APPENDIX B

TECHNICAL SPECIFICATIONS FOR CLOSURE METHODS

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TECHNICAL DETAILS

REFERENCE DRAWINGS

WARNING SIGNS

Materials

Sign: Plastic with high visibility lettering as provided by The Nova Scotia Department of Natural Resources or equivalent sign fabricated from plastic, metal or wood.

Posts: Wooden 100 mm by 100 mm square or 100 m diameter round posts, 1.8 to 2.4 m in length. Can be treated with a wood preservative.

Galvanized steel post, 50 to 75 mm in diameter, 1.8 to 2.4 m in length

Live tree

Fasteners: Galvanized nails, screws, bolts or threaded lag bolts

Tool/Equipment List

Shovel or auger
Hammer, axe, saw, screwdriver, wrench
Rock drill, drill rods, bits and air compressor

Installation

- Signs should located to ensure they are visible to anyone travelling near an abandoned mine opening. Refer to Figure 5 for suitable and recommended locations.

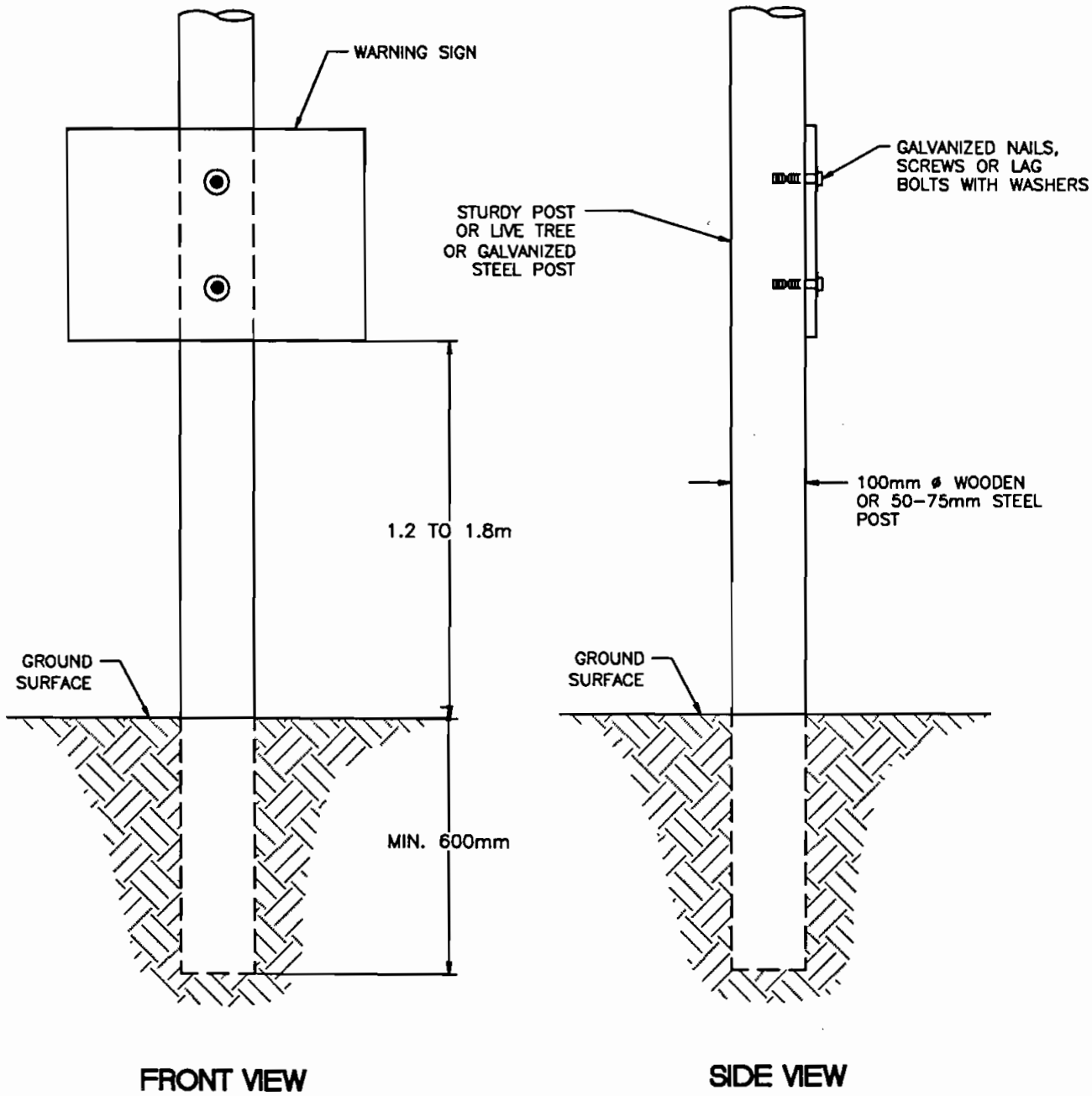
- Dig or auger a hole a minimum of 600 mm in depth then install wooden or steel post and backfill hole, compacting soil to provide solid support

  Steel posts can also be installed in a bore hole drilled into competent rock. The hole should be 50 mm larger in diameter than the post and once inserted, the post should be grouted into the hole with cement.

  A live tree can be used as a post, provided low branches which may obscure the sign are removed.

- Attach the sign between 1.2 and 1.8 m high using an appropriate fastener.

WARNING SIGNS
REFERENCE DRAWING No.1



CHAIN LINK FENCING

Materials

Chain Link Fence: 1.8 m high, 50 mm mesh of 9 gauge galvanized wire

End and Corner Posts: 64 mm inside diameter, round galvanized pipe

Line Posts: 50 mm inside diameter, round galvanized pipe

Top and Brace Rails: 32 mm inside diameter, round galvanized pipe

Tension Wire: 7 gauge galvanized steel wire

Fasteners: Galvanized 11 gauge steel wire, 7 gauge aluminum wire or other suitable fastener bands or brackets

Barbed Wire: Galvanized 12.5 gauge steel wire with 14 gauge galvanized steel 2-point barbs, spaced at 100 to 125 mm centres

Grout: Portland Type II concrete

Tool/Equipment List

Shovel, auger, axe, sledgehammer, wire cutters
Come-a-long
Rock drill, drill rods, bits and air compressor

Fabrication

Commercially available galvanized steel chain link fencing need only be cut to the appropriate length to extend around the perimeter or across the entrance of an abandoned mine opening. Galvanized steel posts should be cut to final length in the field to compensate for anchor holes of varying depth. Fencing should be securely attached to posts and top rails with wire or alternative fasteners in a manner such that they cannot be easily removed. If wire rope clips are used as fasteners the bolt heads on the clips should be rounded to prevent intentional loosening. A tensioned, galvanized wire must run through the bottom mesh of the fencing to prevent access under the fence. Any non-galvanized steel components should be painted with a zinc-rich protective coating.

Installation

Vertical Shafts, Inclined Shafts and Raises

- Inspect the area of installation to ensure safe working conditions.

- Clear away any wood, metal or debris around the shaft or raise opening and within the enclosure area. Any equipment or machinery within the fence enclosure area should also be moved outside the fence perimeter to prevent individuals from entering the area to inspect or salvage this material.

- Clear the perimeter area where the fence will be installed of trees, brush or any other obstruction.

- Dig or auger holes around the perimeter of the enclosure, at a spacing not to exceed 3 m. Holes should be not less than 300 mm in diameter and between 750 mm and 1 m deep. Where competent rock is present, fence posts may be set in holes drilled in the rock. The drilled holes should be 50 mm larger in diameter than the fence post.

- Set posts in concrete base in holes or grout posts in rock boreholes using concrete.

- Securely fasten the chain link fencing to the posts at 300 mm intervals and top rails at 500 mm intervals using 11 gauge galvanized steel wire, 7 gauge aluminum wire or other suitable fastener. The end sections of fencing should be attached to a corner post using a metal stretch bar extended through the chain link mesh and attached to the post using metal brackets.

- Run tension wire through the bottom of the fence and attach it to the corner posts.

- Cap all open post tops and either weld nuts to the bolts, round the heads or damage the threads to prevent removal.

- Seal any gaps greater than 75 mm between the bottom of the fence and the ground surface using durable, rock boulders.

- Attach three strands of barbed wire at 100 mm spacing around the top of the chain link fence.

- Paint any nongalvanized bare steel with a zinc-rich protective paint.

Adits, Declines and Slopes

- Scale down or support any loose rock above and beside the entrance of the opening as appropriate to prevent it from falling and possibly impacting the fence.

- Clear away any wood, metal or debris around the mine opening within the enclosure area. Any steel equipment or machinery within the fence enclosure area should also be moved outside the fence perimeter to prevent individuals from entering the area to inspect or salvage this material.

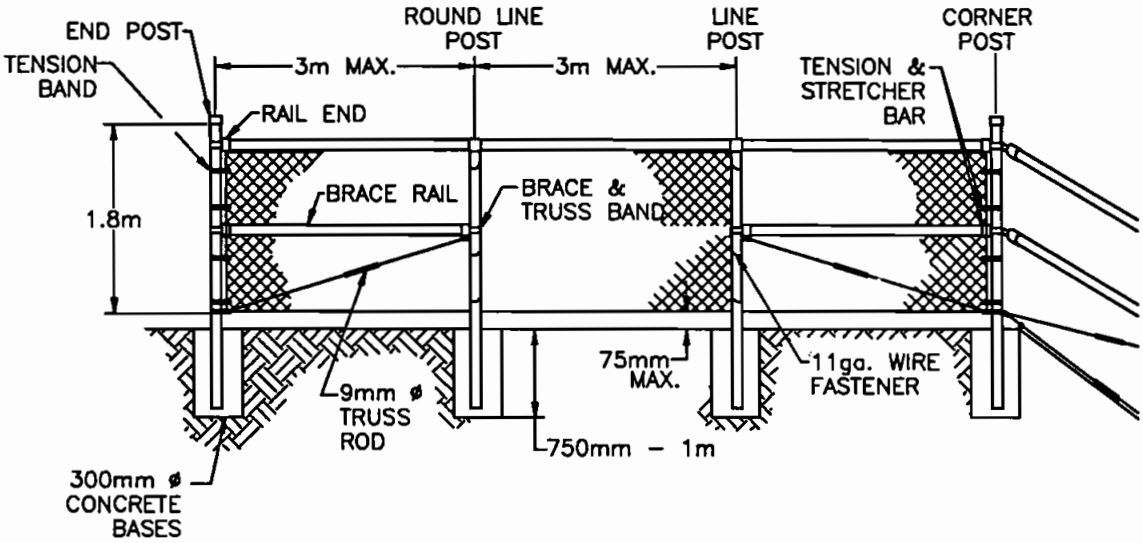
- Clear the perimeter area where the fence will be installed of trees, brush or any other obstruction.

