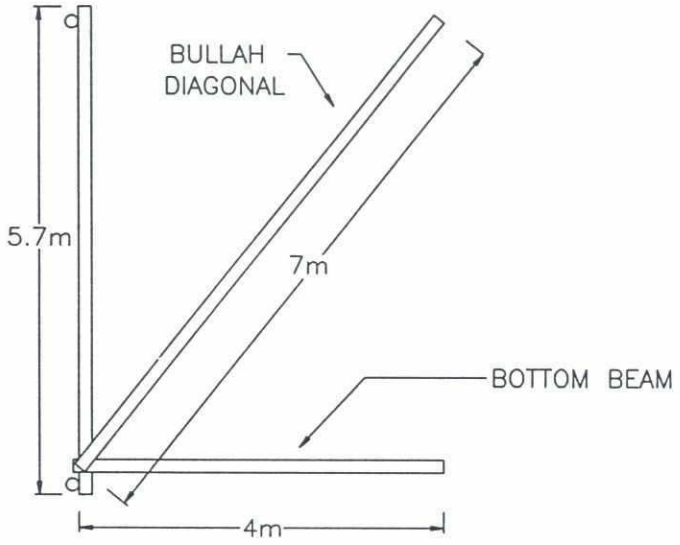
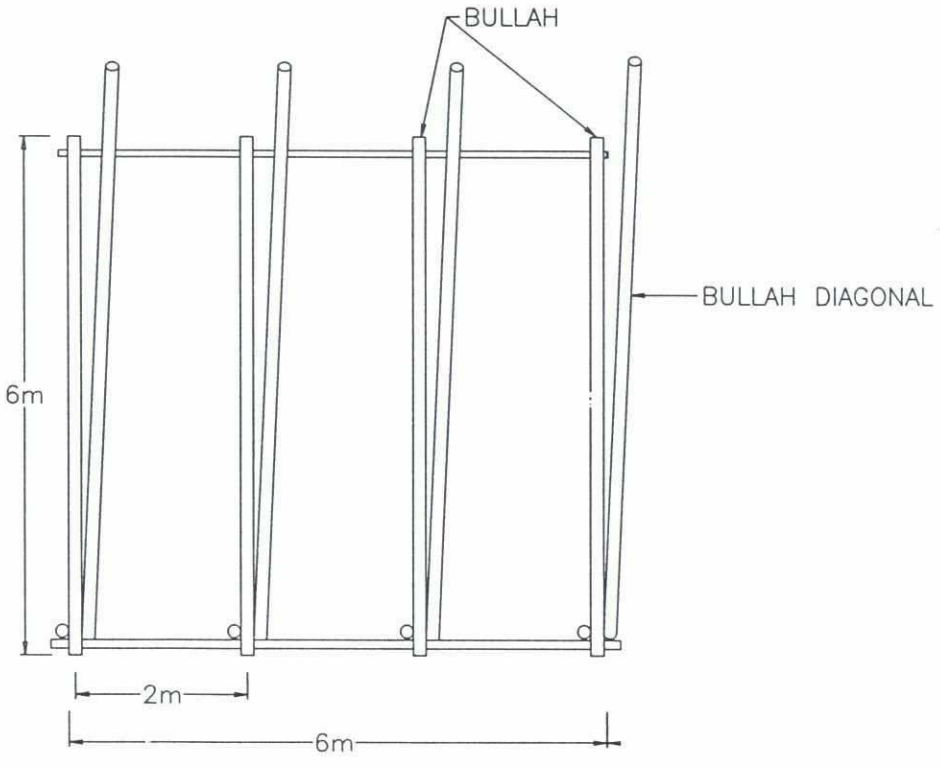


Figure 2.16: PRINCIPLE OF BANK PROTECTION USING SCREENS



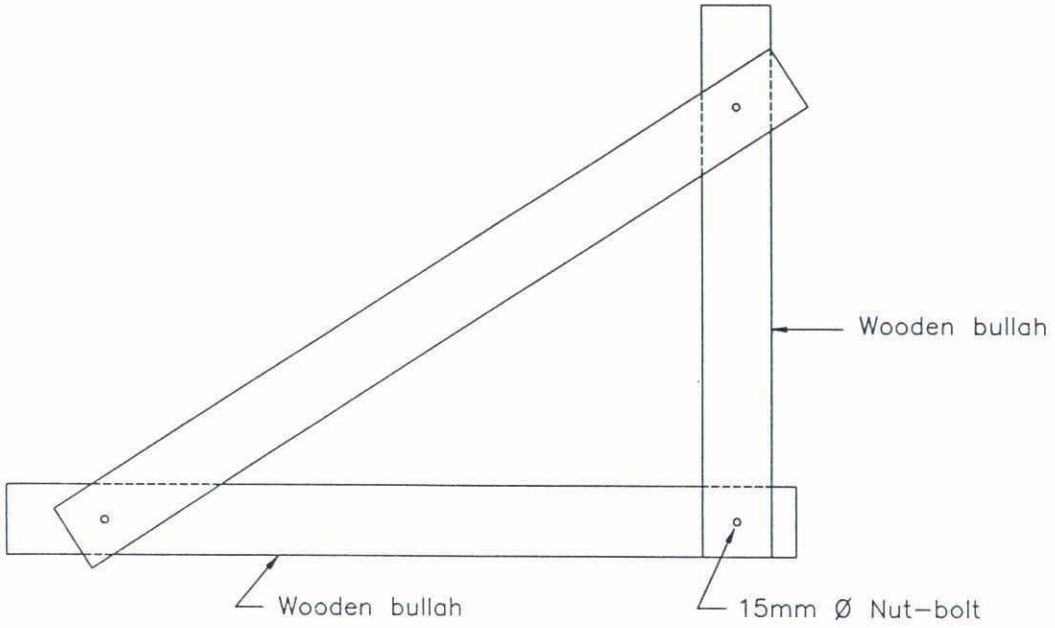
CROSS SECTION



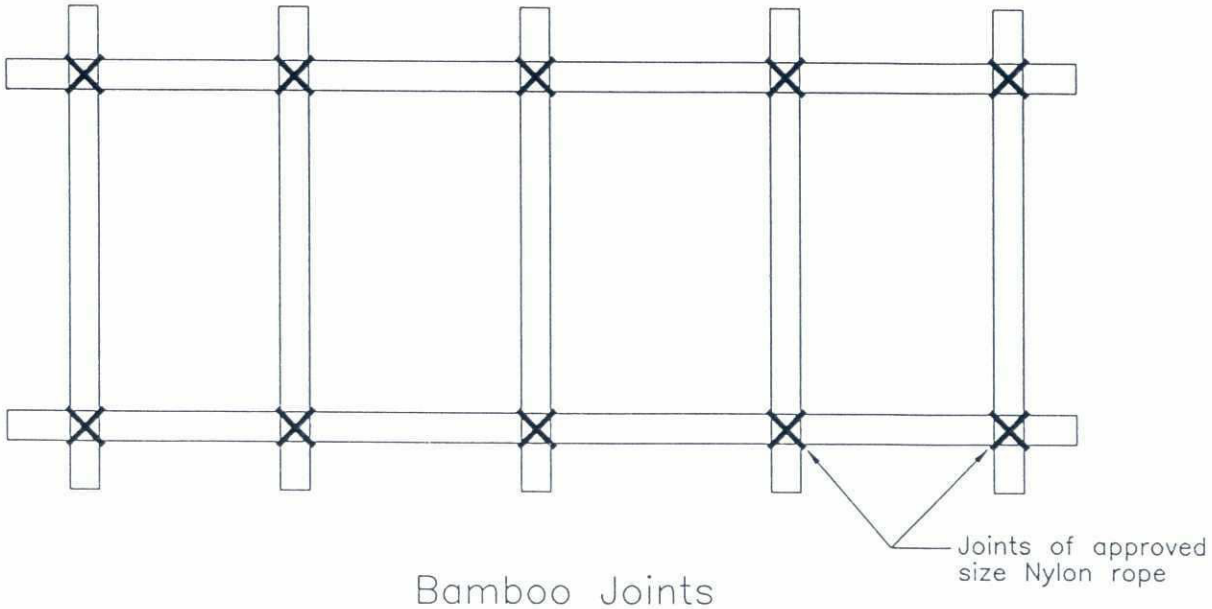
SIDE VIEW

Figure 3.1: Lay-out of side panel of caisson

File D:\Peter\Report\Spur1.dwg



Typical Wooden Bullah Joints



Bamboo Joints

Figure 3.1a: Caisson Joints

File D:\Peter\Report\Spur1A.dwg

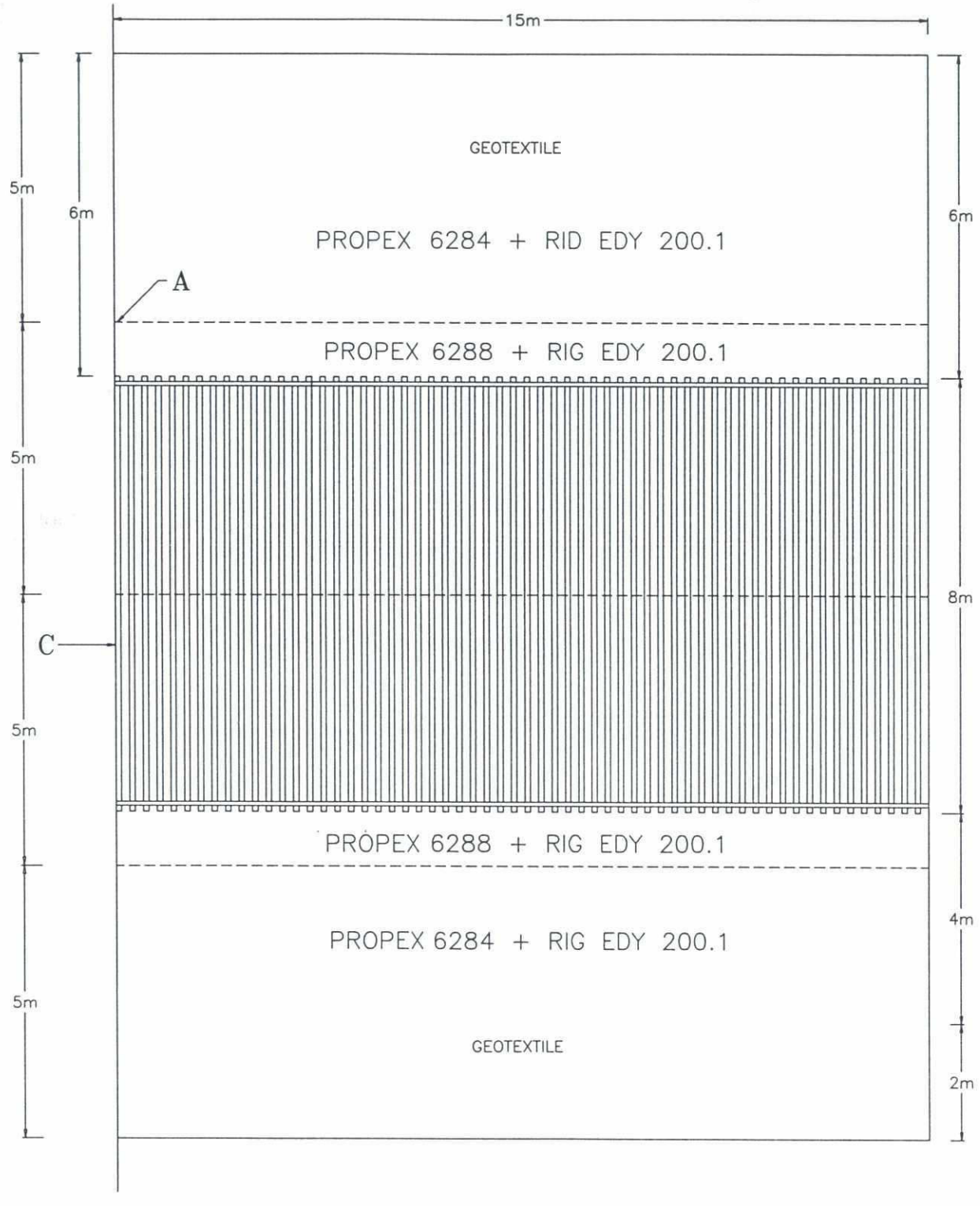
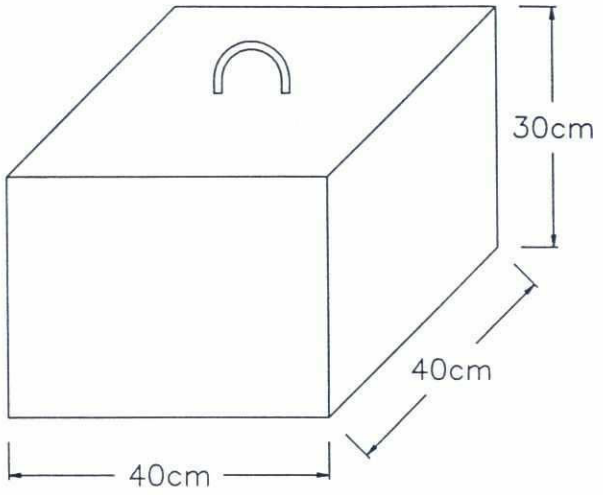
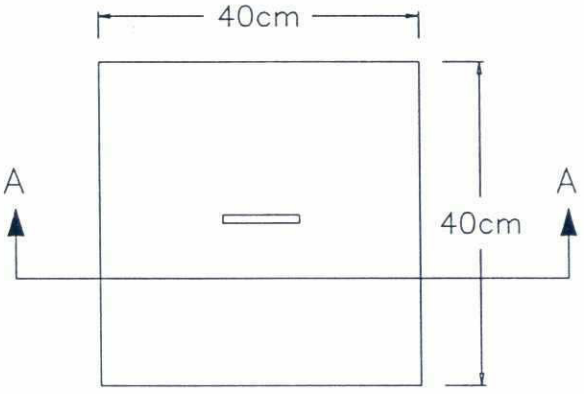