- Install fence as outlined in the previous section. If the rock in the area of the mine opening entrance is nearly vertical, end posts can be located adjacent to the rock face provided gaps which exceed 150 mm to not exist between the post and the rock wall.

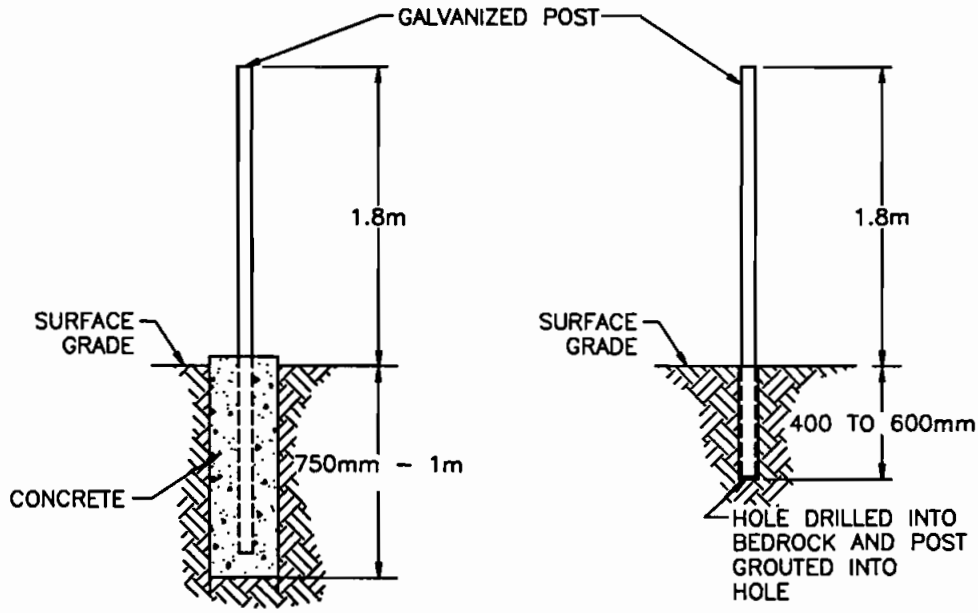
  Alternatively, the fence can be attached directly to a vertical rock face using 450 mm long rock bolts or rebar pins spaced at 300 mm intervals over the height of the fence. The chain link mesh should be pinned between the rock face and washers installed on the end of the rock bolts or rebar pins.

- Paint any nongalvanized bare steel with a zinc-rich protective paint.

CHAIN LINK FENCING
REFERENCE DRAWING No.2



FENCE WITH RAILED TOP



POST ANCHORING IN SOIL

POST ANCHORING IN BEDROCK

GENERAL CONSTRUCTION DETAILS

STEEL WIRE SCREENING CLOSURES

Materials

Steel Screen: Concrete reinforcing steel wire mesh or steel screen

Anchors: Expansion shell rock bolts, 450 mm length, 18 mm diameter with washer and cast bolt head.

Reinforcing steel anchor pins, minimum No. 6 rebar, 450 mm length with washer welded to rebar 100 mm from end.

Concrete expansion shell anchor bolts.

Grout: Nonshrink mortar or epoxy resin grout.

Tool/Equipment List

Rock drill, drill rods, bits and air compressor
Drill chuck adaptor for rock bolts or rebar installation
Cable or wire cutters
Sledge hammer, shovel
Concrete drill and bit

Fabrication

Commercially available steel wire screen need only be cut to the appropriate size to cover the opening and to allow sufficient overlap for attachment. To cover openings larger than the width of the wire screen, two or more sections of screen can be tack welded together or attached with wire rope clips. If wire rope clips are used, the bolt heads on the clips should be rounded to prevent intentional loosening. Steel wire screen should be painted with a zinc-rich protective coating.

Installation

Vertical Shafts, Inclined Shafts and Raises

- Clear away any wood, metal or debris around the shaft or raise opening. If a structurally sound concrete shaft collar is not exposed, excavate and remove any loose rock or soil away from the

shaft collar to expose competent bedrock. Bedrock should be exposed a minimum of 1 m around the opening. Proper installation requires that the screening be firmly anchored to competent bedrock or a stable concrete shaft collar.

- Position the steel wire screen over the opening, ensuring it overlays the perimeter a minimum of 500 mm. Temporarily anchor the wire screening to prevent it from falling into the opening.

- Drill vertical anchor holes within the mesh grid at 450 mm spacing and to a depth of 500 mm. Anchor the screen in place by installing rock bolts or rebar anchors into the drill holes and pinning the mesh to the bedrock with the rock bolt or anchor bolt washers.

- For installation over a concrete shaft collar, expansion shell anchors can be installed in the concrete to attach the steel screen over the shaft opening.

- Paint the steel screen and any other bare steel with a zinc-rich protective paint.

Adits, Declines and Slopes

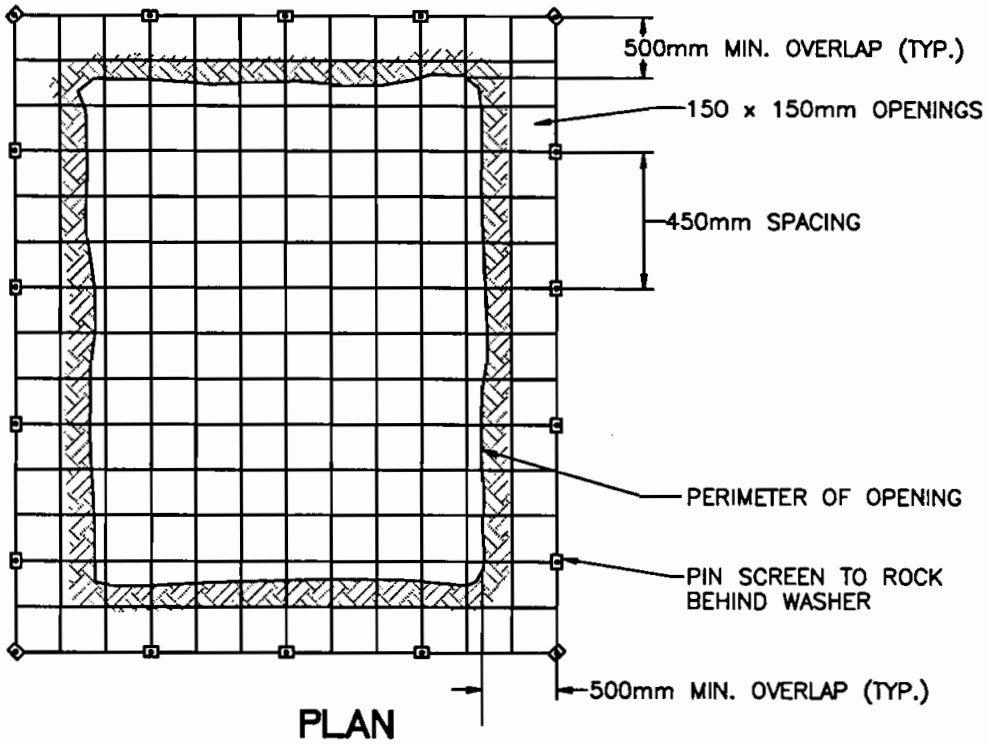
- Scale down or support any loose rock above and beside the entrance or on the roof and walls of the opening as appropriate.

- Clear away any vegetation, debris, loose rock and other items from around the entrance and/or inside the opening (if the screening is to be installed inside the abandoned mine opening) which may interfere with the installation.

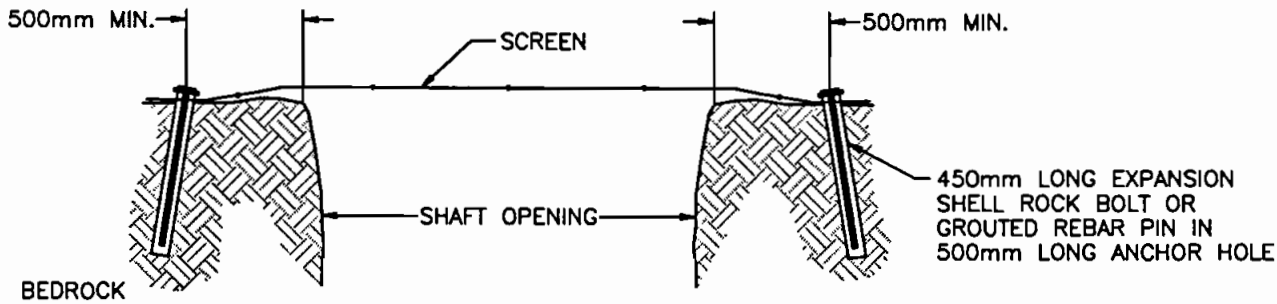
- Install the steel screen as outlined above, using the same anchor bolt spacing and drill hole depths.

- Paint the steel screen and any other bare steel with a zinc-rich protective paint.

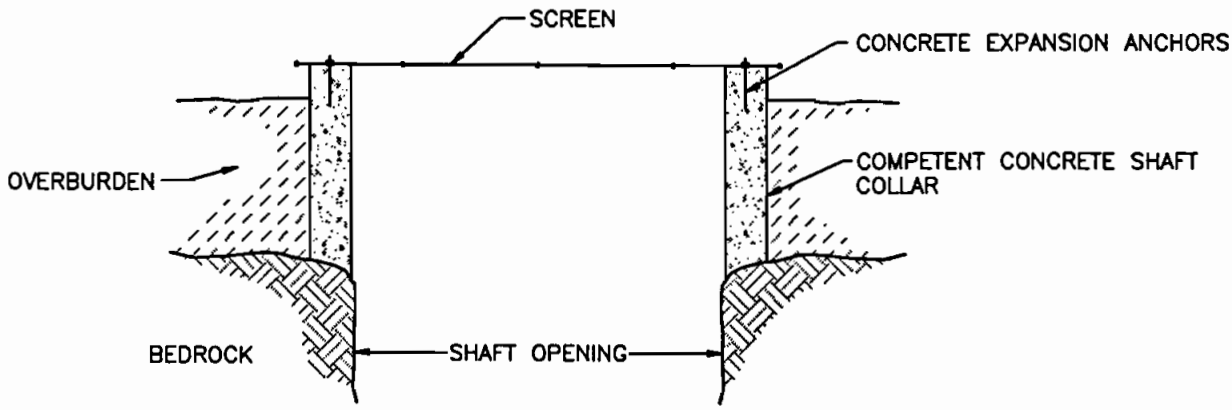
STEEL WIRE SCREENING CLOSURES
VERTICAL SHAFTS AND RAISES
REFERENCE DRAWING No. 3



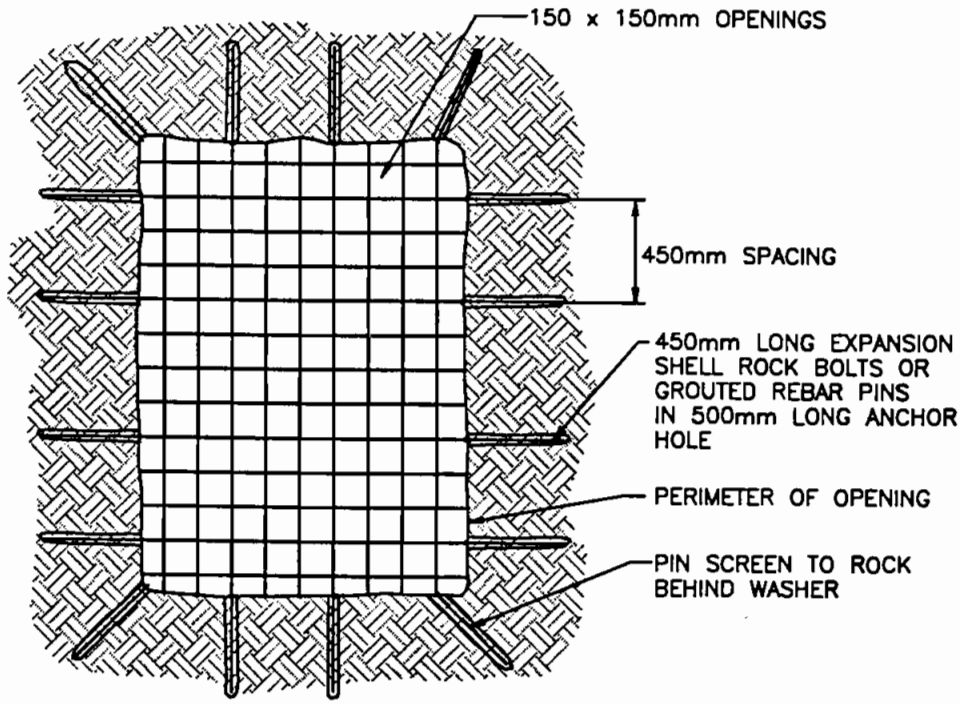
PLAN



TYPICAL SECTIONS

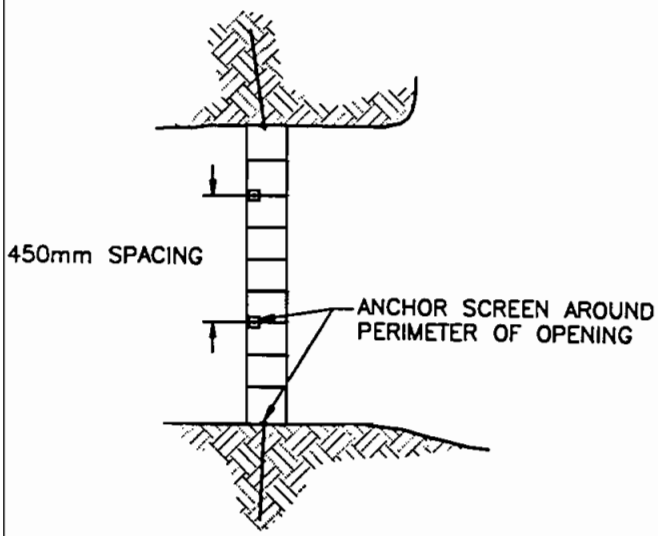


STEEL WIRE SCREENING CLOSURES
ADITS, INCLINED SHAFTS AND SLOPES
REFERENCE DRAWING No. 3A

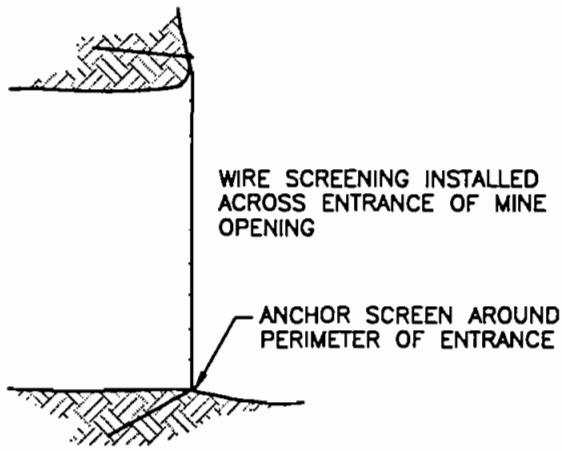


SECTION ACROSS OPENING

TYPICAL SECTIONS



WIRE SCREEN INSTALLED INSIDE OPENING



WIRE SCREEN INSTALLED ACROSS ENTRANCE OF MINE OPENING

STEEL GRATE CLOSURES

Materials

NOTE: Design specifications for steel frames and reinforcing requirements for steel grate closures to be installed over a vertical mine opening, should be provided by a qualified Professional Engineer.

Steel Grating: Commercially available steel floor grating or fabricated from steel stock. Maximum opening 150 mm by 150 mm for fabricated grating.

Structural Steel: As required based on size of opening. Minimum 50 by 50 by 6 mm angle iron should be used.

Anchors: Expansion shell rock bolts, 450 mm length, 18 mm diameter with washer and cast bolt head.

Reinforcing steel anchor pins, minimum No. 6 rebar, 450 mm length with washer welded to rebar 100 mm from end.

Concrete expansion shell anchor bolts.

Grout: Nonshrink mortar or epoxy resin grout.

Tool/Equipment List

Rock drill, drill rods, bits and air compressor
Drill chuck adaptor for rock bolts or rebar installation
Sledge hammer, shovel
Concrete drill and bit

Fabrication

The steel grates can be fabricated by overlying square or round steel stock and spot welding them together at each intersection and to a steel frame. Commercially available floor grating can also be welded to a steel frame. Individual sets of steel grate frames can be joined together as required to fit individual openings.

Installation

Vertical Shafts, Inclined Shafts and Raises

- Clear away any wood, metal or debris from around the shaft opening. If a structurally sound concrete shaft collar is not exposed, excavate and remove any loose rock or soil to expose competent bedrock a minimum of 1 m around the perimeter of the shaft opening. Proper installation requires that the steel grating be firmly anchored to competent bedrock or a stable concrete shaft collar.

- Once a competent anchorage is exposed around the opening, the frame can be positioned ensuring it overlays the perimeter a minimum 500 mm. As the size of the opening dictates, weld or bolt separate steel grate frames together. If bolts are used, the heads should be welded or rounded to prevent loosening and removal by unauthorized people. It may be necessary to chip or trim the bedrock to provide a uniform contact between the bedrock and frame.

- Drill vertical anchor holes within the mesh grid at 450 mm spacing and to a depth of 500 mm. Anchor the steel grating in place by installing rock bolts or rebar anchors into the drill holes and pinning the grating to the bedrock with the rock bolt or anchor bolt washer. Alternatively, the steel frame can be welded to the anchor bolts.

- If gaps greater than 100 mm exist between the frame and the bedrock, they should be filled with a mortared rock fill or sections or rebar, angle iron or floor grating welded to the frame.

- For installation on top of a concrete shaft collar, concrete expansion shell anchors can be used with fabricated brackets to attach the steel grate frame over the shaft collar. The steel grating can also be anchored into a cast-in-place concrete collar positioned around the perimeter of the existing collar.

- Paint the steel grating and any other bare steel with a zinc-rich protective paint.

Adits, Inclined Shafts and Slopes

- Scale down or support any loose rock above and beside the entrance or on the roof and walls of the opening as appropriate.

- Clear away any vegetation, debris, loose rocks and other items which may interfere with the installation from around the entrance, or inside the opening if the screening is to be installed inside the abandoned mine opening.