Figure 3.2: Layout of geotextile foundation

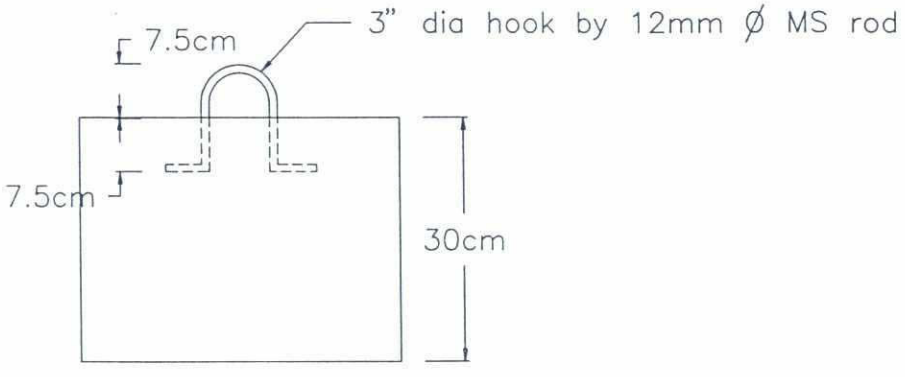
File D:\Peter\Report\Spur2.dwg



Isometric View



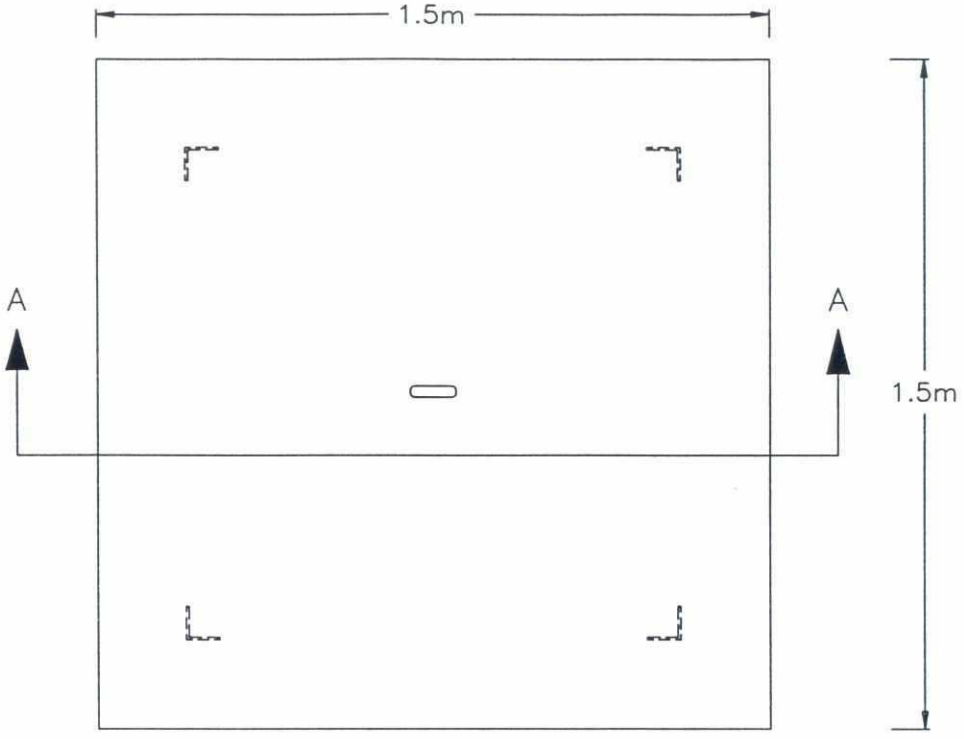
PLAN



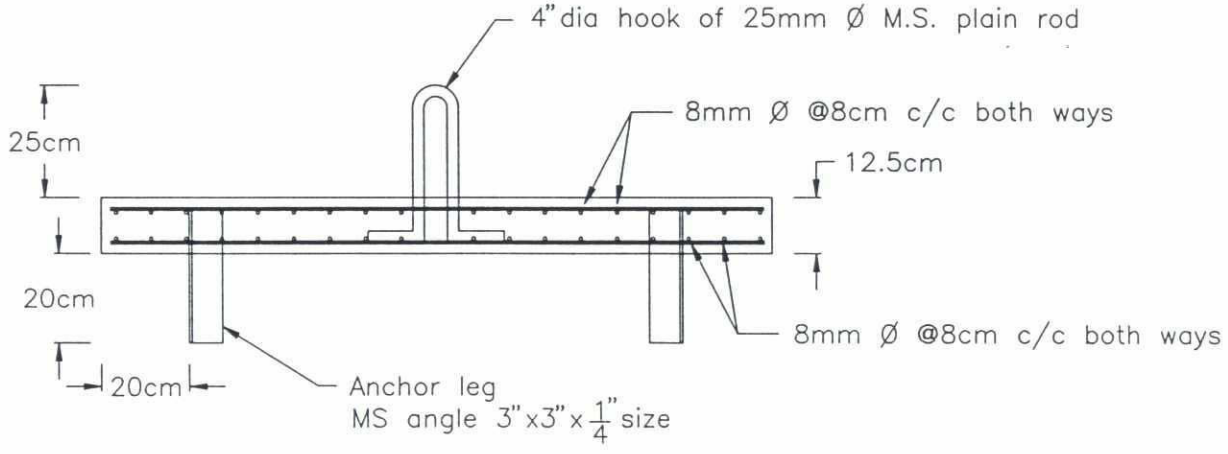
SECTION A–A

Figure 3.3: Design of concrete block

File D:\Peter\Report\Spur3.dwg



PLAN



SECTION A–A (for Khorki, bottom slab)

Figure 3.4: Dimensions of anchor base

File D:\Peter\Report\Spur4.dwg

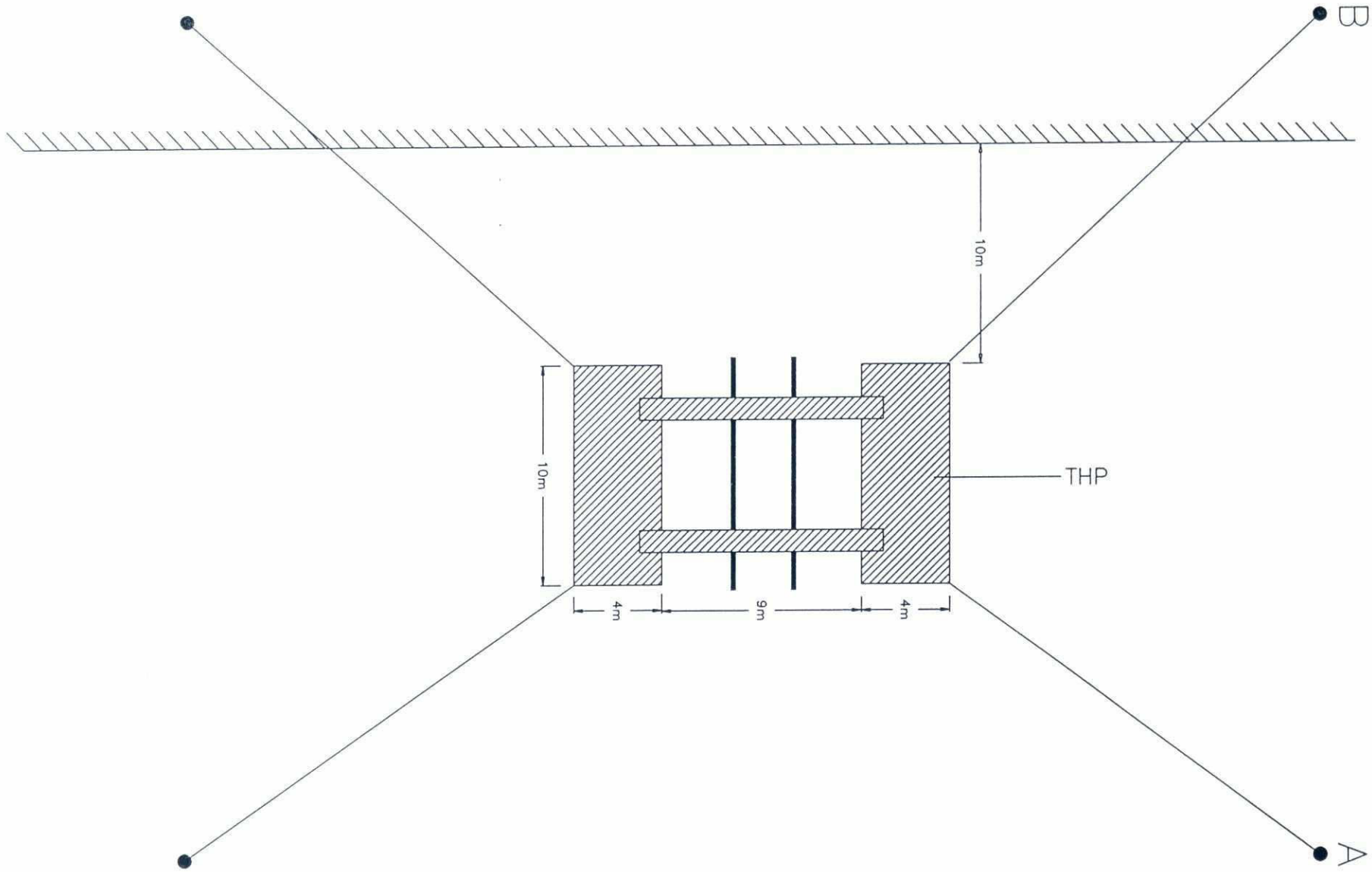
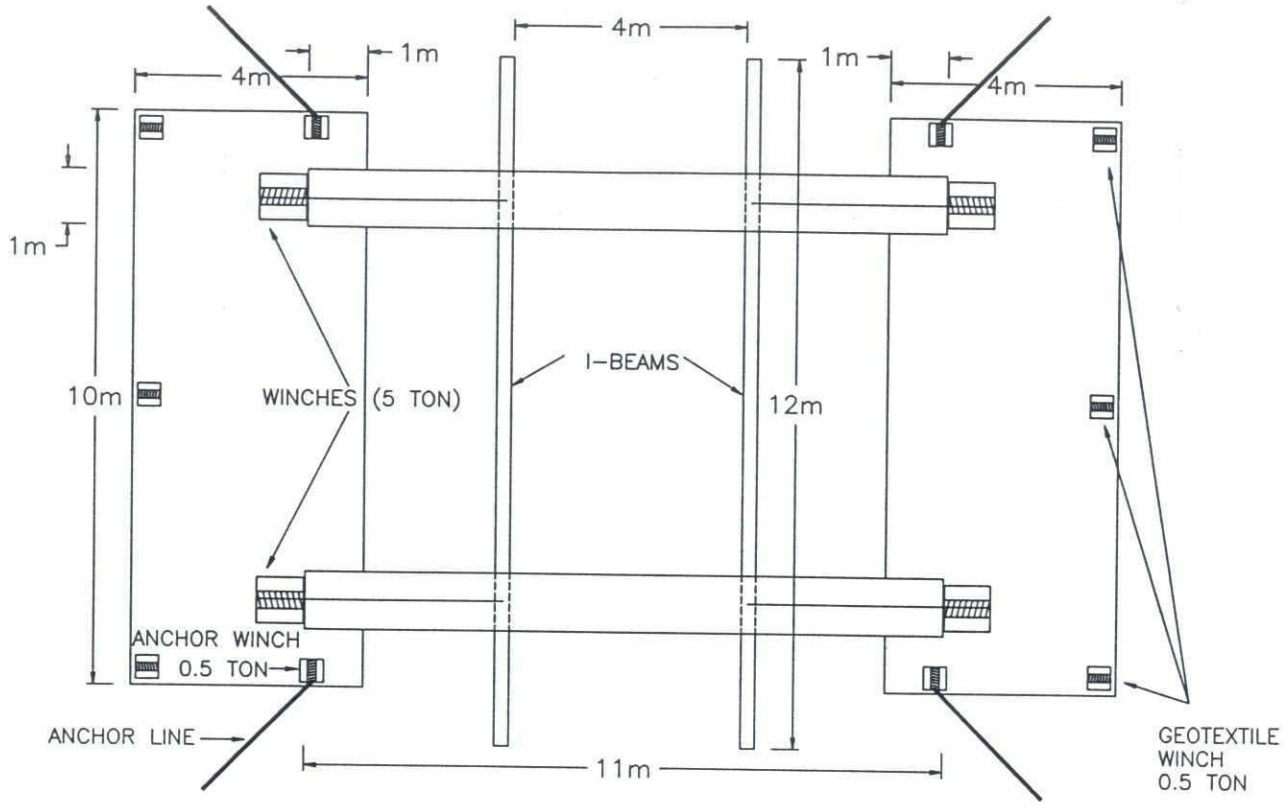
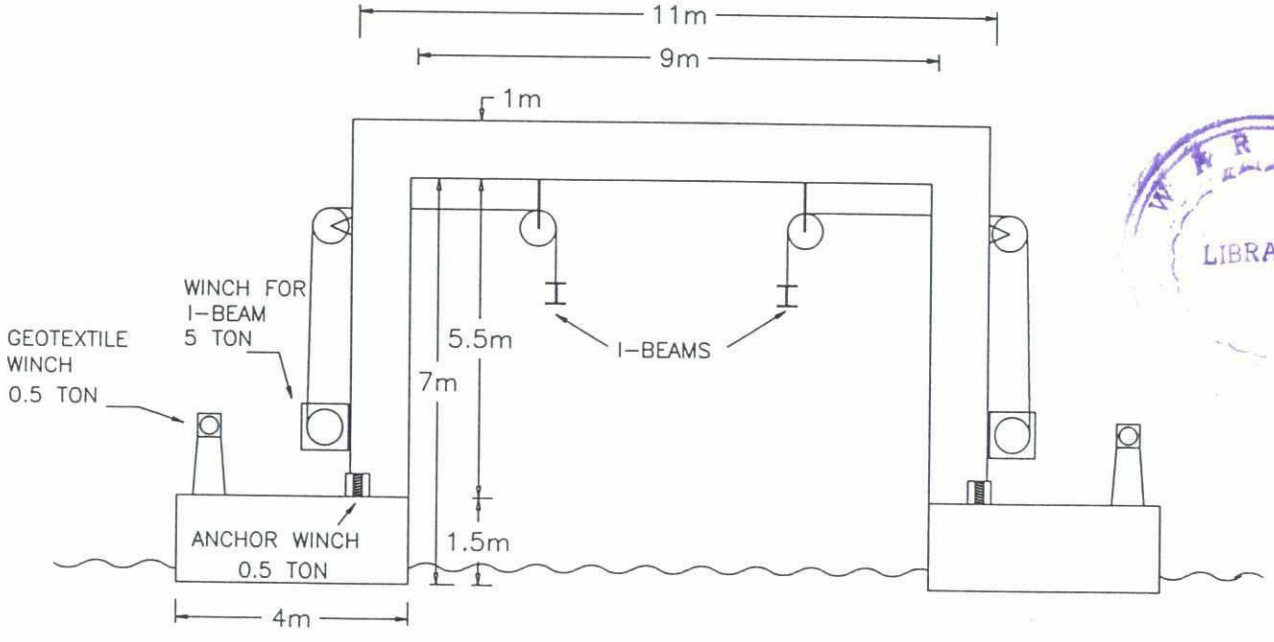