- Chip or trim rock around the area of the steel grate installation as required to minimize gaps and ensure uniform contact between the steel frame and the rock face or the perimeter wall. All rubble and other material must be removed to the original floor elevation of the opening at the location where the grating is to be installed.

- For installation over the entrance of the opening, the grating can be attached as described in the previous section.

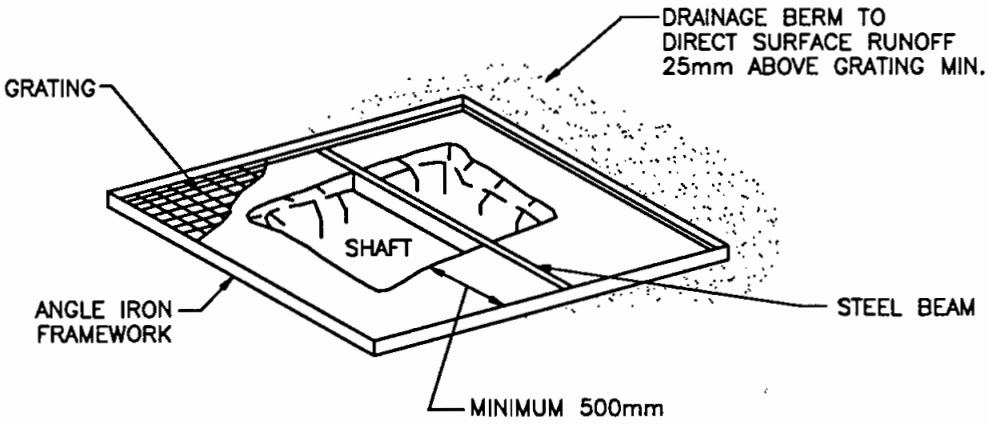
- For installation inside a mine opening, the grating must be sized to extend from the roof of the opening to the floor and be cut and welded to fit the irregularities of the opening. If the floor is competent rock, the grating may be anchored directly to the floor; otherwise, the grate must be anchored to a 300 mm wide by 300 mm high, cast-in-place, reinforced concrete footing, which extends across the full width of the opening.

  The grating should be welded or bolted to rock bolts or rebar anchor pins installed around the perimeter of the opening on 300 mm centres. The rock anchors should be anchored to a minimum depth of 200 mm in competent rock and extend 300 mm into the opening.

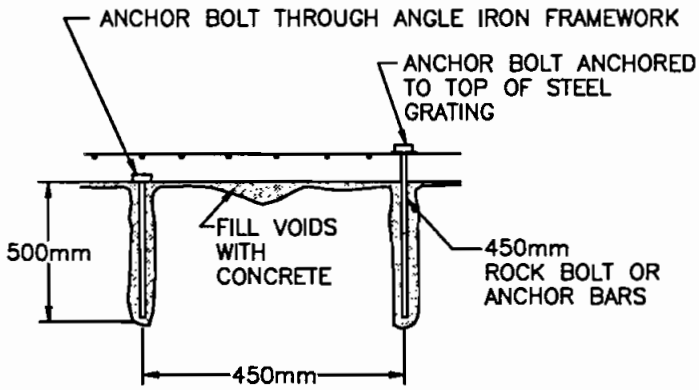
- Where gaps greater than 100 mm exist between the frame and rock, the gaps should be filled with sections of rebar, angle iron or floor grating welded to the frame.

- Paint the steel grate and any other bare steel with a zinc-rich protective paint.

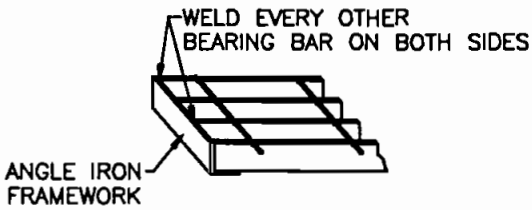
STEEL GRATE CLOSURES
REFERENCE DRAWING No. 4



PLAN



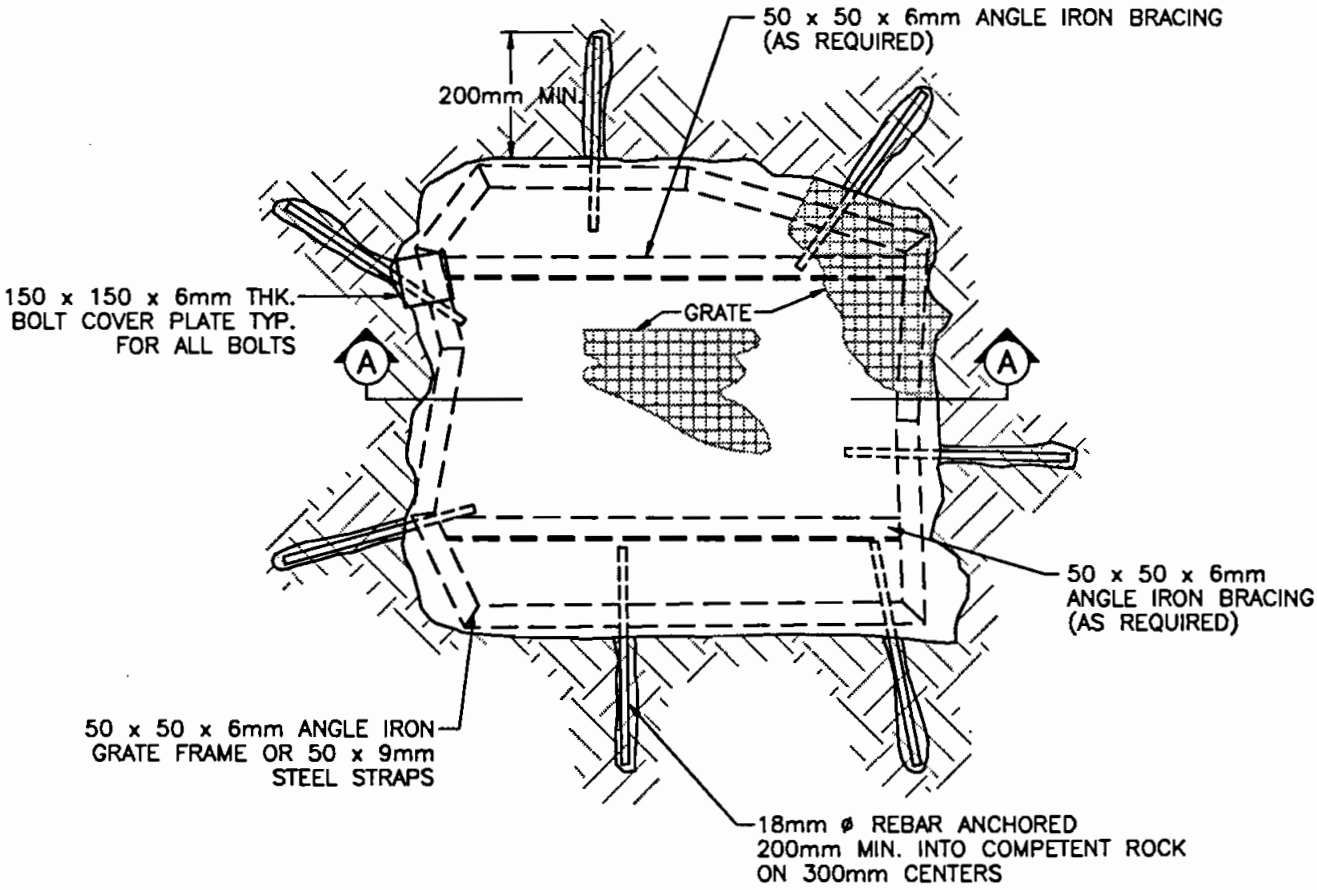
ANCHORING DETAILS



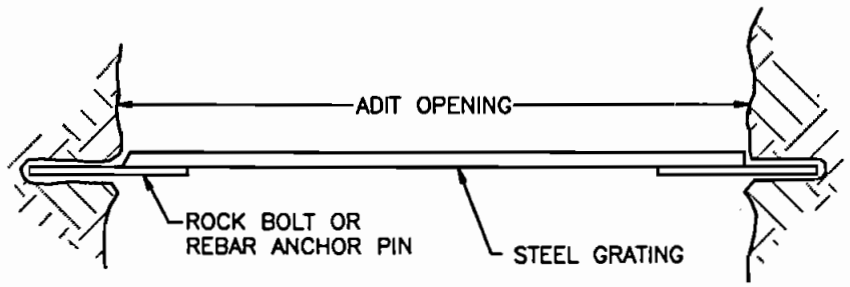
EDGE DETAIL

VERTICAL SHAFTS AND RAISES

STEEL GRATE CLOSURES
REFERENCE DRAWING No. 4A



GRATED ACCESS OPENING



SECTION A-A

ADITS, INCLINED SHAFTS AND SLOPES

NATIVE ROCK AND CONCRETE BLOCK BULKHEADS

Materials

Native Rock: Durable, sound rock, free from major fractures. Coarse blasted waste rock is generally suitable.

Concrete Block: Construction-quality concrete block suitable for exterior use in freeze-thaw conditions. Sulphide resistant concrete should be used if acid drainage is present or expected.

Mortar: Masonry quality mortar. Sulphide resistant mortar should be used if acid drainage is present or expected.

Drainage Pipe: Noncorrosive galvanized, stainless steel or Schedule 60 PVC pipe sized for actual or potential flow.

Tool/Equipment List

Masonry hammer and chisel. If electric power is available, a masonry saw is recommended to cut concrete block
Mortar, sand, water, mixing bin, shovel, trowel
Level or plumb bob, string

Construction

Adits, Inclined Shafts and Slopes

- Scale down or support any loose rock above and beside the entrance or on the roof and walls of the opening as appropriate.

- Clear away any vegetation, debris, loose rocks and other items from around the entrance of the mine opening.