Figure 3.5: Positioning of THP

File D:\Peter\Report\Spur5.dwg

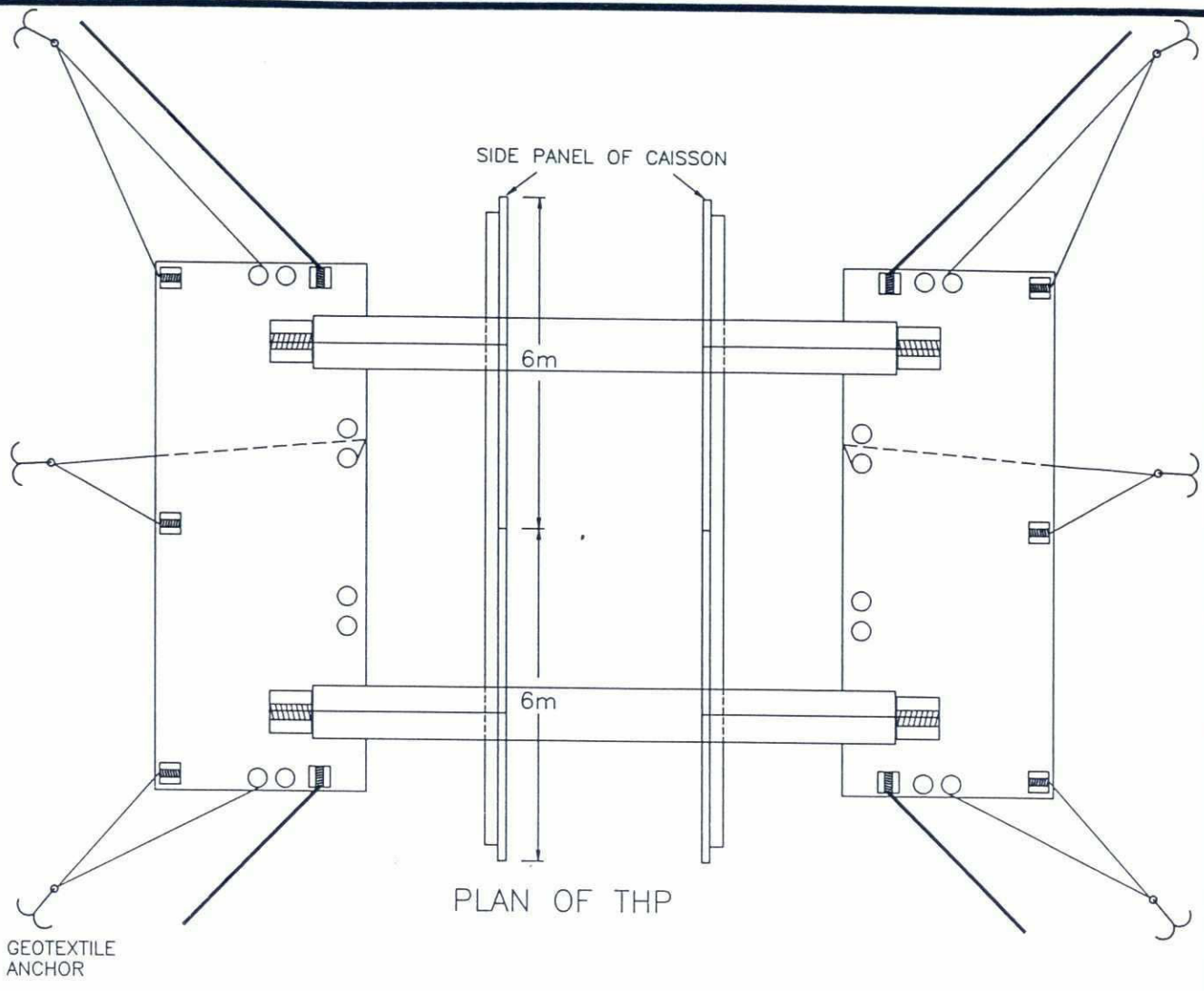


PLAN OF TWIN HULL PONTOON



FRONT VIEW OF TWIN HULL PONTOON

Figure 3.6: Pontoon layout



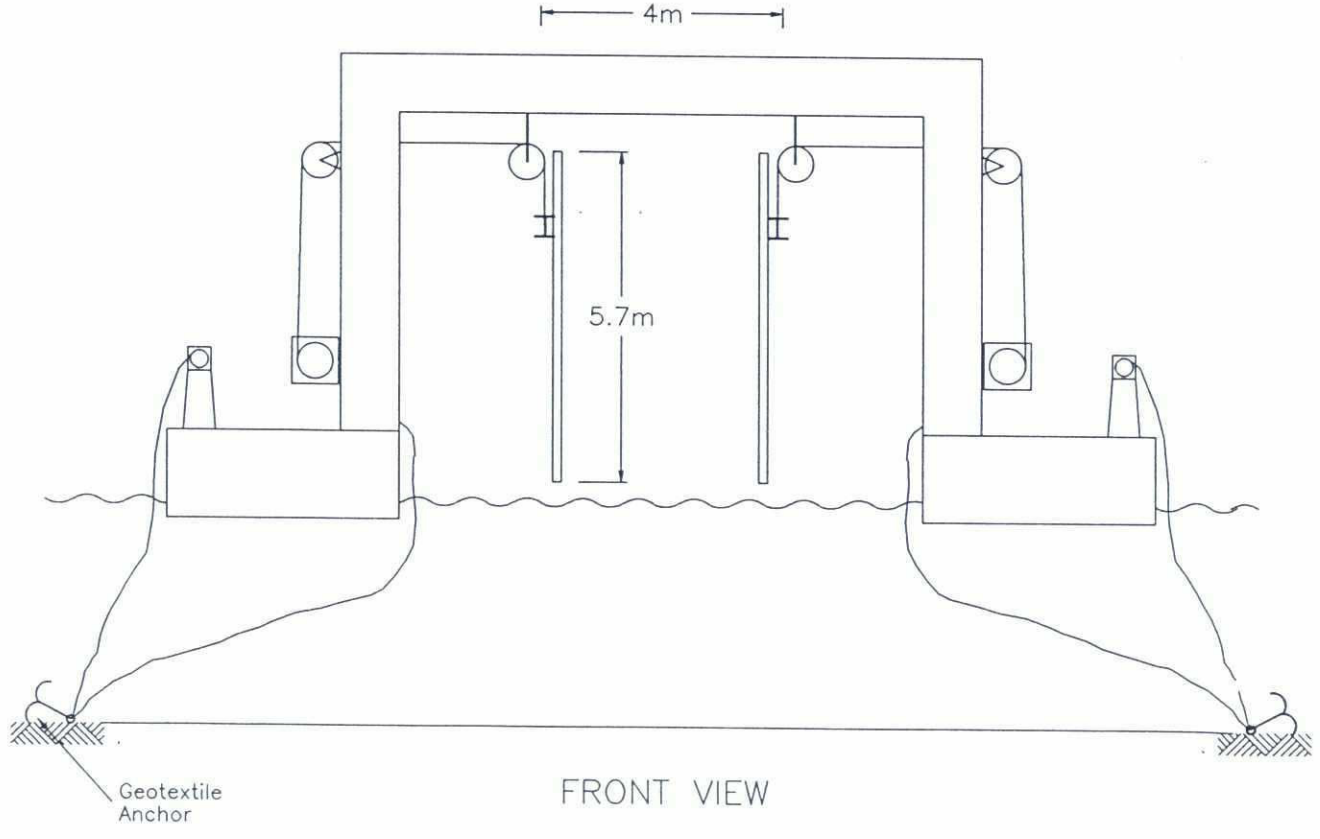
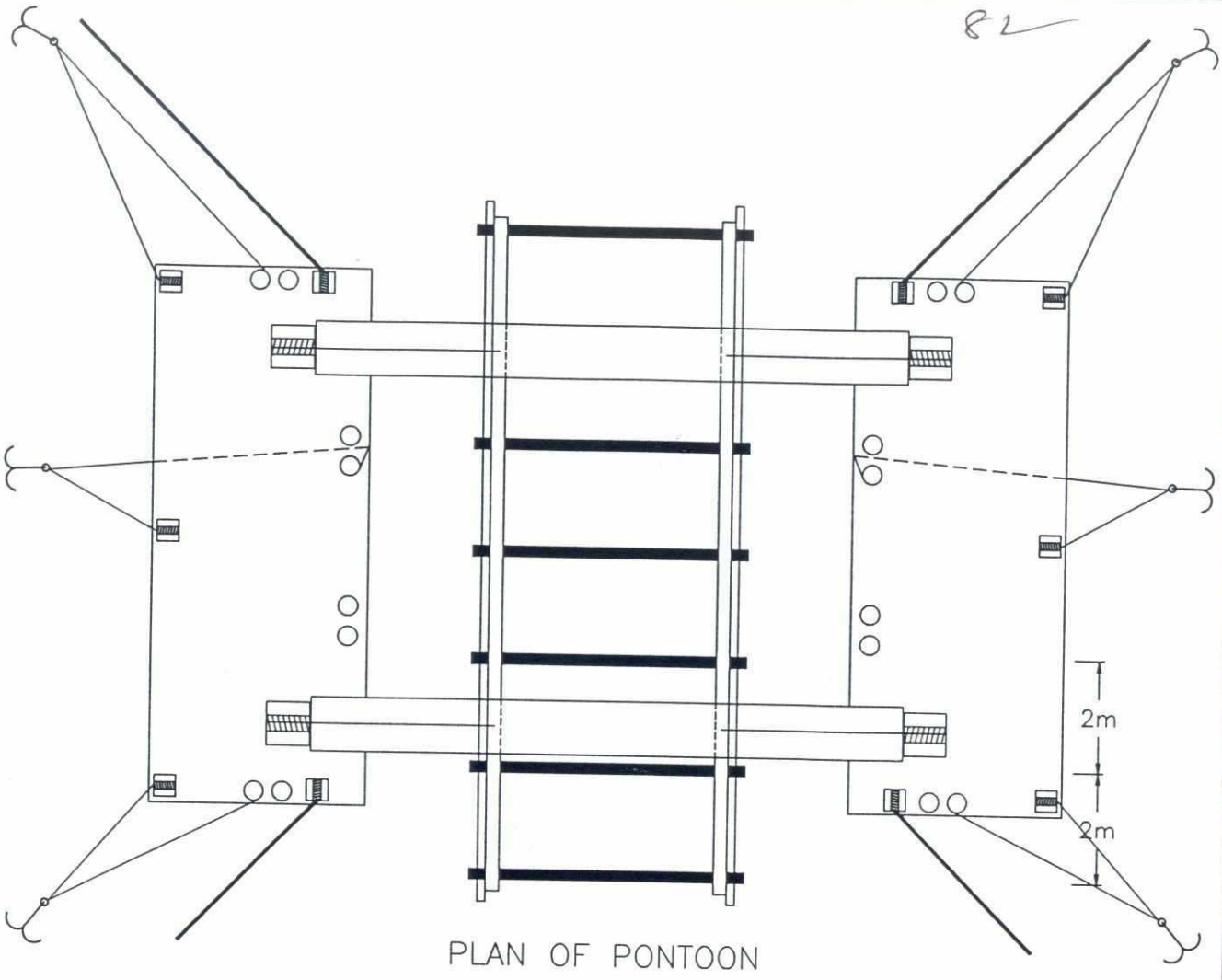
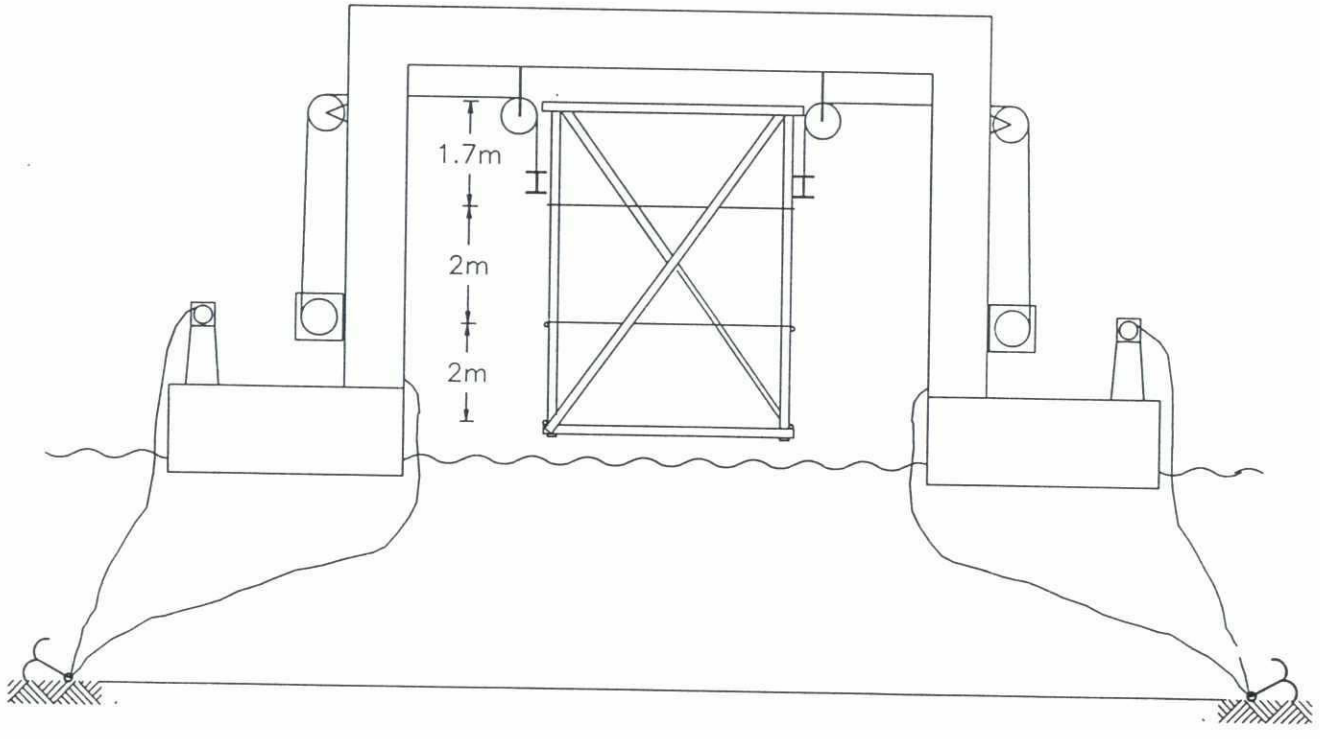


Figure 3.7: Lifting side panels of caisson and installation of Geo-Textile anchors

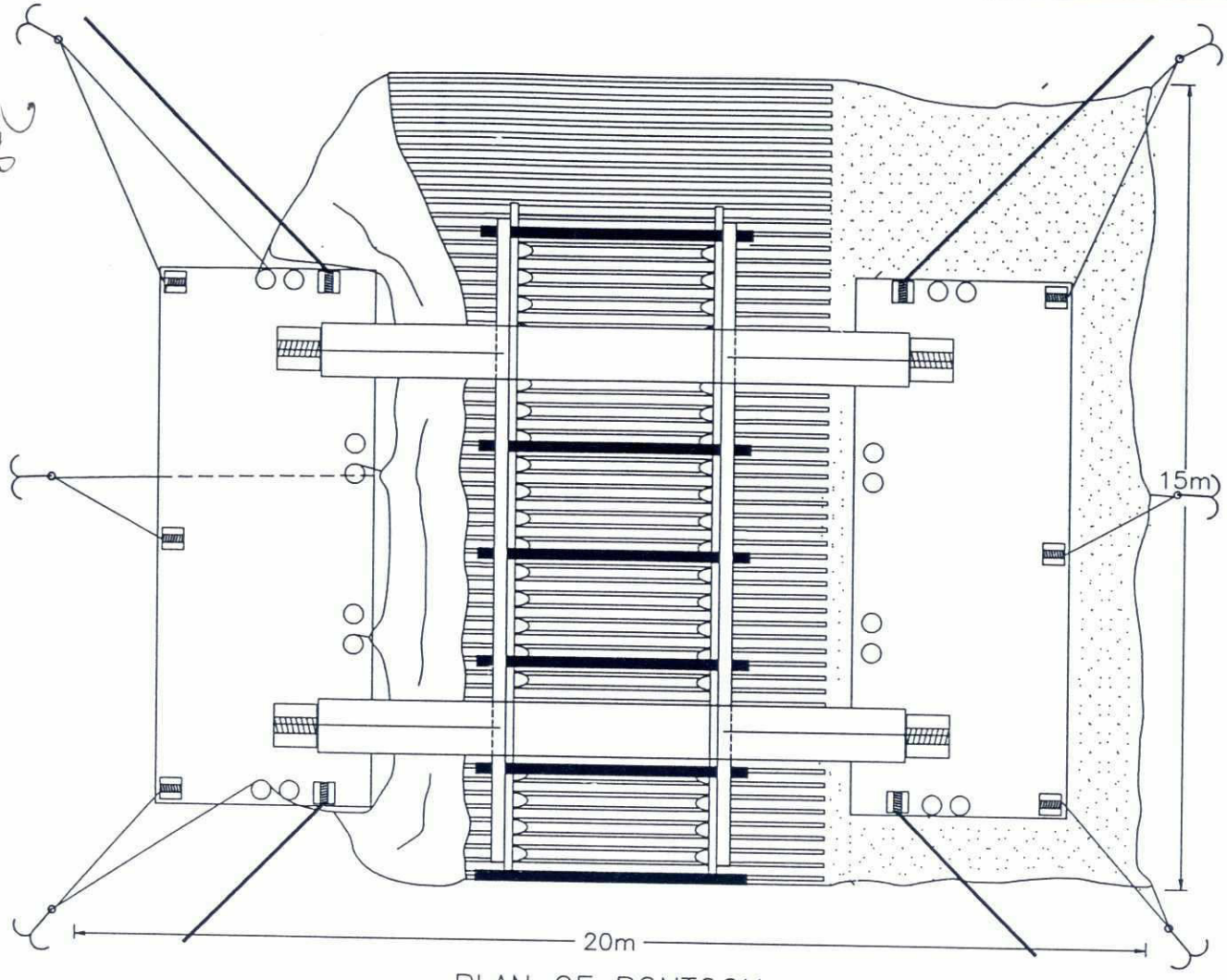


PLAN OF PONTOON

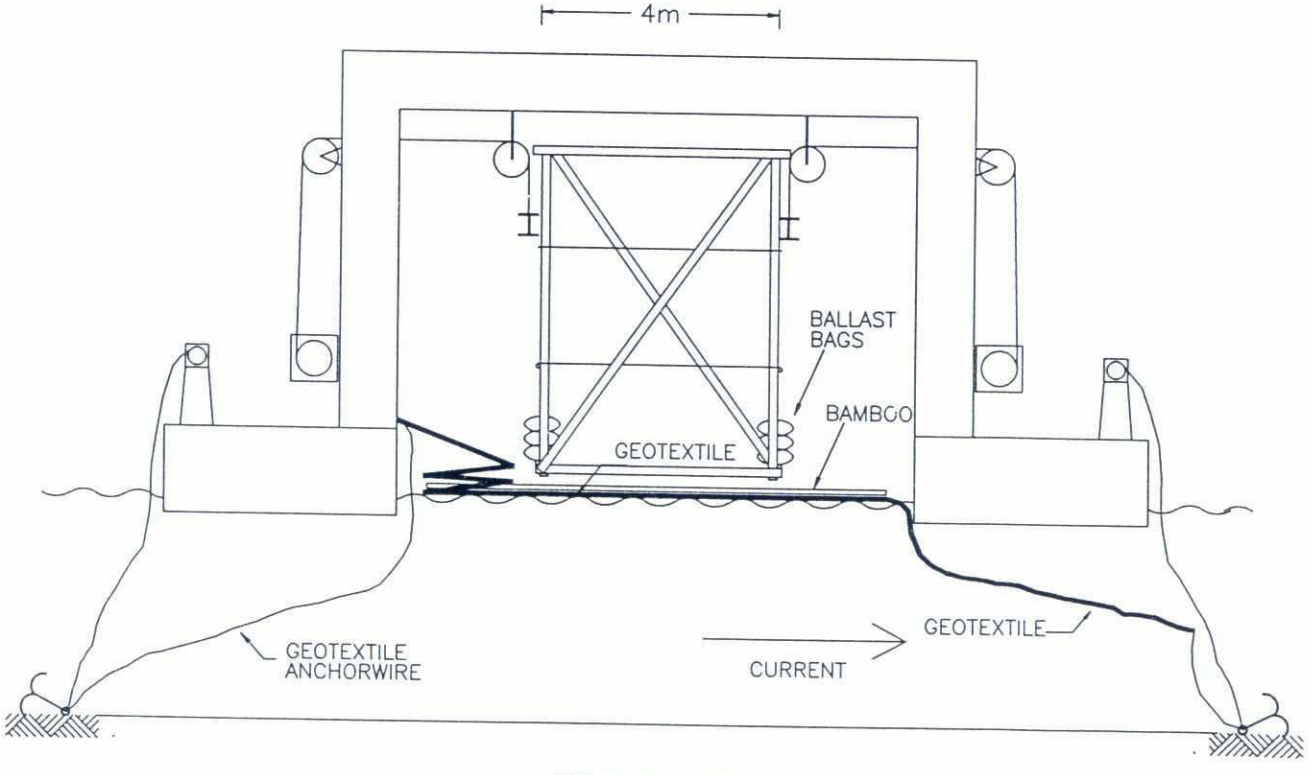


FRONT VIEW

Figure 3.8: Assembling caisson

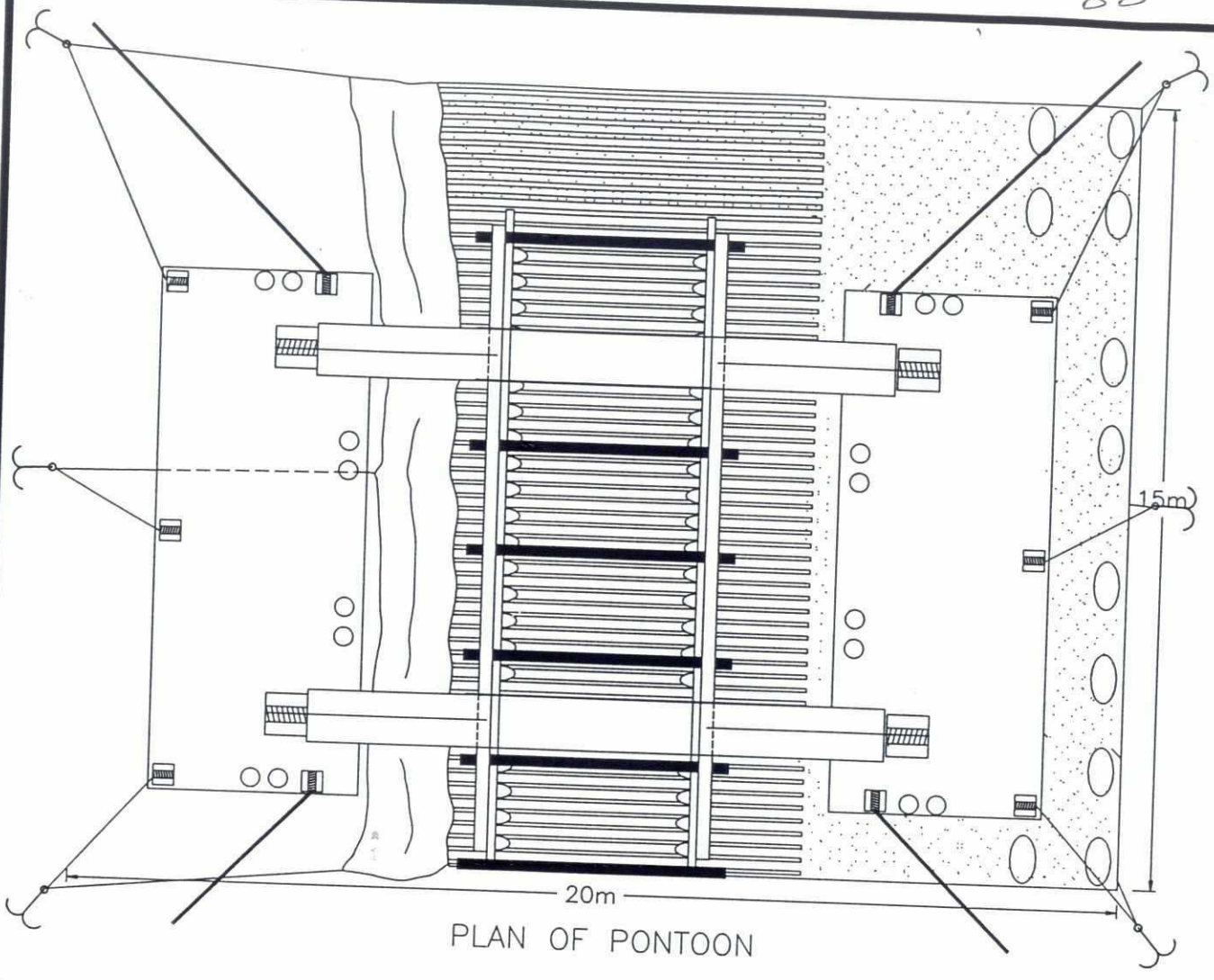


PLAN OF PONTOON

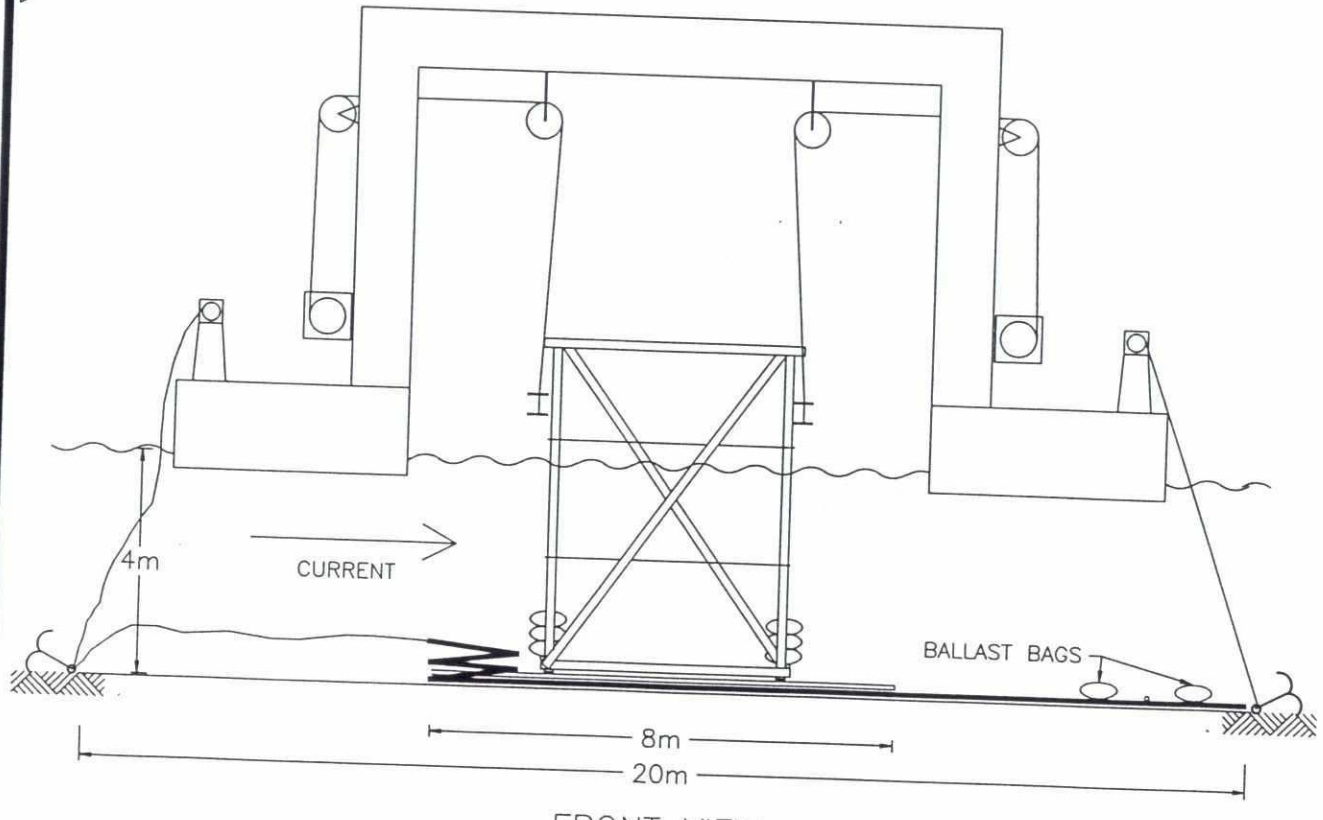


FRONT VIEW

Figure 3.9: Float geotextile inside THP

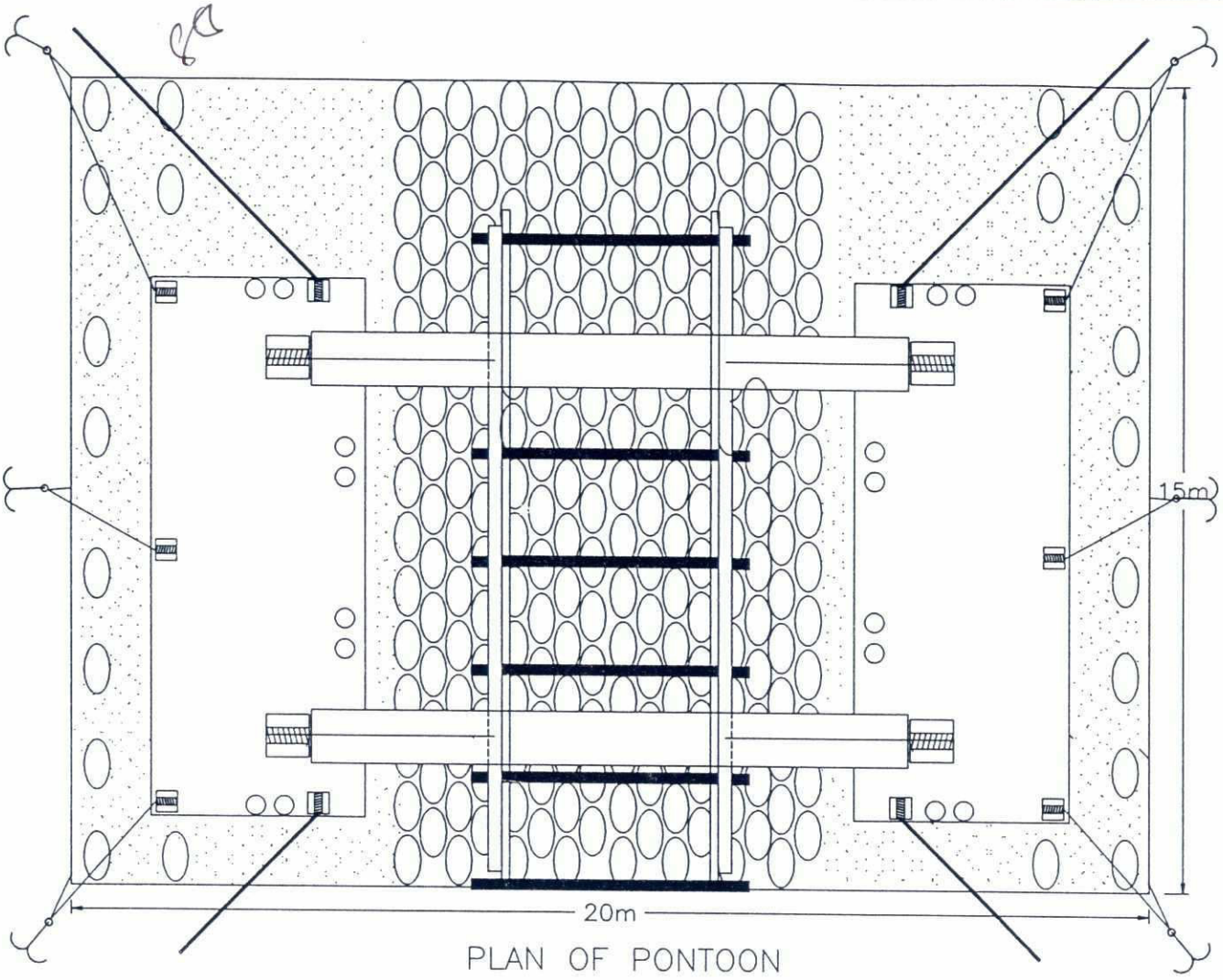


PLAN OF PONTOON

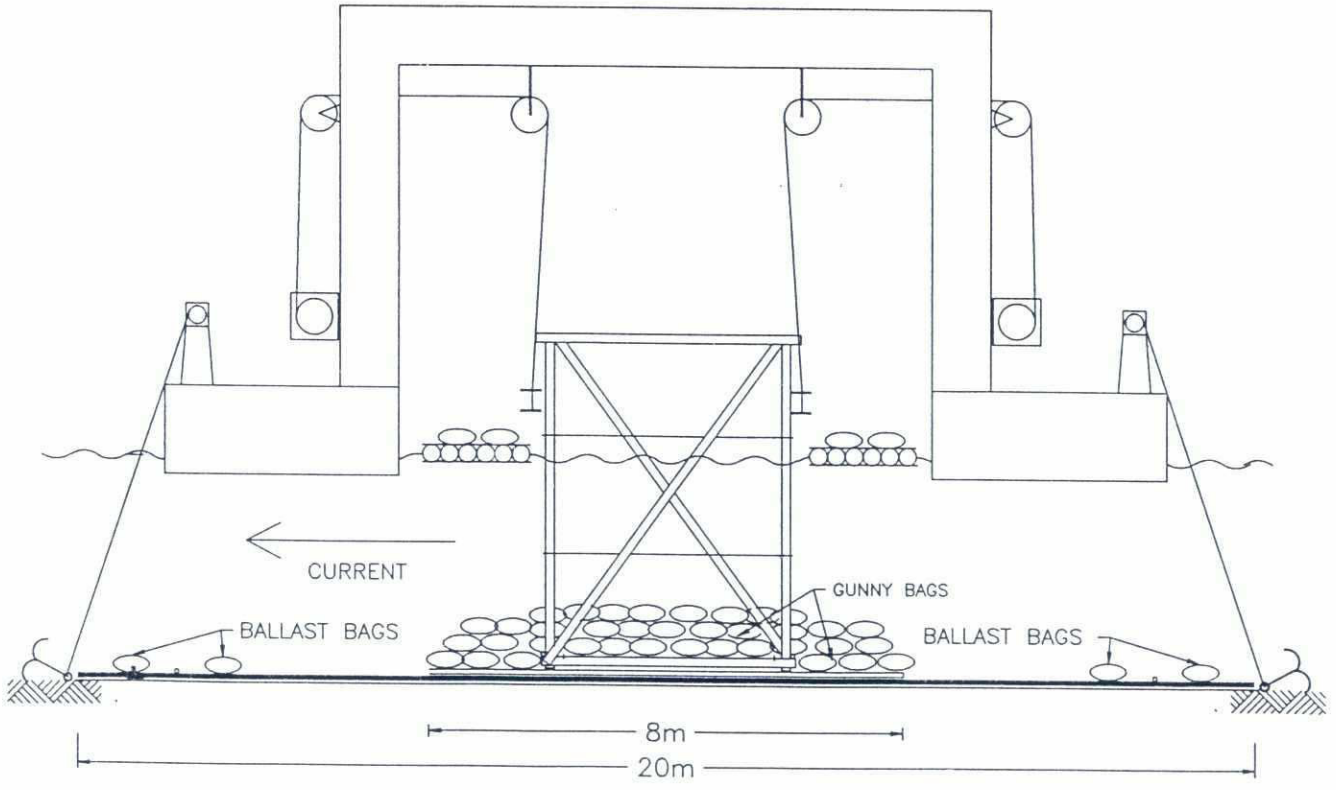


FRONT VIEW

Figure 3.10: Lowering caisson and positioning downstream end of Geo-Textile

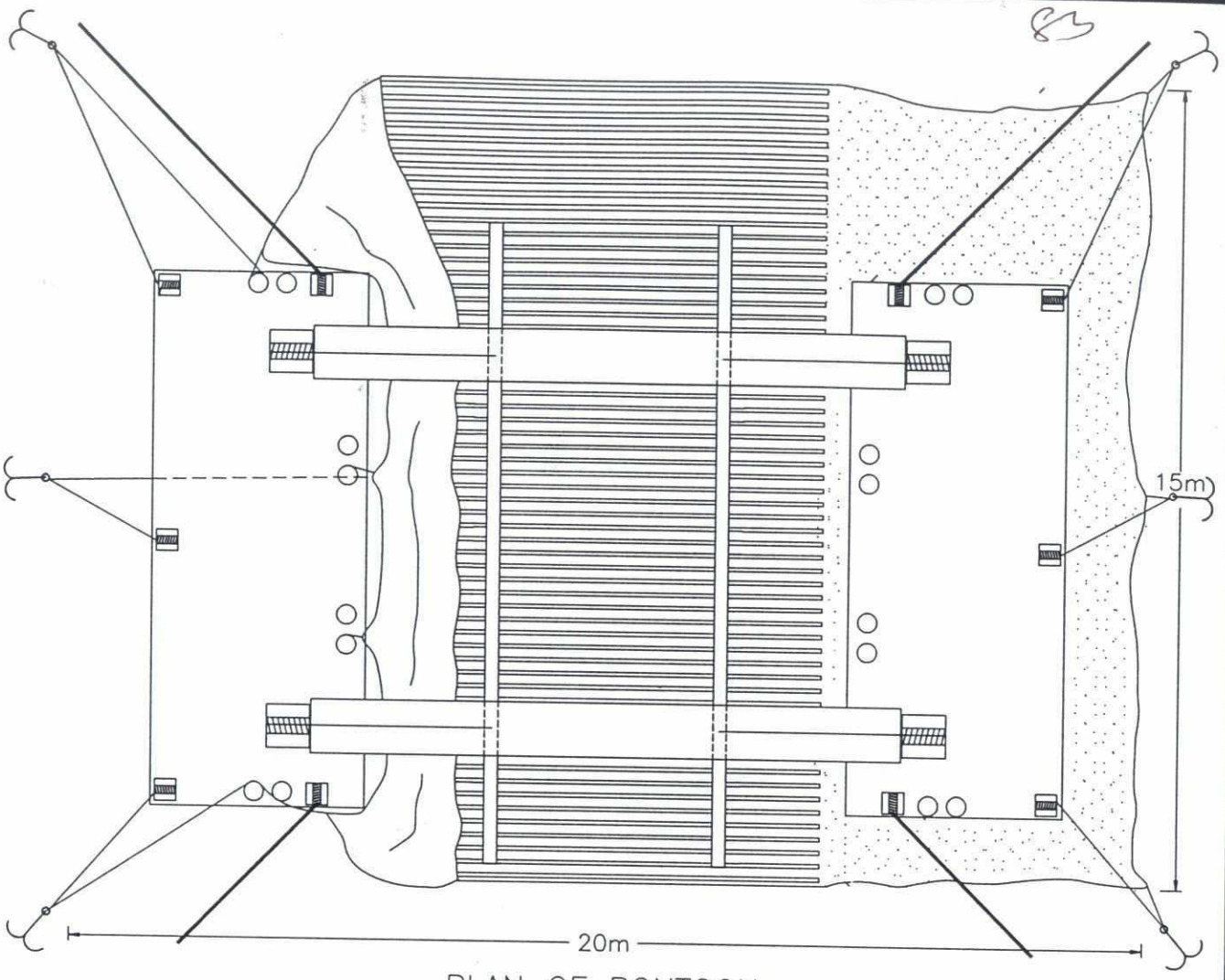


PLAN OF PONTOON