- Chip or scale any loose rock off the walls and roof of the opening at the location of the bulkhead.

- Establish a sound foundation on competent rock at the location of the bulkhead. Clear away any loose rock and unconsolidated material to the original floor elevation. If the foundation is not level and a concrete block bulkhead is to be used, a level concrete rebar reinforced footer should be cast-in-place across the full width of the opening. The concrete foundation should be a minimum of 300 mm high and as wide as the bulkhead.

- Construct the bulkhead, sealing as close as possible to the walls and roof of the opening. If a concrete block bulkhead is constructed, use partial concrete blocks as necessary to obtain a close seal. If acid drainage is identified or expected, a sulphate resistant concrete mortar should be utilized.

  The recommended bulkhead thickness for the size of the abandoned opening is provided in the following table.

Size of Mine Opening (Height by Width)	Bulkhead Thickness	
	Native Rock Bulkhead	Concrete Block Bulkhead
1.8 m by 1.8 m	600 mm	Single Block
2.4 m by 2.4 m	750 mm	Single Block
2.4 m by 3.0 m	900 mm	Double Block
3.0 m by 3.7 m	1,050 mm	Double Block

  For a concrete block bulkhead, the following reinforcement should be incorporated:

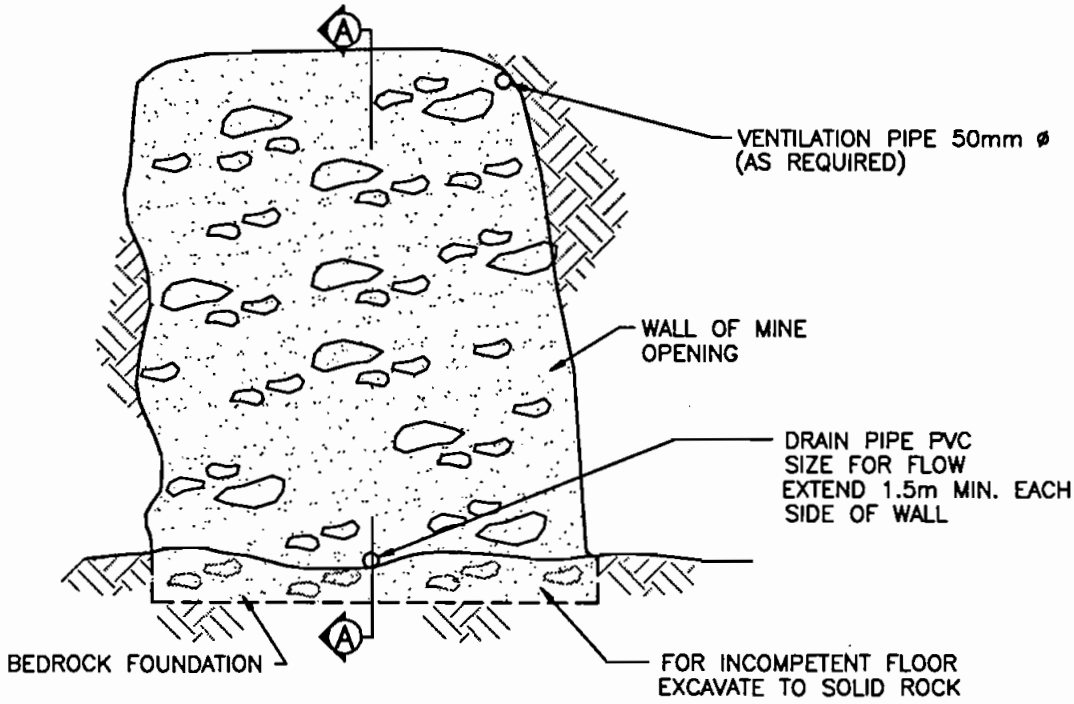
  - Fill inside of concrete blocks with mortar and insert No. 5 reinforcing steel rebar between rows of blocks.

  - On double block bulkhead construction, insert No. 9 wire or steel tie straps between walls and apply mortar between walls.

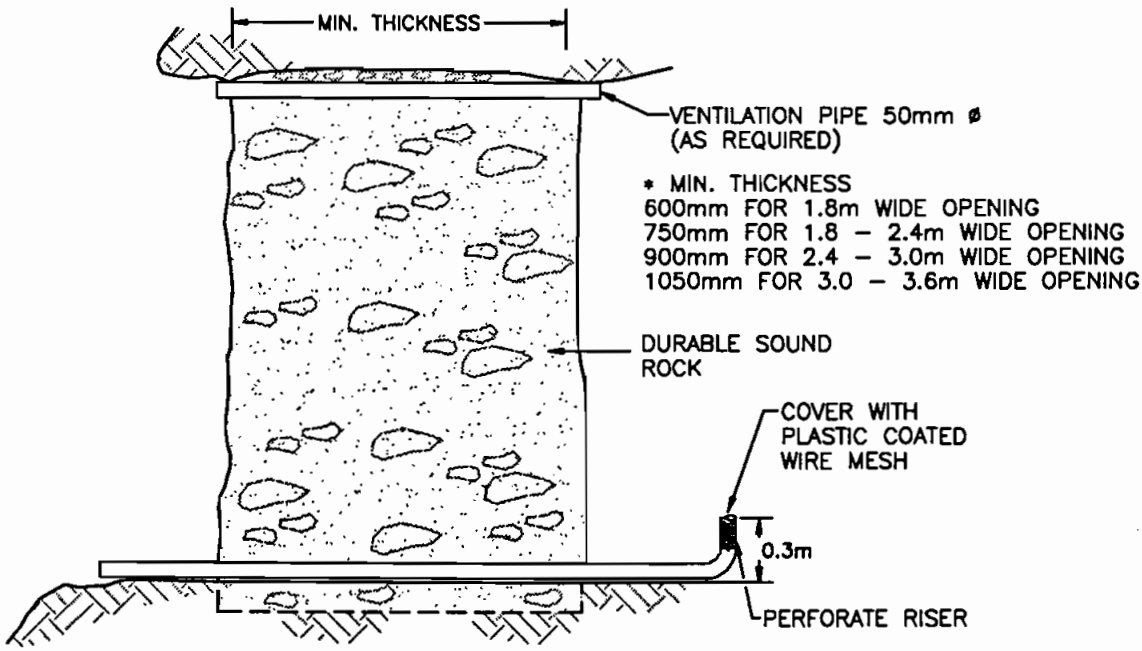
- Seal any gaps with mortar and rock or concrete block fragments, so that no openings remain between the bulkhead and the walls and roof of the opening.

- If drainage is required from the adit opening, position a drain pipe at the base of the bulkhead. The drain pipe should extend a minimum 1.5 m beyond each side of the bulkhead. A minimum 300 mm perforated riser should be attached to the inside portion of the pipe. To reduce the potential for blockage, a galvanized or rubber covered mesh should be affixed to both ends of the pipe. At a minimum, the diameter of the drainage pipe should be 150 mm, however, the size should be selected to ensure adequate drainage.