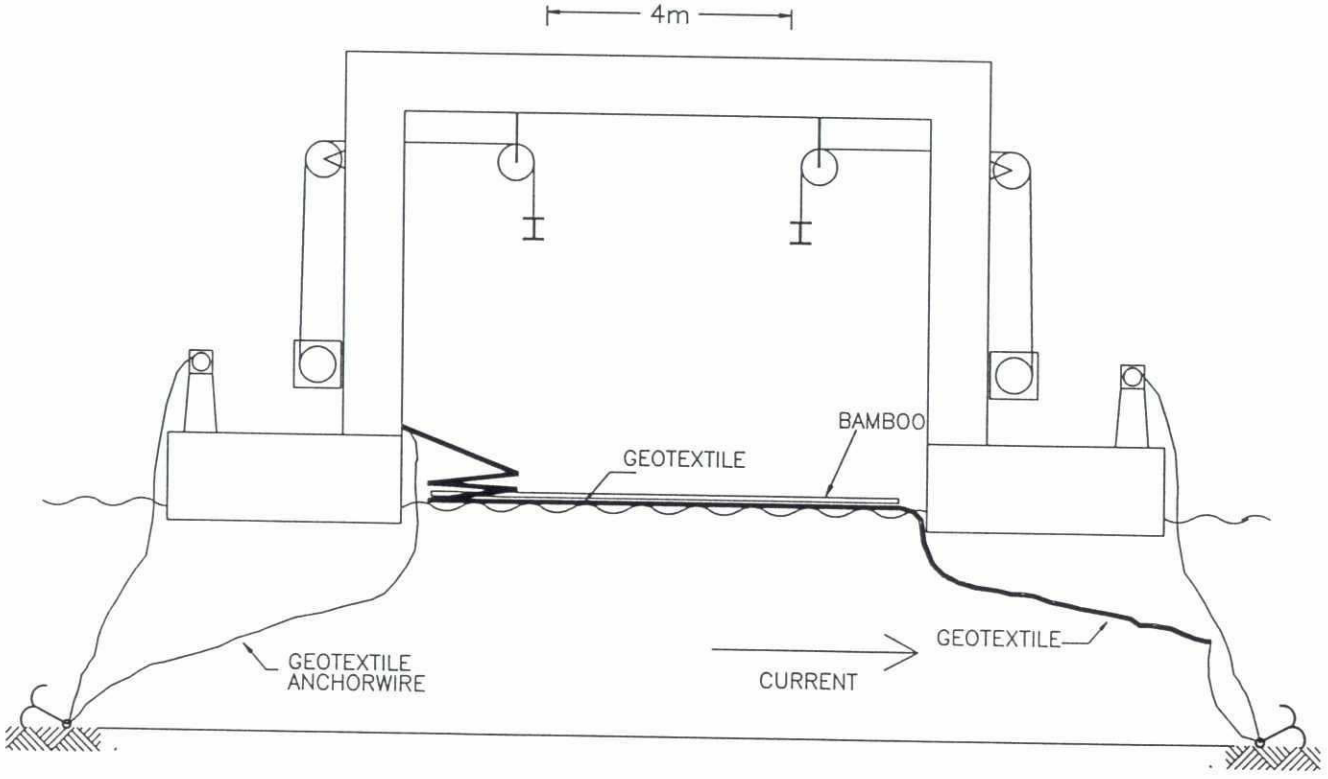


FRONT VIEW

Figure 3.11: Dumping gunnybags and positioning of other end of Geo-Textile

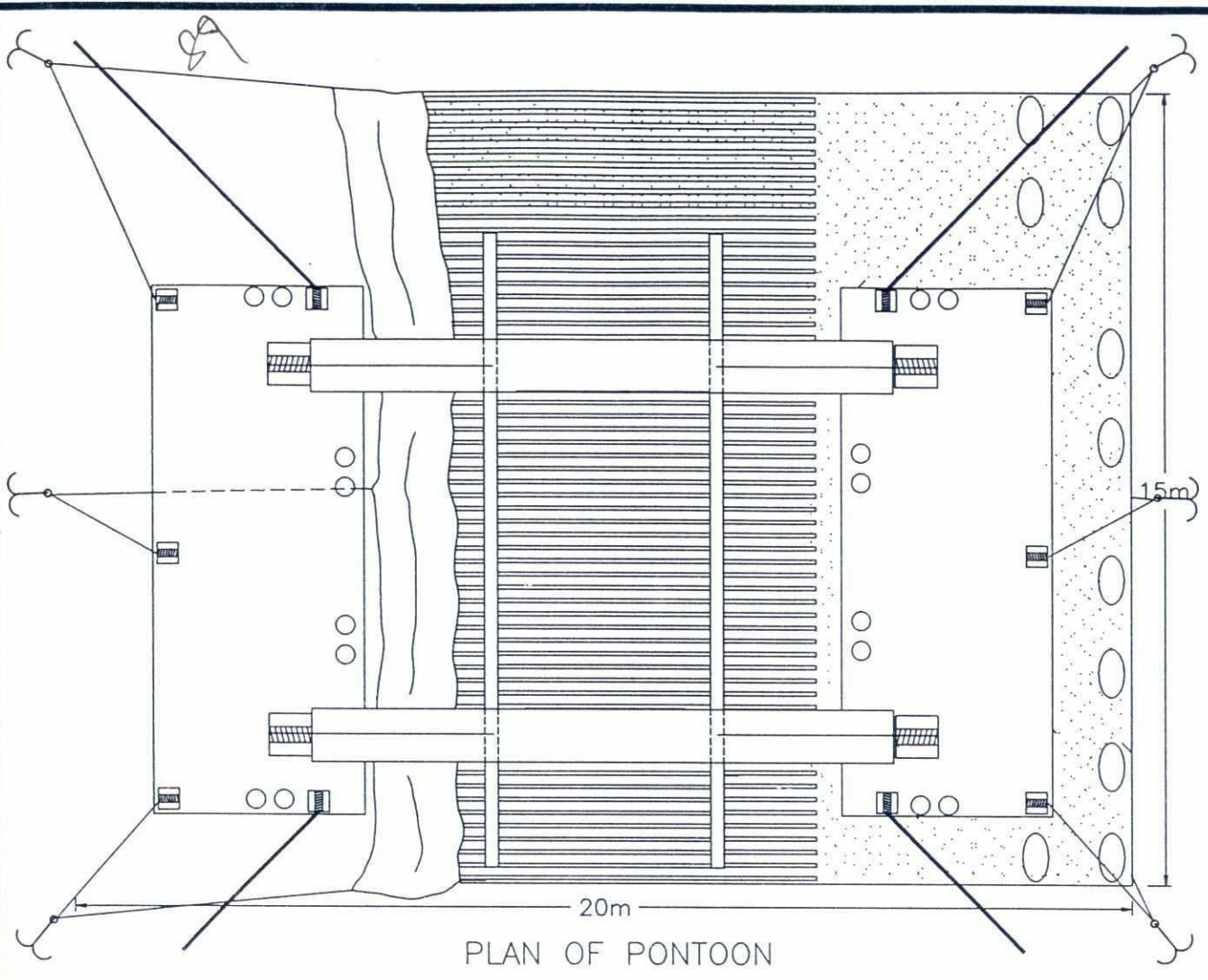


PLAN OF PONTOON

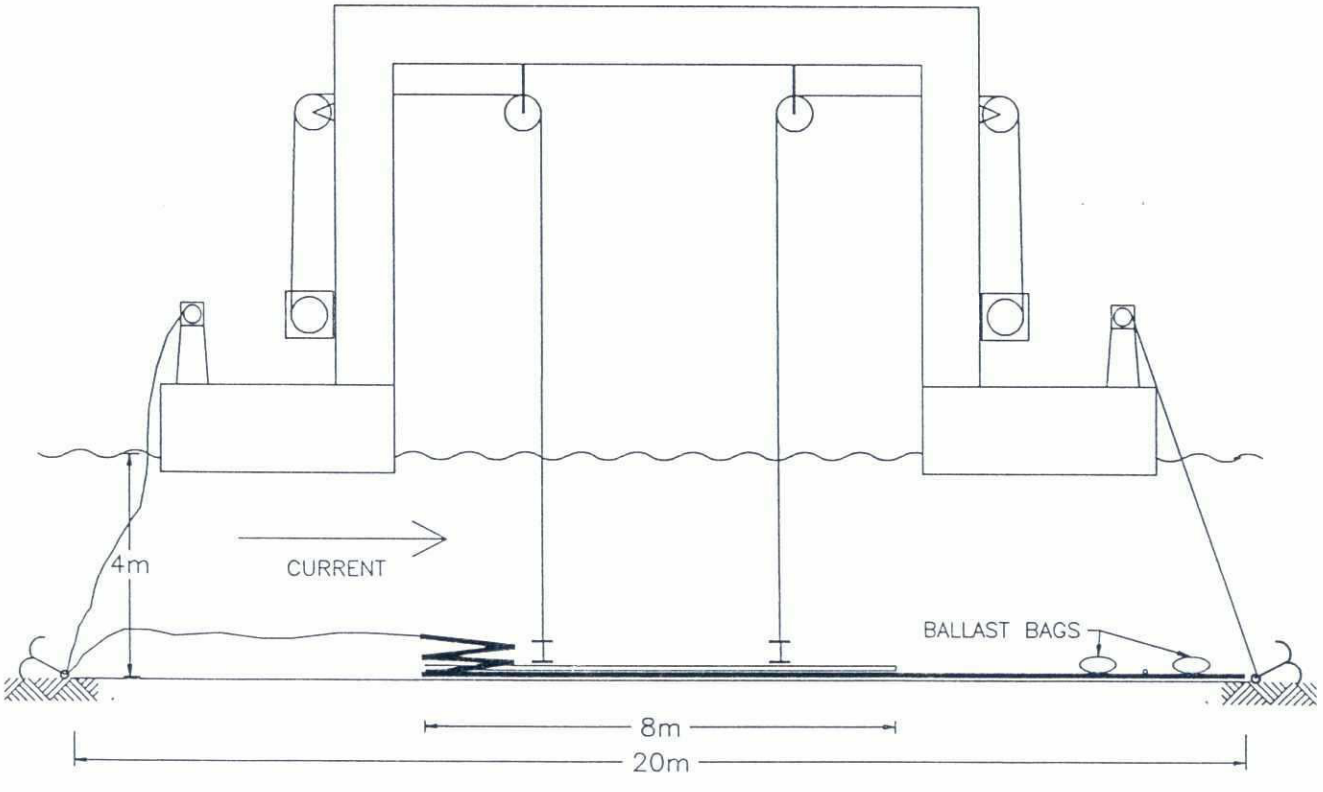


FRONT VIEW

Figure 3.12: Float geotextile inside THP



PLAN OF PONTOON



FRONT VIEW

Figure 3.13: Lowering Geo-Textile and positioning downstream end

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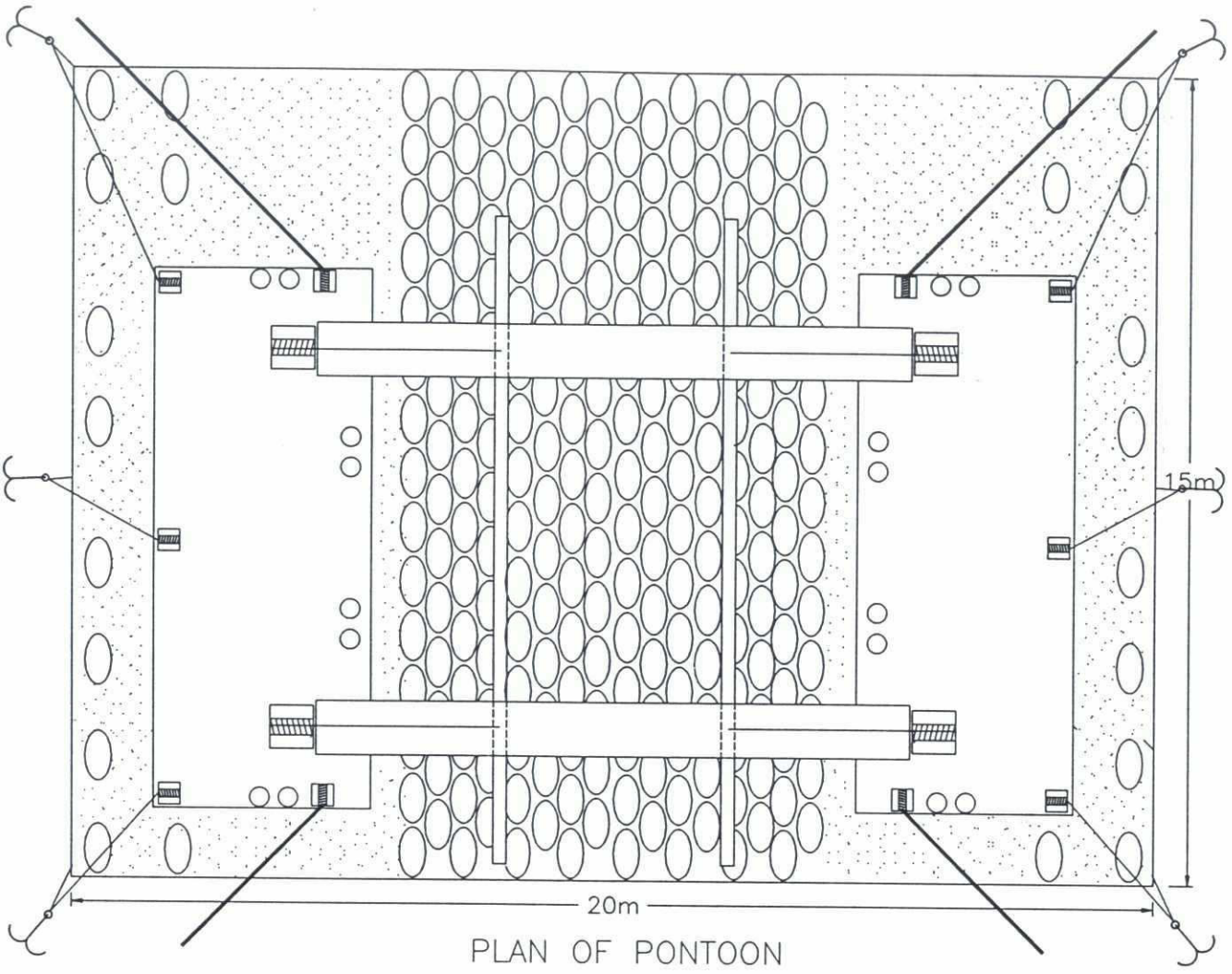
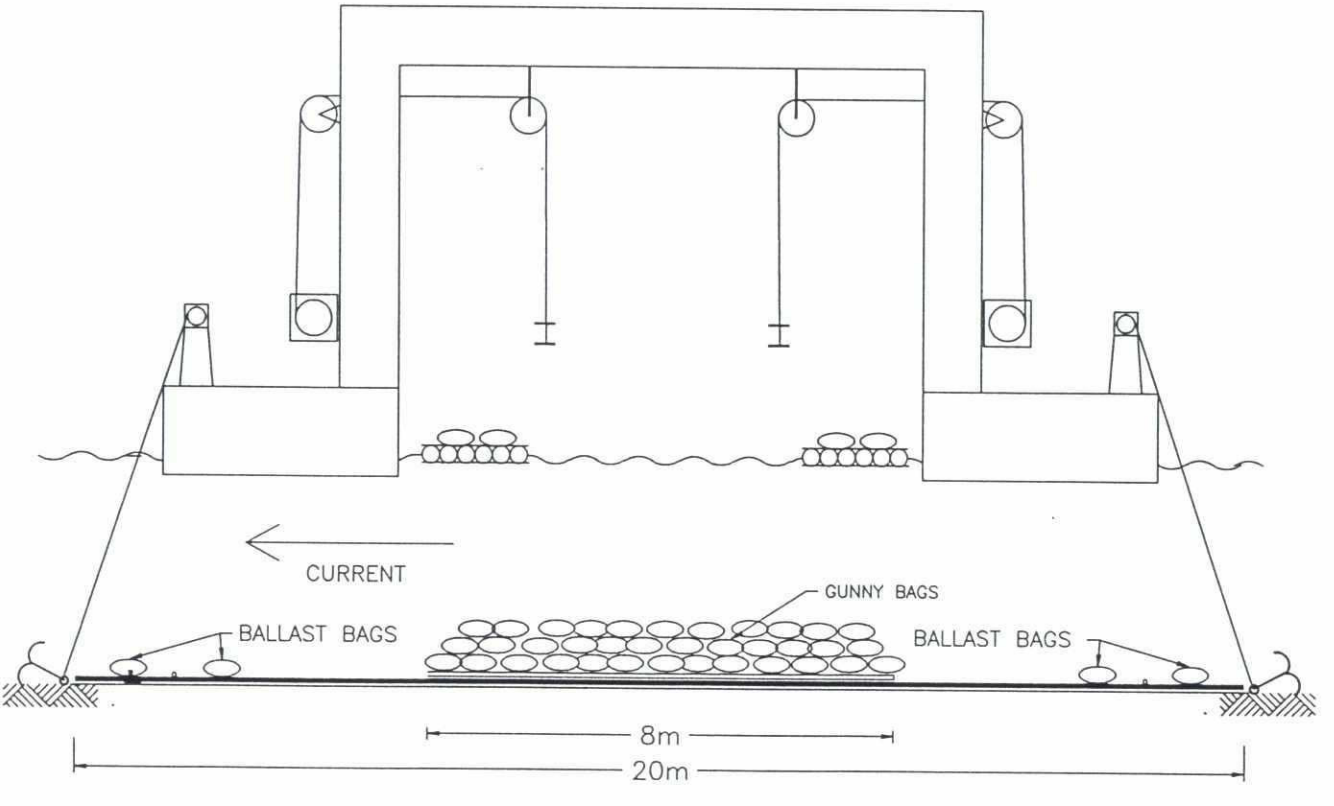


PLAN OF PONTOON



FRONT VIEW

Figure 3.14: Dumping gunnybags and positioning of other end of Geo-Textile

Realised Erosion Protection at Haim Char

(scale 1:2000)

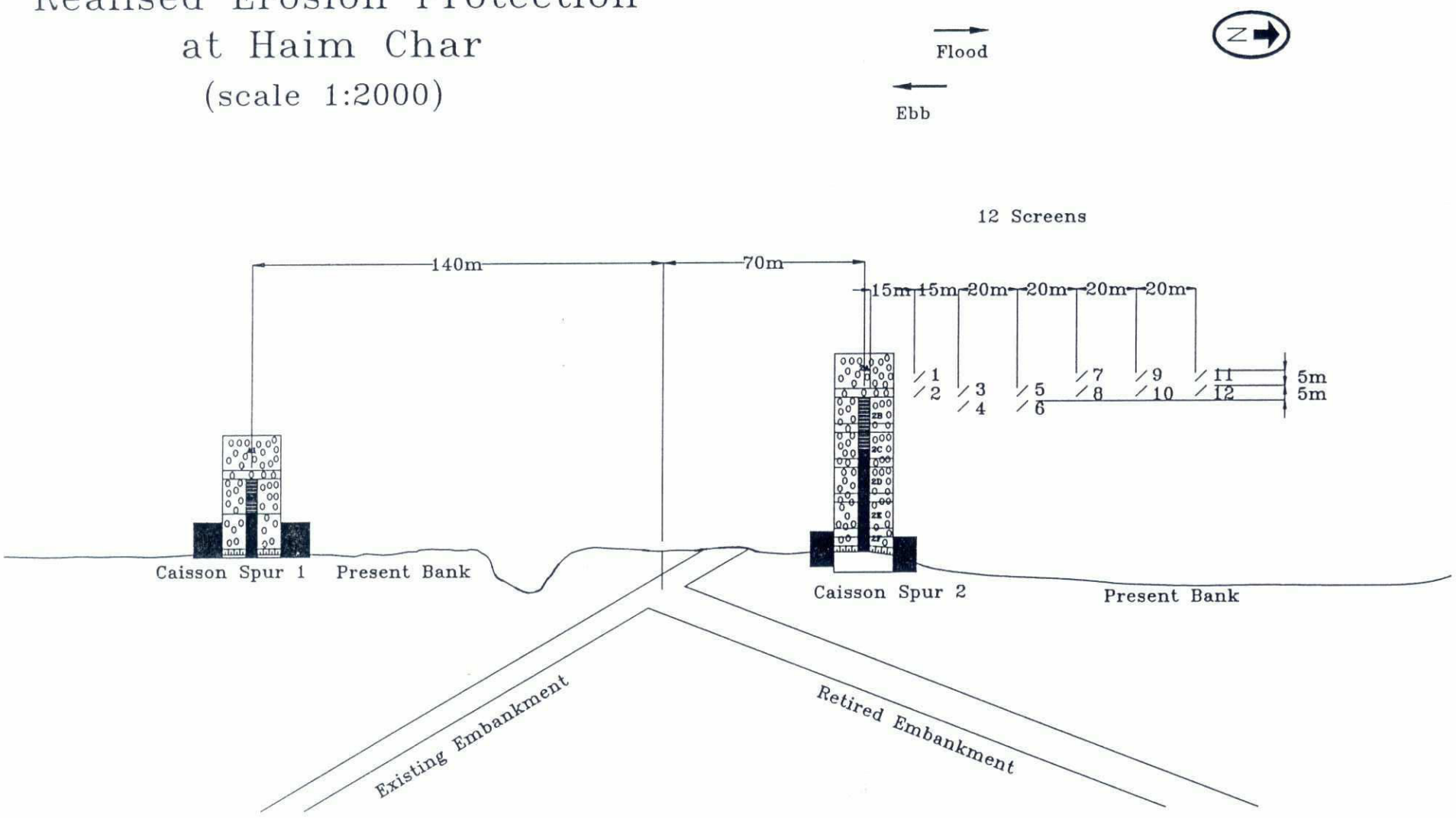


Figure 3.15

Realised Erosion Protection at Haim Char, Caisson Spur 1

(schaal 1:500)

SECTION	PART OF CAISSON SPUR	LxB (M)
1A	GEOTEXTILE MATTRESS	15 x 20
1B	CAISSON	12 x 4
1B	GEOTEXTILE MATTRESS	15 x 20
1C	GUNNY BAG DAM	15 x 4
1C	GEOTEXTILE MATTRESS	15 x 20
1D	PROFIX	12 x 4

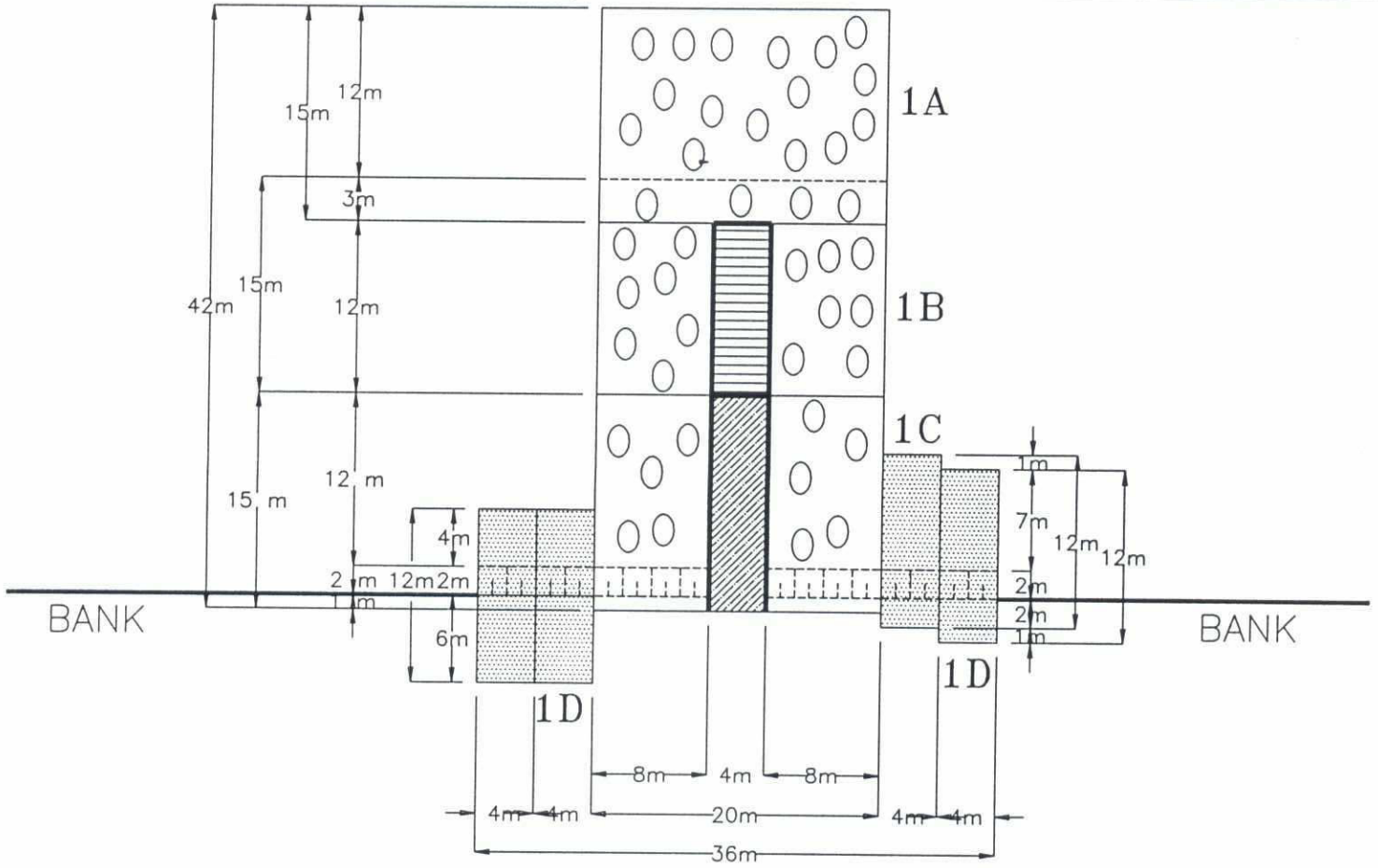
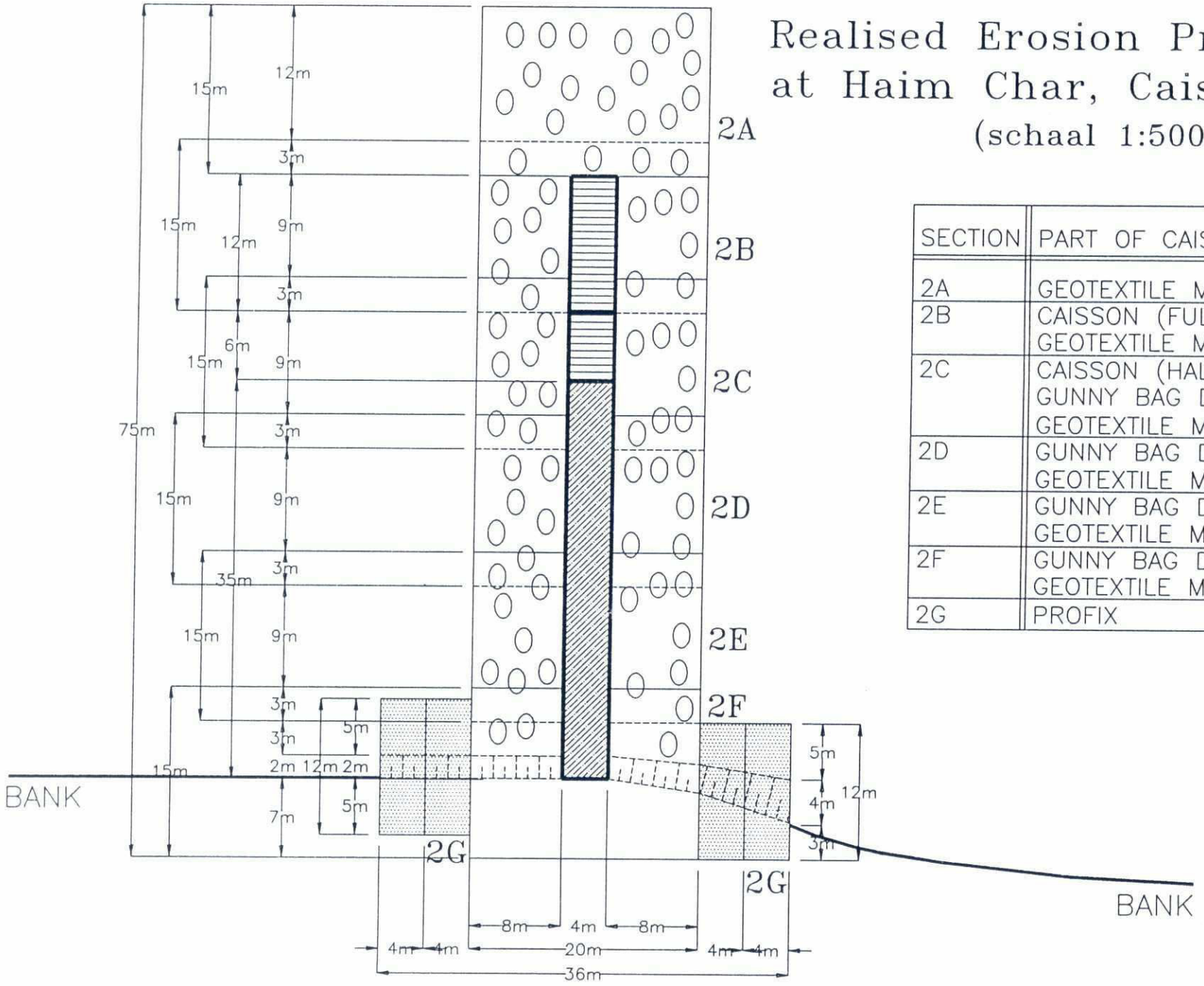