NATIVE ROCK BULKHEAD
REFERENCE DRAWING No.5

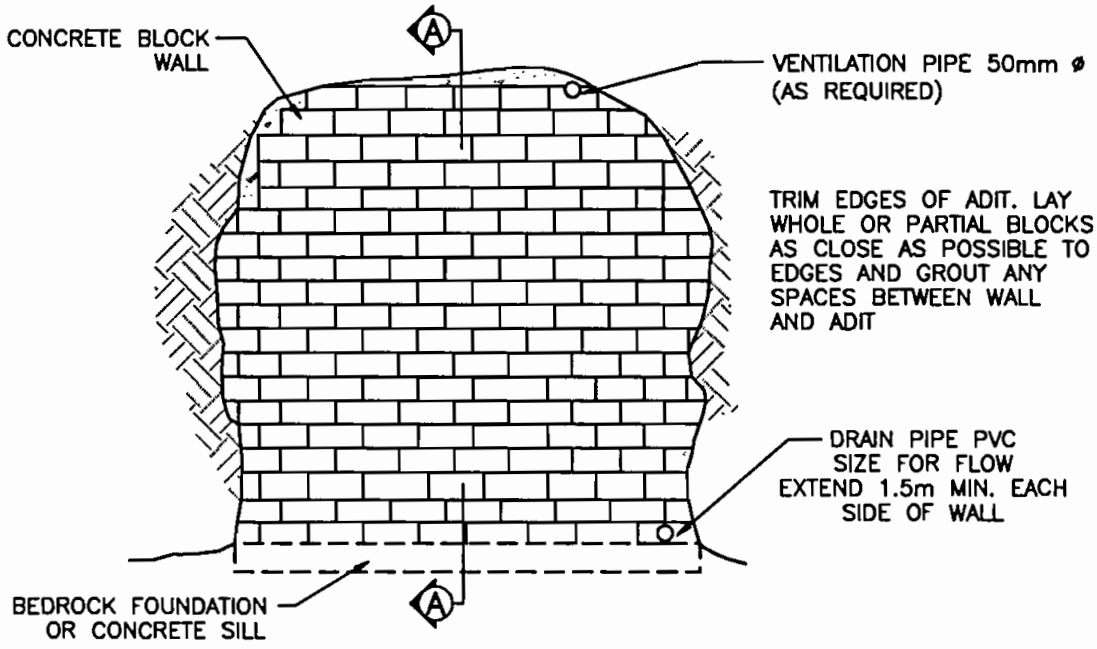


SECTION ACROSS OPENING

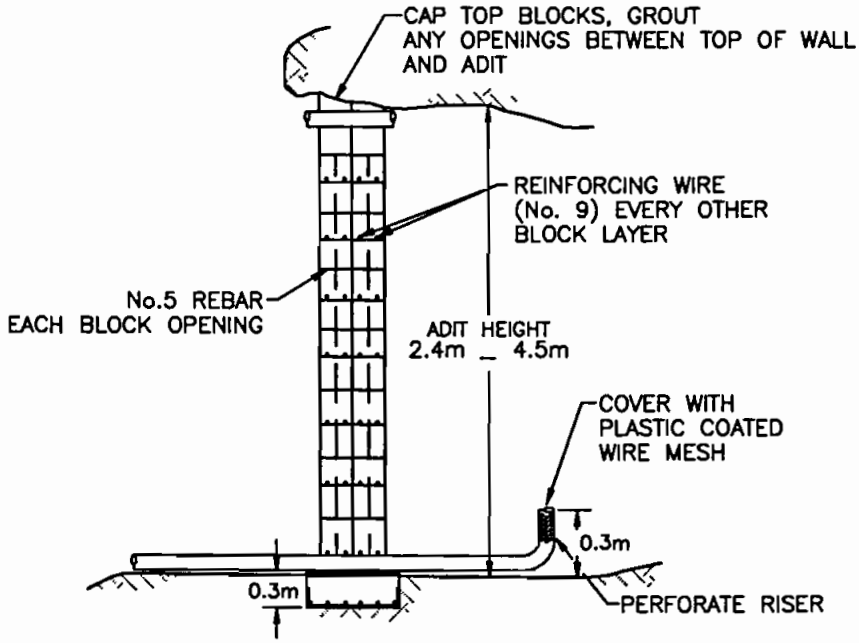


SECTION A-A

CONCRETE BULKHEAD
REFERENCE DRAWING No.5A



SECTION ACROSS OPENING



SECTION A-A

CONCRETE SHAFT OR RAISE CAPS

Materials: Pre-Cast Concrete Panels

NOTE: Size and strength specifications for concrete panels and support beams should be provided by a qualified Professional Engineer.

Concrete Panels:	Pre-cast, custom made or commercially available pre-cast reinforced concrete sections with lifting rings.
Support Beams:	Concrete or steel beams may be required for support of concrete sections if width of shaft opening exceeds length and/or allowable span of concrete sections. Size and strength specifications should be supplied by a qualified structural engineer based on the size of the opening.
Corrosion Protection:	Tar or epoxy resin for steel beams.
Support Fill:	Uniform 20 mm Class A, chemically inert, crushed gravel

Materials: Cast-In-Place Concrete

NOTE: Concrete mix specifications, thickness of cap, quantity and size of rebar and type of form should be provided by a qualified Professional Engineer.

Concrete:	Type II Portland cement. Sulphate resistant cement should be used if acid drainage is expected or identified.
Aggregate:	Good quality gravel aggregate free from wood and other organic material.
Water:	Potable
Reinforcement:	Steel reinforcing rods
Forms:	Wood or corrugated, galvanized stay-in-place steel forms.
Drainpipe:	Noncorrosive, 50 mm diameter, Schedule 60 PVC or galvanized pipe.

Materials: Monolithic Concrete Cap

NOTE: Size, thickness and concrete strength specifications for monolithic concrete cap should be provided by a qualified Professional Engineer based on size of mine opening and thickness of overburden cover.

Concrete:	Type II Portland cement. Sulphate resistant cement should be used if acid drainage is expected or identified.
Aggregate:	Good quality gravel aggregate free from wood and other organic material.
Water:	Potable
Reinforcement:	Steel reinforcing rods
Forms:	None required, concrete cap takes the shape of the base of the subsidence feature.

Tool/Equipment List

Excavator or backhoe (clear site and lift materials)
Shovel, sledge hammer, lifting slings or cables, level
Concrete (On-site mixer if access is not available for redi-mix concrete truck)
Concrete vibrator, rake, shovel

Backfill

Unclassified rock and soil, free from any debris, trash and toxic or hazardous waste. Non-acid producing mine waste rock is generally suitable. Overburden or native till should be comparable to surrounding surficial material.

Installation/Construction

Pre-Cast Concrete Panels or Cast-in-Place Concrete Cap

Clear and remove any loose rock, soil, vegetation and debris from around the shaft collar. Where a structurally sound, concrete shaft collar is not available, excavate to bedrock and remove any loose or weathered rock around the shaft opening. Bedrock must be exposed back from shaft opening, a minimum of 1 m to permit placement of the concrete closure cap.

Pre-Cast Concrete Cap

- Where a structurally sound concrete shaft collar is not present, create a relatively even bedrock surface by chipping away any major irregular surfaces a minimum of 1 m beyond the perimeter of the shaft opening.

- Place a minimum 50 mm thick gravel pad on the exposed bedrock around the shaft extending 300 to 600 mm past the ends of the pre-cast concrete panels. A uniform 20 mm Class A, chemically inert, crushed gravel should be used. The pre-cast concrete panels can be positioned directly on this gravel levelling course. The panels must overlay the shaft opening a minimum 300 mm and be equal on both sides of the shaft opening. A 25 mm gap should be left between each pre-cast concrete panel.

- If support beams are required, they should be positioned in notches cut into the bedrock to maintain a level support with the bedrock surface for the pre-cast concrete panels. Any support beams should extend a minimum of 300 mm beyond the edge of the pre-cast concrete panels. Place concrete panels on any support beams ensuring the panels overlap the support beam a minimum of 75 mm and a 25 mm gap is maintained between panels.

  Support beams should be positioned on a gravel pad or a concrete levelling course cast into the notches. If concrete is used, the support beams should be totally encased in concrete for the entire length of the beam within the notch except for the top portion on which the pre-cast concrete panels will rest. The concrete should be cast a minimum of 80 mm thick over the ends, sides and exposed top portion of the beam.

- Prior to installation, any steel support beams should be coated with a tar or epoxy resin for corrosion protection. Steel or concrete support beams should also be set at right angles to the long dimension of the concrete panels.

- Pre-cast panels should rest uniformly on the gravel fill or support beams with no discernible rocking. Minor levelling can be accomplished by shimming or adding additional gravel fill.

- Remove any lifting hooks or rings, and cover panels with a 100 mm thick gravel fill. Fill should also be placed around the ends and sides of the cap to the same level.

If a concrete collar is available, the concrete support beans and/or panels can be positioned directly on the top of the concrete collar.

Cast-In-Place Concrete Cap

- A cast-in-place concrete cap can be constructed on a competent bedrock shaft or raise collar or on a structurally sound, concrete shaft collar. The concrete is cast into forms positioned on bedrock, a concrete shaft collar or keyed into the shaft below the bedrock elevation.

- Wood or metal stay-in-place concrete forms can be used. They must be mortar tight and sufficiently rigid to prevent bending and flexing during placement and vibration of the concrete. Forms constructed on bedrock over a shaft or raise opening should overlap the opening a minimum 600 mm on all sides and provide for a minimum 300 mm thick cap. Concrete caps cast directly onto a concrete shaft collar should be "keyed" into the inside of the collar a minimum of 50 mm. The form design and cap thickness should be designed and approved by a qualified registered Professional Engineer prior to construction.

- Place reinforcing rebar in the form, ensuring the reinforcement is supported approximately 50 mm above the bottom of the form using plastic chairs or an equivalent support method. Tie the reinforcement together using steel wire - **Do Not Weld**. To assist with drainage, install 50 mm diameter, non-corrosive pipes through the concrete form at 1.2 m centres.

- Inspect and approve forms and reinforcement prior to concrete placement. Concrete can be mixed on site or delivered by a commercial redi-mix supplier if vehicle access is available. Minimum 5,000 psi (28 day test), compressive strength concrete should be used. During the pour, distribute the concrete around the reinforcing steel and systematically consolidate using mechanical vibrators until the top of the form is reached. The rate of the concrete pour should be controlled to prevent deflection of the form.

- For caps constructed below surface grade, once the concrete has set (2 to 3 days), cover the concrete cap with a 100 mm thick gravel fill, and fill in level around the ends and sides.

- Backfill the opening over the gravel fill cover once the concrete has reached a minimum compressive strength of 3,000 psi. Fill in 600 mm lifts, compacting each lift with mechanical compactors or available heavy equipment. The top layer of fill should consist of a minimum 300 mm cap of native till to permit revegetation. Mound the final layer of fill above the surface grade to provide a gentle slope around the perimeter of the backfill down to the original surface to provide drainage away from the shaft area.

- Caps cast directly onto concrete shaft collars located above surface grade need not be covered with fill.

Monolithic Concrete Cap

Depending upon the condition of the subsidence cone over a shaft or raise opening, it may be necessary to scrape the sides of the slopes with a backhoe or excavator to remove debris and vegetation. The size of the subsidence feature may also require enlargement, to ensure the monolithic concrete cap extends a minimum of 1 m beyond the perimeter of the shaft or raise opening to provide adequate cover and support. During excavation, care must be taken to not break through into the mine opening.

Monolithic Concrete Cap

A monolithic cast-in-place concrete cap can be constructed directly on the base of a subsidence cone over the location of a shaft or raise opening, where soil or fill over the opening has caved into the shaft or raise opening, although the mine opening is not visible. Monolithic concrete caps are cast-in-place directly onto the soil or fill on the bottom of the subsidence feature, using the sides of the subsidence feature to contain the concrete.

- Using a backhoe or excavator scrape away any debris and/or vegetation which can be safely reached, along the sides and the bottom of the subsidence cone. If the size of the shaft or raise opening is known, the bottom of the subsidence cone should be enlarged so the sides of the excavation extend a minimum of 1 m beyond the perimeter of the underground opening. As the base of the subsidence cone is being enlarged, it should also be flattened.

- If the bucket of the back hoe or excavator can safely reach the bottom of the subsidence opening, the bottom of the opening should be loaded by pushing down with the bucket. If the surface slumps or shows signs of collapse, it will be necessary to place timber or other appropriate supports across the bottom of the opening to provide initial support to the concrete cap while the concrete is being cast into the opening. Timber supports should be placed adjacent to each other and covered with a layer of rock fill.