Figure 3.16

Realised Erosion Protection at Haim Char, Caisson Spur 2

(schaal 1:500)



SECTION	PART OF CAISSON SPUR	LxB (M)
2A	GEOTEXTILE MATTRESS	15 x 20
2B	CAISSON (FULL)	12 x 4
	GEOTEXTILE MATTRESS	15 x 20
2C	CAISSON (HALF)	6 x 4
	GUNNY BAG DAM (1)	6 x 4
	GEOTEXTILE MATTRESS	15 x 20
2D	GUNNY BAG DAM (2)	12 x 4
	GEOTEXTILE MATTRESS	15 x 4
2E	GUNNY BAG DAM (3)	12 x 4
	GEOTEXTILE MATTRESS	15 x 20
2F	GUNNY BAG DAM (4)	5 x 4
	GEOTEXTILE MATTRESS	15 x 20
2G	PROFIX	12 x4

Figure 3.17

ANNEXES

Annex A

Screen Installation Procedure

Screen Installation Procedure

1 Depth-measurements and checking riverbed

Equipment : country boat, bamboo-pole (8 meter), measuring tape, diving equipment
Duration : 2 hours

- Measure the depth at the installation site.
- Check the riverbed of the proposed installation site for debris like trees and remainder of buildings and bank protection.

Recommendation:
It is preferable to do the measurements and checking during slack water.

2 Position THP

Equipment : tugboat, engine boat, bullah pole, sledge hammer, 2 loudspeakers
Duration : 3 hours during slack water
Drawing number : 2.8

- Position THP with the tugboat.
- Construct anchor points on shore and fix the shore lines.
- Drop the anchors by engine boat.
- Pull the THP with the anchors at correct position.

Special attention:
Place the anchors at least 20-30 meter from THP.
Special problem:
The THP floats easily downstream, place extra anchor at upstream side.
Recommendation:
Place a buoy with flag above each anchor.

3 Load the anchors on auxiliary pontoon

Equipment : auxiliary pontoon, crane, pushcart, tripod, chain tackle
Duration : 12-16 complete anchors in a day

- Place the anchor base with the tripod on the pushcart.
- Push the car to the pontoon.
- Place the anchor base with the crane on the pontoon.
- Same for the anchor slab, place it with the crane on the anchor base.

4 Sew the RCC beam and floats in the screens and prepare them for transport

Equipment : needles, thread, frame, rope, tugboat, auxiliary pontoon(?), crane(?)
Duration : 2 days
Drawing number : 2.6

- Sew the floats in the screen.
- Sew the RCC beam in the screen.
- Roll the three floats in the screen and fix this with rope.
- Pull the screen in the river and transport it to THP.

Recommendation:
Consider if it is easier to transport the screens on the pontoon, instead of towing behind the tugboat.
Transport the screens when the tide is favourable.

5 Assemble the screen in the THP

Equipment : tugboat, auxiliary pontoon, chain tackles, shackles, 2 marker buoys
Duration : 1 hour
Drawing number : 2.9 till 2.13

- Sail the auxiliary pontoon with the tugboat in the THP.
- Lift two anchors from the pontoon and sail it out of the THP.
- Lower the anchors till the hook is just below the waterlevel.
- Fix the chain tackles with shackles to the lifting wires.
- Float the screen in the THP.
- Fix the screen with shackles to the anchors.
- Remove the ropes around the screen.
- Fix marker buoys to the anchors.

6 Lower the screen

Equipment : measuring rope (2 pieces),
mark-bamboo, diving equipment
Duration : Lowering : 15 minutes
Repositioning (5 meters) : 15 minutes
Repositioning (20 meters): 3 hours
Drawing number : 2.14 and 2.15

- Position the THP.
- Lower the complete screen to the riverbed.
- Detach the screen.
- Reposition THP for the next screen.

Annex B

Caisson Installation Procedure

Caissons Installation Procedure

1 Depth-measurements and checking riverbed

Equipment : country boat, bamboo-pole (8 meter), measuring tape, diving equipment
Duration : 2 hours

- Measure the depth at the installation site.
- Take 11 lines perpendicular on the shore, with 5 meter between them. Take lines of 50 meter and measure-points each 2 meter.
- Make a scaled drawing of the center line.
- Check the riverbed of the proposed installation site for debris like trees and remainder of buildings and bank protection.

Recommendation:
It is preferable to do the measurements and checking during slack water.
Fix a rope (with knots each 2 meter) on shore.

2 Position THP for part 1B of the caisson spur

Equipment : tugboat, engine boat, bullah pole, sledge hammer, 2 loudspeakers
Duration : 3 hour during slack water
Drawing number : 3.5 and 3.16

- Position THP with the tugboat.
- Construct anchor points on shore and fix the shore lines.
- Drop the anchors by engine boat.
- Pull the THP with the anchors at correct position.

Special problem:
Place the anchors at least 20-30 meter from the pontoon.
The THP floats easily downstream, place extra anchor at upstream side.
Recommendation:
Place a buoy with flag above each anchor.

3 Lift side panels

Equipment : pulling-ropes, fixing-ropes
Duration : 2 hour
Drawing number : 3.7

- Float 2 side-panels with pulling-ropes in the THP
- Connect them with fixing-ropes to the lifting-frame. (As close as possible to the second horizontal bamboo counted from above)
- Lift the side-panels.
- Do the same with the other 2 side-panels.

How to speed up:
Put 3 laborers on every winch and lead the people from THP.
Transport the panels and the geotextile when the tide is favourable.

4 Fix pulleys on side panels

Equipment : pulleys, rope (d=20 mm)
Duration : 10 minutes
- Fix the hook of the pulleys on left side-panel.
- Attach a rope on the right side of THP.
- Pull the other end trough the pulleys.
- Bring this end to the right side of THP.
- Do the same with the right side panel.

Attention-point:
Give the laborers rope that is not to thick for the pulleys.
How to speed up:
Start fixing the pulleys during lifting the panels.
Use rafts instead of climbing in the panels.

5 Assemble the caisson

Equipment : pulleys, rope (d=20 mm), 2 electric drills, generator, nuts and bolts
Duration : 5 hours
Drawing number : 3.8
- Pull side panels together.
- Fix all bottom bars first with ropes.
- Pull the upper end of side panels together (use pulleys).
- Fix upper bars also first with ropes.
- Attach diagonals.
- Exchange rope-connection for nut-bolt-connection.

How to speed up:
Use two or three electric drills.

6 Bring geotextile (1B) under the caisson

Equipment : ropes, diving equipment
Duration : 2 hours (finish before slack water!)
Drawing number : 3.9 and 3.16
- Pull the anchor wires trough the pulleys on the anchors (both sides).
- Place the anchors and fix two geobags on the anchors.
- Fix the wire-end on deck of THP.
- Float the geotextile in the right position before the caisson.
- Pull it under the caisson and stretch it as much as possible.
- Upstream side: Fix side flap on deck of THP.
- Downstream side: Fix the anchor wires on the geotextile and strech the side flap.

Special attention:
Make sure the geotextile is folded on shore in the right way.
Stretch the geotextile under the caisson spur as much as possible.

7 Lower the caisson, fix geobags and anchors

Equipment : divers, rafts and geobags, anchors with geobags
2 loudspeakers
Duration : 3 hours (during slack water!)
Drawing number : 3.10, 3.11 and 3.16
- Putt geobags in the side panels to make it heavier.
- Lower the spur steadily.
- Pull with the winches the side flaps outward.
- Drop gunny bags in and next to the caisson.
- Divers: Pull the geotextile flat and fix 2 rows of geobags at the edge.
- Fix the anchors.
- When the current has turned the same has to be done with the other side flap.

Special attention:
For safety of the divers, make sure there are no bags dropped where they are working!

8 Move THP and prepare geotextile (1A) in front of the caisson spur for lowering

Equipment : ropes, divers, engine boat
Duration : 2 hours (finish before slack water!)
Drawing number : 3.12 and 3.16
- Move bullah-poles and anchors.
- Bring THP in correct position for part 1A of the caisson spur.
- Pull the anchor wires trough the pulleys on the anchors (both sides).
- Place the anchors and fix two geobags on the anchors.
- Fix the wire-end on deck of THP.
- Float the geotextile in the right position in the THP.
- Unroll it and stretch it as much as possible.
- Upstream side: Fix side flap on deck of THP.
- Downstream side: Fix the anchor wires on the geotextile and strech the side flap.

Special attention:
Make sure the geotextile is folded on shore in the right way.
Stretch the geotextile as much as possible.
Recommendation:
To stretch the geotextile, the eyes on the lifting beam could be used.

9 Place geotextile (1A) in front of caisson spur, fix geobags and anchors

Equipment : divers, rafts and geobags, anchors with geobags,
2 loudspeakers
Duration : 3 hours (during slack water!)
Drawing number : 3.13 and 3.14
- Lower the geotextile with the lifting beams steadily.
- Pull with the winches the side flaps outward.
- Drop gunny bags on the geotextile.
- Divers: Pull the geotextile flat and fix 2 rows of geobags at the edge.
- Fix the anchors.
- When the current has turned the same has to be done with the other side flap.

Special attention:
For safety of the divers, make sure there are no bags dropped where they are working!

10 Place geotextile (1C) at the slope

Equipment : gunnybags, geobags
Duration : 1.5 day
Drawing number : 3.16
- Make a slope at the water board for the geotextile, 20 meter wide.
- Unroll the geotextile.
- Drop geo- and gunnybags at the edges to prevent folding of the geotextile.

Recommendation:
Construct a kind of step to prevent the people from slipping.
Special attention:
Control during low tide whether or the geotextile is folded, if so: remove bags and stretch it again.

11 Construct the gunny bag dam , part 1C of the caisson spur

Equipment : gunnybags, geotextile, geobags, concrete blocks, pontoon
Duration : 1.5 day
Drawing number : 3.3 and 3.16
- Construct the dam between caisson and the shore.
- Cover the dam with geotextile.
- Fix this geotextile to the geotextile on the river bed (Above the water by sewing, under water by ropes).
- Fix geobags on the geotextile.
- Place concrete blocks on the dam and also in front of, next to and inside the caisson.

12 Install the ProFix, part 1D of the caisson spur

Equipment : pump, pipe (5 meter long, diameter 0.15 meter)
Duration : sewing and preparing slope : 4 hours per piece
filling : 8 hours per piece
Drawing number : 3.16
- Prepare slope for the ProFix.
- Sew the ProFix.
- Putt the pipe in the slit.
- Fill it by putting sand and water in the pipe.