- Prepare a steel rebar reinforcement mat as per design specifications and place it on the base of the excavation using the backhoe or excavator, elevated a distance of 50 to 100 mm above the base of the opening, depending upon the design thickness of the slab. Rocks or bricks tied to the bottom of the rebar mat or thrown into the opening and positioned with the backhoe or excavator bucket can be used to support the rebar above the bottom of the excavation. Tie the reinforcement together using steel wire - **Do Not Weld.**

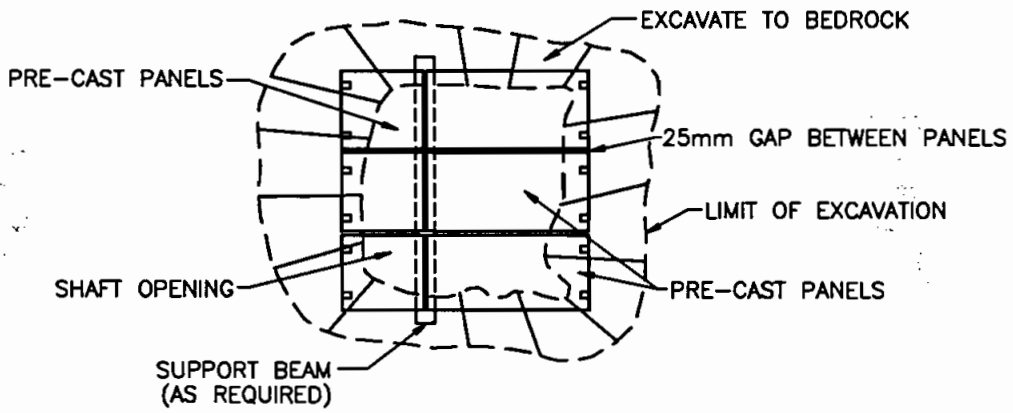
- Cast the required quantity of concrete for the monolithic cap in one continuous pour. Concrete can be mixed on site or delivered by a commercial redi-mix supplier if vehicle access is available. Minimum 5,000 psi (28 day test), compressive strength concrete should be used. The backhoe or excavator bucket can be used to assist levelling or placement of the concrete within the

excavation and to distribute the concrete around the reinforcing steel. The thickness of the cap must be designed to support overlying backfill and the dead weight of the concrete slab should continued subsidence into the mine opening create a void between the shaft or raise opening and the bottom the concrete slab. At a minimum, a monolithic slab should be between 350 and 400 mm thick. All concrete and reinforcement specifications should be designed and approved by a qualified, registered Professional Engineer.

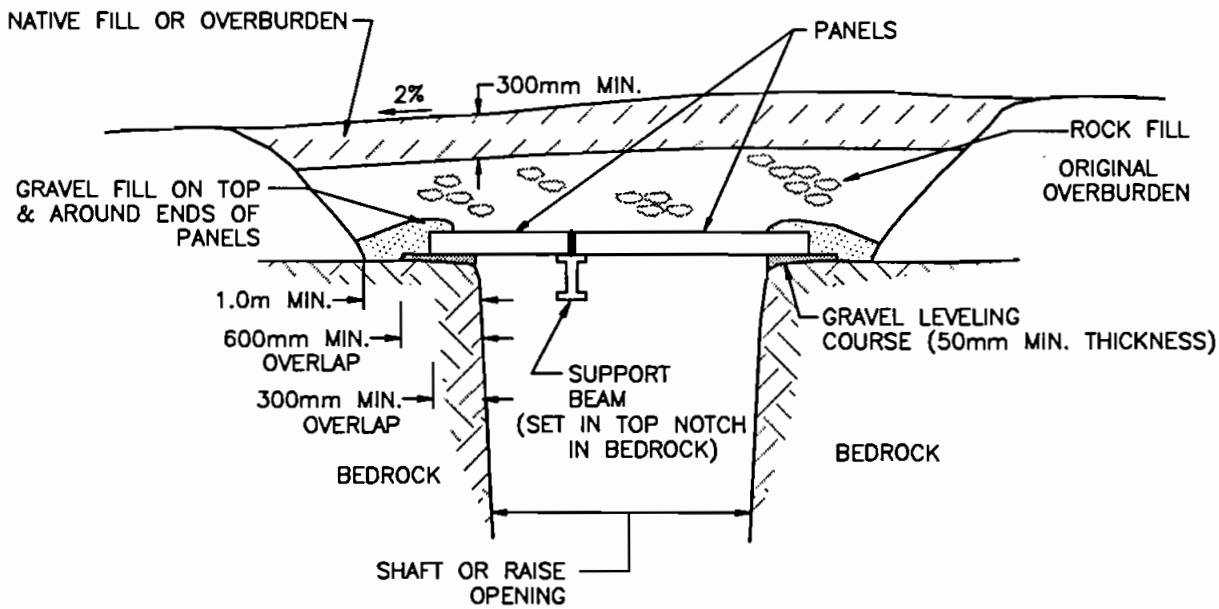
- Backfill the opening once the concrete has reached a minimum compressive strength of 3,000 psi. Fill in 600 mm lifts, compacting each lift with mechanical compactors or available heavy equipment. The top layer of fill should consist of a minimum 300 mm cap of native till to permit revegetation. Mound the final layer of fill above the surface grade to provide a gentle slope around the perimeter of the backfill down to the original surface to provide drainage away from the shaft area.