Annex C

Required labour for screens

Required labour for assembling screens

Action	Nr /screen	Production per day	Labour required		Mandays/ screen	
			Skilled	Unskil.	Skilled	Unskil.
Screen						
Cut geotextile for screen						
Sow rope in edges of textile						
Attach floats to textile						
Fix PVC strips						
Transport to assemble site	1	0.5	2	0.5	4	1
Beam						
Assemble beam reinforcement	1	10	5	5	0.5	0.5
Position reinforcement in PVC pipe						
Put PVC pipe upright						
Seal bottom end						
Mix concrete						
Pour concrete in PVC pipe	1	10	6	12	0.6	1.2
Harden concrete						
Transport to assemble site	1	20		10	0	0.5
Anchor base						
Assemble anchor base reinforcement	4	10	4	4	1.6	1.6
Assemble anchor base casing						
Assemble anchor slab reinforcement						
Assemble anchor slab casing						
Mix concrete						
Pour concrete in casing	4	10	6	11	2.4	4.4
Harden concrete						
Transport to assemble site	4	20		10	0	2
Assembling						
Place beam on geotextile screen	1	20	0	14	0	0.7
Fix beam to geotextile	1	1	2		2	0
Position anchor base on AP						
Place anchor slab on anchor base	1	16	4	6	0.25	0.375
Place geotextile screen on AP	1	20	0	14	0	0.7

Total labour required for assembling 1 screen	**Skilled**	**Unskil.**
	11	**13**

Required labour for installation of screens

Action	Nr /screen	Production per day	Labour required		Mandays/ screen	
			Skilled	Unskil.	Skilled	Unskil.
Auxiliary pontoon (AP)						
Place screen elements on AP						
Assemble two screens on AP						
Tow AP to THP						
Moore AP inside THP						
Unload screens						
Tow AP to Landing						
Position AP near assembly yard						
Twin Hull Pontoon (THP)						
Place anchors						
Construct anchor point on shore						
Position THP at correct position						
Moore AP inside THP						
Lower lifting frames						
Attach RCC beams to lifting frames						
Lift beams						
Attach anchor slab to RCC beam						
Lift anchor slab & RCC beam from AP						
Remove AP						
Lower screens to river bed						
Detach lifting frame						
Raise lifting frame						
Reposition THP	1	4	10	15	2.5	3.75

Total labour required to install 1 screen	**Skilled**	**Unskil.**
	3	**4**

Annex D

Required labour for spurs

Required labour for assembling of spurs+A108

Action	Nr /spur	Production per day	Labour required		Mandays/ screen	
			Skilled	Unskil.	Skilled	Unskil.
Panels						
Assemble side frame section						
Attach bullah diagonals						
Attach bullah bottom beam	6	1	2	10	12	60
Transport to THP	6	10		10	0	6
Geo-textile foundation						
Cut geo-textile for foundation						
Sow geo-textile together	4	0.5	10		80	0
Attach bamboo to textile	2	1	1	5	2	10
Transport to THP	4	10		10	0	4
Concrete blocks						
Assemble casting frame & hook						
Mix concrete						
Pour concrete in casing	40	20	5	5	10	10
Harden concrete						
Transport to installation site	40	20		2	0	4
Geo bags						
Cut geotextile for gunny bags						
Sow textile into bags	150	10	1	0	15	0
Fill bags with earth	150	35	0	1	0	4.3
Transport to installation site	150	200		10	0	7.5
Gunny bags						
Fill bags with earth	4500	35	0	1	0	128.6
Transport to installation site						

Total labour required for assembling 1 spur	**Skilled**	**Unskil.**
	119	**234**

Required labour for installation of spurs

Action	Nr /spur	Production per day	Labour required Skilled	Unskil.	Mandays/ screen Skilled	Unskil.
THP						
Position THP at installation site						
Place anchors						
Construct anchor point on shore						
Position THP at correct position						
Anchor blocks						
Transport anchor blocks to THP						
Lift anchor blocks with lifting boom						
Attach anchor wire to anchor blocks						
Place anchor blocks						
Side panel						
Float side panel inside THP						
Lower lifting frame						
Attach side panel to lifting frame						
Lift frame						
Geo-textile base						
Float geotextile inside THP						
Lower side frames						
Fix side panels to geotextile						
Fix bottom beams and diagonals						
Attach anchor block wires to geotextile						
Place gunny bags in base of caisson						
Lower caisson to riverbed						
Pull geotextile to anchor blocks						
Ballast						
Transport ballast bags to THP						
Place ballast bags on geotextile						
Transport concrete blocks to THP						
Place concrete blocks on geotextile	2	1	20	15	40	30
Geo-textile on shore						
Adjust bank slope						
Spread geo-textile						
Fix geo-bags						
Fix geotextile on shore	2	1	2	10	4	20
Pro-Fix						
Place Profix at installation site						
Cut Pro-Fix in appropiate size						
Fill Profix with sand						
Re-profile river bank	4	0.5	2	6	16	48

Total labour required to install 1 spur	**Skilled**	**Unskil.**
	60	**98**

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Annex E

Costs calculation principles

General

The cost estimate for the innovative bank protection schemes is set-up according to the guidelines described in the "Flood Action Plan; Guidelines for Project Assessment" . The guidelines recommend a breakdown of the base costs into the following items:

1. person power
2. materials
3. equipment
4. other

Costs of local labour and materials is based on the BWDB Standard Schedules of rates for the Bhola W.D. Circle (1995). These rates include:

1. site overhead
2. profit and risk of the contractor
3. taxes

The standard rates have been increased by 100% to account for the following:

1. Inflation since 1995
2. Costs for transport and accommodation of labour, as some labour will have to be hired from outside of the project area
3. Costs for transport of materials to the project location, as materials will have to be acquired from outside of the area

The rates for hiring equipment are based on experience gained during the Char Alexander and Khorki Bank Protection Pilot Schemes.

Person power

Three types of person power can be distinguished:

1. management and supervision
2. skilled labour
3. unskilled labour

Management and supervision

Management and supervision staff consist of a team manager (1000 Tk/day), site engineers (750 Tk/day) and fore men (400 Tk/day).

Skilled labour

Skilled labour are for instance concrete workers to build the concrete anchors, operators of equipment and textile workers. Rates for skilled labour vary from 200 to 300 Tk/day. The rate for divers (1000 Tk/day) includes the use of professional diving equipment

Unskilled labour
Unskilled labour will be used to fill the ballast bags and to place them in the bank protection scheme. Rates for unskilled labour are estimated on 100 Tk/day.

Materials

The main construction materials are:
1. Geotextile for screens, bed protection and ballast bags
2. PVC pipes for screen floats
3. Concrete for beams and anchors
4. Bamboo and bullah poles for caissons
5. Earth filled gunny bags

Geotextile for screens, bed protection and ballast bags
The geotextile will have to be imported from outside Bangladesh. Based on a quotation for material used for the pilot schemes the following rates are applied:

- Propex 6288 for screens and cross-dam cover 2.0 US$/m^2
- Propex 6284 with non-woven layer for caisson foundation 2.5 US$/m^2
- Propex 6282 with non-woven layer for ballast bags 2.0 US$/m^2
- Profix 82/86/40/30 for bed protection 7.0 US$/m^2

All rates are including transportation costs. Import tax of 72 % have been added separately in local currency (Tk).

PVC pipes
The PVC pipes will be prefabricated in the factory. The floats consist of 5,2 m 8" PVC pipes sealed off at both ends. The quotation of the factory was about 6.000 taka per pipe. The open ended PVC pipe used for the beam is quoted for 3500 taka per pipe.

Concrete for beam and anchors
The cost of reinforced concrete is estimated to be about 10.000 Tk/m3. Based on a quotation for material used for the pilot schemes the following rates are applied:

- RCC beams 520 * 6" diameter 3500 Tk
- RCC anchor slabs 150*150*12.5 3000 Tk
- CC ballast blocks 40*40*40 400 Tk

Bamboo and bullah poles
Bamboo and bullah poles will be used to construct the box-type caissons. As it is expected that there will not be sufficient bamboo and bullah poles available near the installation site, transportation costs have to be incorporated in the costs. The cost of a 6 m, 6 inch bamboo pole, including transportation costs, is estimated to be 180 Tk/pole. Bullah poles with a diameter of 15 cm are estimated to cost 320 Tk/m.

Earth filled gunny bags
Earth filled gunny bags will be used as core material of the cross-dam. While the second hand gunny bags could in principle be used, the time required to collect such quantity on the "thin" second-hand market would be excessive. It is therefore assumed that new gunny bags will be used. The cost for new gunny bags with a capacity of 50 kg is estimated to be 20 Tk/bag. This price includes the costs of the earth-filling but excludes the labour cost to fill and place the bags.

Equipment

The main equipment to be used shall be:
1. Installation pontoon
2. Auxiliary pontoon
3. Tugboats
4. Engine boats
5. Mobile crane

Installation pontoon
A custom made steel pontoon will be used to assemble and install the bamboo caissons and to install the screens. The total cost of building such a pontoon is estimated to be 7.000.000 Tk. Considering a depreciation rate of 10% per year, annual maintenance costs of 50.000 Tk and an effective use of 150 days per year, the day rate of the installation pontoon is 5.000 tk/day.

Auxiliary pontoon
An auxiliary pontoon will be used for transportation of materials and to assist with the installation of the screens. The day rate of an 16 meter long, 6 meter wide pontoon is about 3.000 Tk/day

Tugboat
Tug boats will be required to position the installation pontoon and move the mooring anchors. The rate for renting a tugboat is estimated to be 10.000 Tk/day.

Engine boat
Engine boats will be used transport construction materials and labour to the work site and installation pontoon. Engine boats can be rented for 3.000 Tk/day.

Mobile crane
Mobile cranes will be used for lifting and transport of concrete blocks and The rate for renting a mobile crane with a 3 ton lifting capacity is estimated to be 5.000 Tk/day.

Annex F

Cost calculation for screens

Screens

Exchange rate	46	Tk/US$
Taxes on import	72	%

Required materials		1 unit	Unit price	Unit	Costs [Tk]	Costs [US$]
Screens		*1*				
Screen	Propex 6288	42	2.0	US$/m2	2,756	83
PVC pipes	PVC pipes; double sealed	3	6,000	Tk/pc	18,000	
PVC pipes	PVC pipes; open end	1	3,500	Tk/pc	3,500	
PVC rods	PVC, 21,5 diameter	4	600	Tk/pc	2,400	
Beam	Reinforced concrete with anchor hook	1	3,500	Tk/pc	3,500	
Anchor blocks	Reinforced concrete with anchor hook	4	3,000	Tk/pc	12,000	
Sewing material	Polyester yarn	200	0.05	US$/m	331	10
					42,487	93
					46,774	**Tk**

Equipment	Specification	Nr. / operation	Duration operation	Total [days]	Price [Tk/day]	Total [Tk]
THP		1.0	0.25	0.25	5,000	1,250
Pontoon		1.0	0.25	0.25	3,000	750
Tugboat		1.0	0.25	0.25	10,000	2,500
Engine boat		1.0	0.25	0.25	1,000	250
Crane		1.0	0.25	0.25	5,000	1,250
						6,000

Manpower	Specification	Nr. / operation	Duration operation	Total [day]	Price [Tk/dy]	Total [Tk]
Team manager		1.0	0.25	0.25	1,000	250
Site engineer		1.0	0.25	1	750	750
Fore man		4.0	0.25	1	400	400
Diver		1.0	0.25	1	1,000	1,000
Skilled labour	See Annex C	14.0	1	14	200	2,800
Unskilled labour	See Annex C	17.0	1	17	100	1,700
						6,900

Summary

Materials	46,774	Tk
Equipment	6,000	Tk
Manpower	6,900	Tk
Costs of 1 screen	**59,674**	**Tk**

Annex G

Cost calculation for spurs

Spurs

Exchange rate 46 Tk/US$
Taxes on import 72 %

Required materials		1 unit	1 spur		Conversion	Unit	Quantity	Unit price	Unit	Costs [Tk]	Costs [NLG]
Caissons		*1*	*6*	*pannels*							
Bullah	Cross beam (4 meter)	4	24	pc	4.0	m	96	325	Tk/m	31,200	
	Side pannel (6 meter)	6	36	pc	6.0	m	216	325	Tk/m	70,200	
	Diagonal (7 meter)	4	24	pc	7.0	m	168	325	Tk/m	54,600	
							480				
Bamboo	Side pannel (6 meter)	20	120	pc	1.0	pc	120	180	Tk/pc	21,600	
	Diagonal (8 meter)	2	8	pc	1.0	pc	8	180	Tk/pc	1,440	
Mattresses		*1*	*4*	*mattresses*							
ProPex 6284 + RIG EDY 200.1	Foundation of caisson	60	240	m	5.2	m2	1,248	2.5	US$/m2	103,334	3,120
Propex 6282	Ballast bags	150	600	pc	0.8	m2	471	2.0	US$/m2	31,215	942
Gunny bags	Impact protection layer	480	1,920	pc	1.0	-	1,920	20	Tk/pc	38,400	
cc blocks	Armour for spurs	48	192	m3	10.0	nr	1,920	400	Tk/pc	768,000	
Bamboo	Base (8 meter)	60	240	pc	1.0	-	240	180	Tk/pc	43,200	
	Bottom protection (8 meter)	12	48	pc	1.0	-	48	180	Tk/pc	8,640	
Spur		*1*	*1*	*spurs*							
Gunny bags	Connection dam	2,400	2,400	pc	1.0		2,400	20	Tk/pc	48,000	
ProFix	Bed protection at tip of spur	250	250	m2	0.7		175	7	US$/m2	40,572	1,225
Sand	Fill for ProFix	25	25	m3	1.0		25	350	Tk/m3	8,750	
										1,269,151	5,287
										1,512,375 Tk	

Equipment	Specification	Nr. / operation	Duration operation	Total [days]	Price [Tk/day]	Total [Tk]
THP		1.0	3	3	5,000	15,000
Pontoon		2.0	3	6	3,000	18,000
Tugboat		1.0	3	3	10,000	30,000
Engine boat		1.0	3	3	1,000	3,000
Crane		1.0	3	3	5,000	15,000
						81,000

Spurs

Manpower	Specification	Nr. / operatio	Duration operatio	Total [day]	Price [Tk/dy]	Total [Tk]
Team manager		1.0	3	3	1,000	3,000
Site engineer		1.0	3	3	750	2,250
Fore man		4.0	3	12	400	4,800
Diver		4.0	3	12	1,000	12,000
Skilled labour	See annex D	179.0	1	179	200	35,800
Unskilled labour	See annex D	332.0	1	332	100	33,200
						91,050

Summary

Materials	1,512,375	Tk
Equipment	81,000	Tk
Manpower	91,050	Tk
Costs of 1 spur (18 m)	**1,684,425**	**Tk**

Annex H

Cost calculation for cross-dams

Cross-dam Caissons

Exchange rate 46 Tk/US$
Taxes on import 72 %

Materials		1 unit	1 caisson		Conversion	Unit	Quantity	Unit price	Unit	Costs [Tk]	Costs [US$]
Caissons		*1*	*4*	*pannels*							
Bullah	Cross beam (4 meter)	4	16	pc	4.0	m	64	320	Tk/m	20,480	
	Side pannel (6 meter)	6	24	pc	6.0	m	144	320	Tk/m	46,080	
	Diagonal (7 meter)	4	16	pc	7.0	m	112	320	Tk/m	35,840	
Bamboo	Side pannel	20	80	pc	1.0	-	80	180	Tk/pc	14,400	
	Diagonal	2	8	pc	1.0	-	8	180	Tk/pc	1,440	
Mattresses		*1*	*1*	*caisson*							
ProPex 6284 + RIG EDY 200.1	Foundation of caisson	60	60	m	5.2	m2	312	2.5	US$/m2	25,834	780
Propex 6288	Cover of crossdam	45	45	m	5.2	m2	234	2.0	US$/m2	15,500	468
Propex 6282 + non-woven mat.	Ballast bags	150	150	pc	0.8	m2	118	2.0	US$/m2	7,804	236
Profix	Bed protection	180	180	m2	1.0	-	180	7.0	US$/m2	41,731	1,260
Sand	Fill for ProFix	42	42	m3	1.0	-	42	350	Tk/pc	14,844	
Gunny bags	Fill of caissons	11,520	11,520	pc	1.0	-	11,520	20	Tk/pc	230,400	
cc blocks	Armour for dam	48	48	m3	8.0	pc	384	400	Tk/pc	153,600	
Bamboo	Walkway	312	312	m	8.0	pc	39	180	Tk/pc	7,020	
	Base (8 meter)	60	60	pc	1.0	pc	60	180	Tk/pc	10,800	
	Bottom protection (8 meter)	12	12	pc	1.0	pc	12	180	Tk/pc	2,160	
										627,933	2,744
										754,139 Tk	

Equipment	Specification	Nr. / operation	Duration operation	Total [days]	Price [Tk/day]	Total [Tk]
THP		1.0	1	1	5,000	5,000
Pontoon		2.0	1	2	3,000	6,000
Tugboat		1.0	1	1	10,000	10,000
Engine boat		1.0	1	1	1,000	1,000
Crane		1.0	1	1	5,000	5,000
						27,000

Manpower	Specification	Nr. / operation	Duration operation	Total [day]	Price [Tk/dy]	Total [Tk]
Team manager		1.0	1.0	1	1,000	1,000
Site engineer		1.0	1.0	1	750	750
Fore man		4.0	1.0	4	400	1,600
Diver		4.0	1.0	4	1,000	4,000
Skilled labour		100.0	1.0	100	200	20,000
Unskilled labour		500.0	1.0	500	100	50,000
						77,350

Summary

Materials	754,139	Tk
Equipment	27,000	Tk
Manpower	77,350	Tk
Costs of 1 cross-dam section	**858,489**	**Tk**