PRE-CAST CONCRETE SHAFT OR RAISE CAP

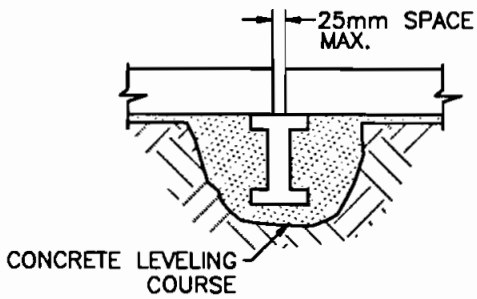
REFERENCE DRAWING No. 6



PLAN

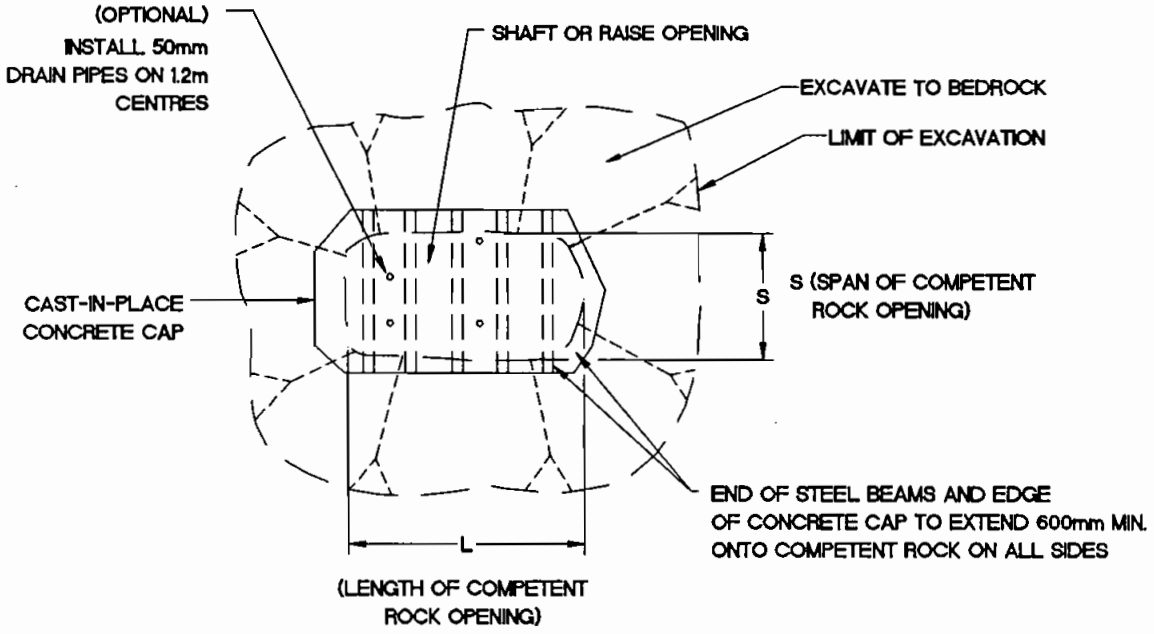


TYPICAL SECTION THROUGH SHAFT OR RAISE

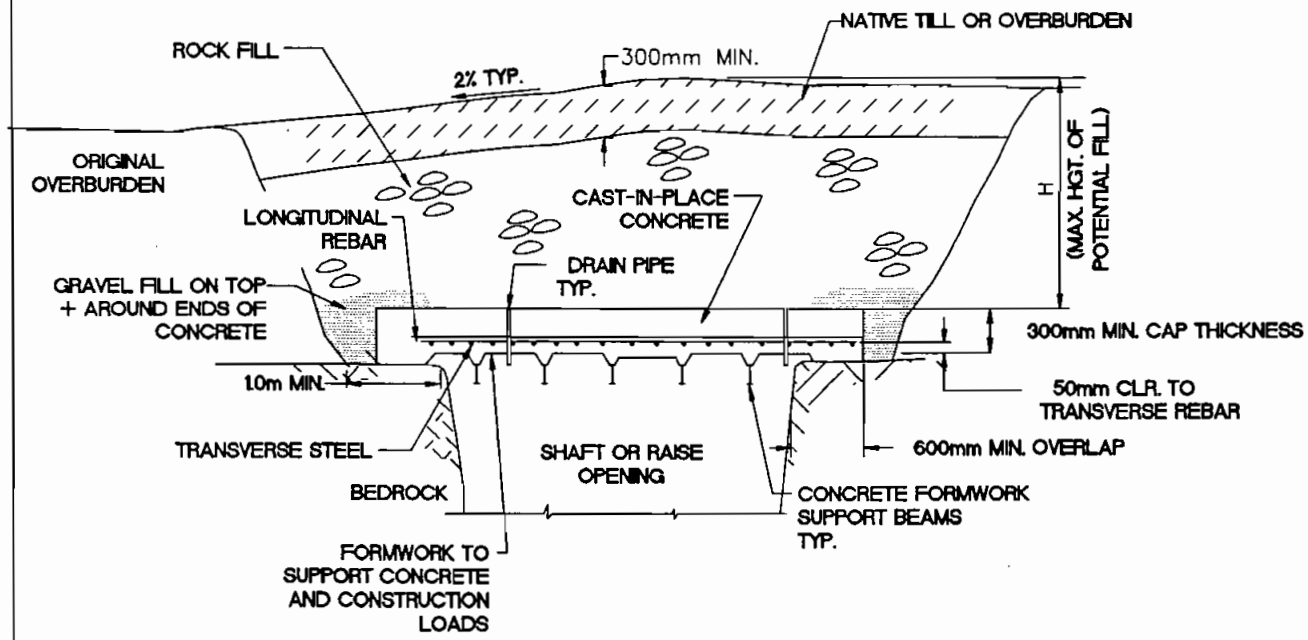


OPTIONAL CONCRETE SUPPORT METHOD FOR SUPPORT BEAM

CAST-IN-PLACE CONCRETE SHAFT OR RAISE CAP
REFERENCE DRAWING No. 6A

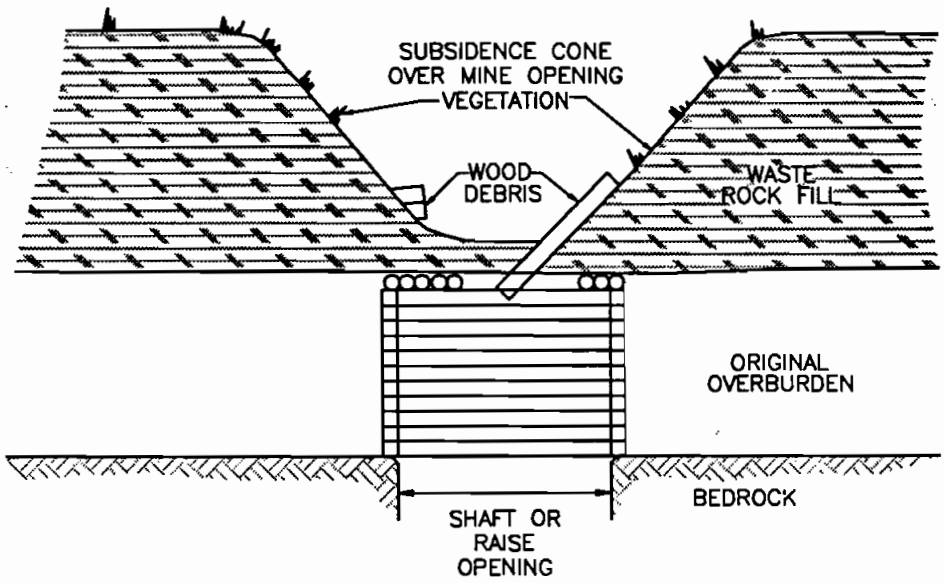


PLAN

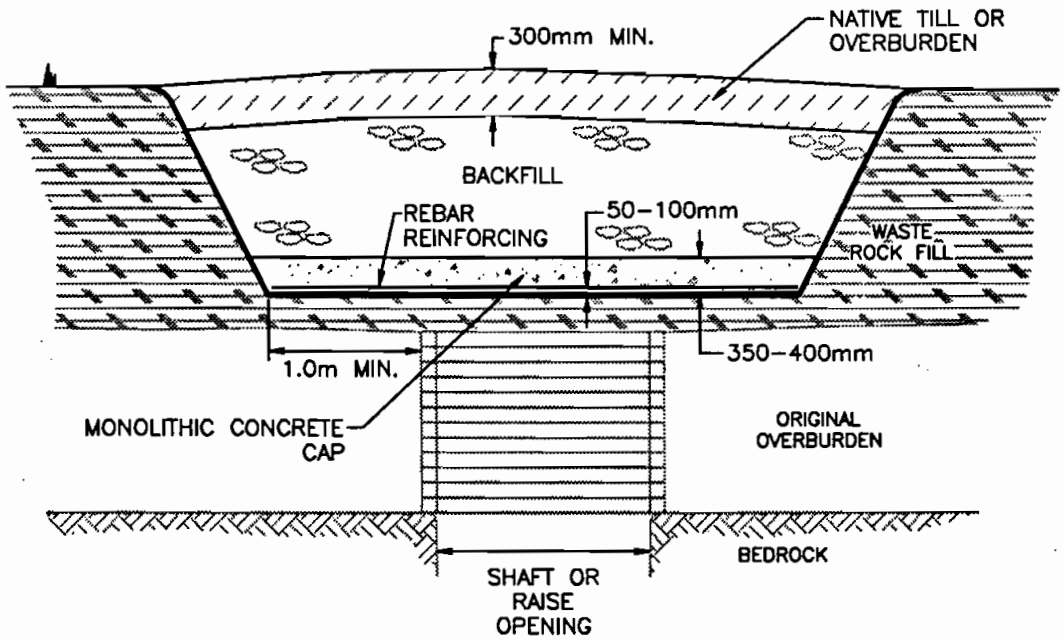


TYPICAL SECTION THROUGH SHAFT OR RAISE

MONOLITHIC CONCRETE SHAFT OR RAISE CAP
REFERENCE DRAWING No. 6B



TYPICAL PRE CAPPING CONDITIONS



TYPICAL SECTION THROUGH SHAFT OR RAISE

BLAST CLOSURE

Materials

Explosives, blasting caps and detonators
Drain pipe (as required)

Tool/Equipment List

Rock drill, drill rods, bits and air compressor, loading sticks

Method

Adits, Declines and Slopes

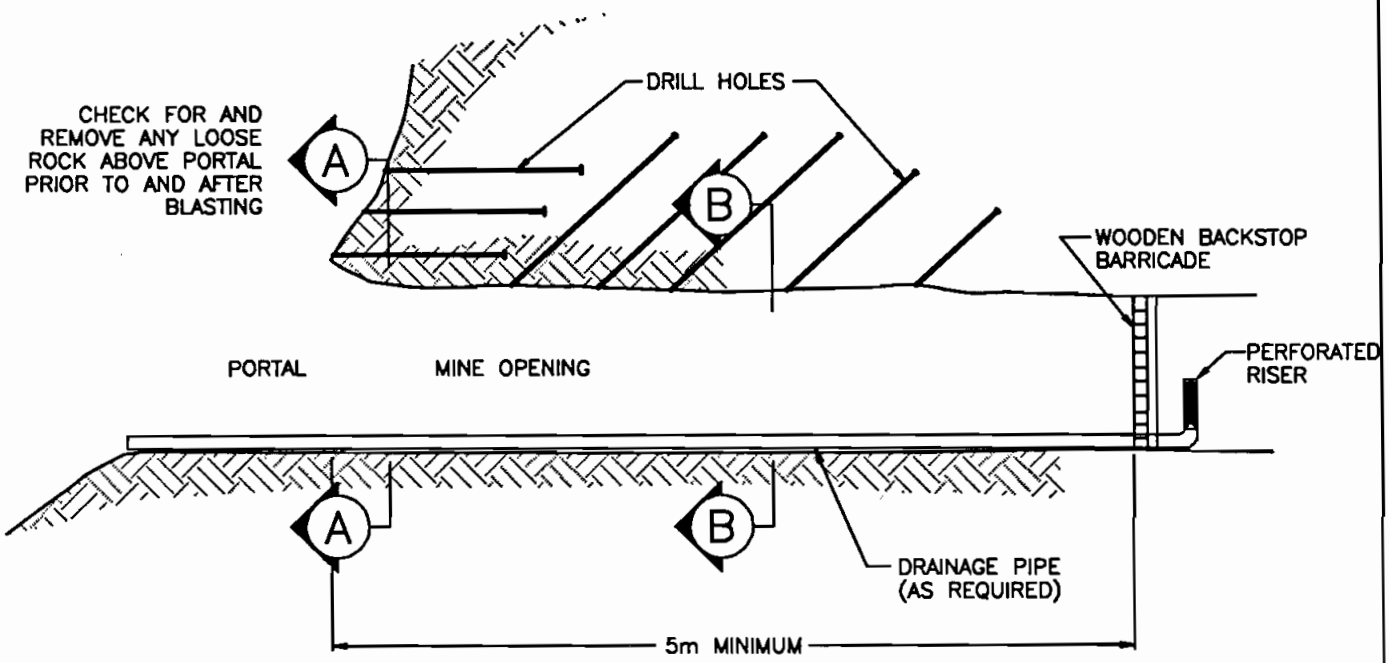
Using an approved blasting plan which details the drill hole pattern, explosive charges and detonation sequence, the required blast holes are drilled. The holes can be drilled above and around the entrance of the opening; however, if conditions permit, it is more effective to drill blast holes inside the mine opening to ensure more complete closure.

The opening should be collapsed a minimum of 5 m back from the entrance of the mine opening. A wooden or rock backstop barricade, placed at the selected closure distance into the opening, may be required to force the blasted rock to fill the opening over this distance. The blast closure must also completely seal the entrance to the mine opening. Following blasting, conditions above and around the opening must be checked for loose rock. This rock must be removed or secured prior to abandonment of the site.

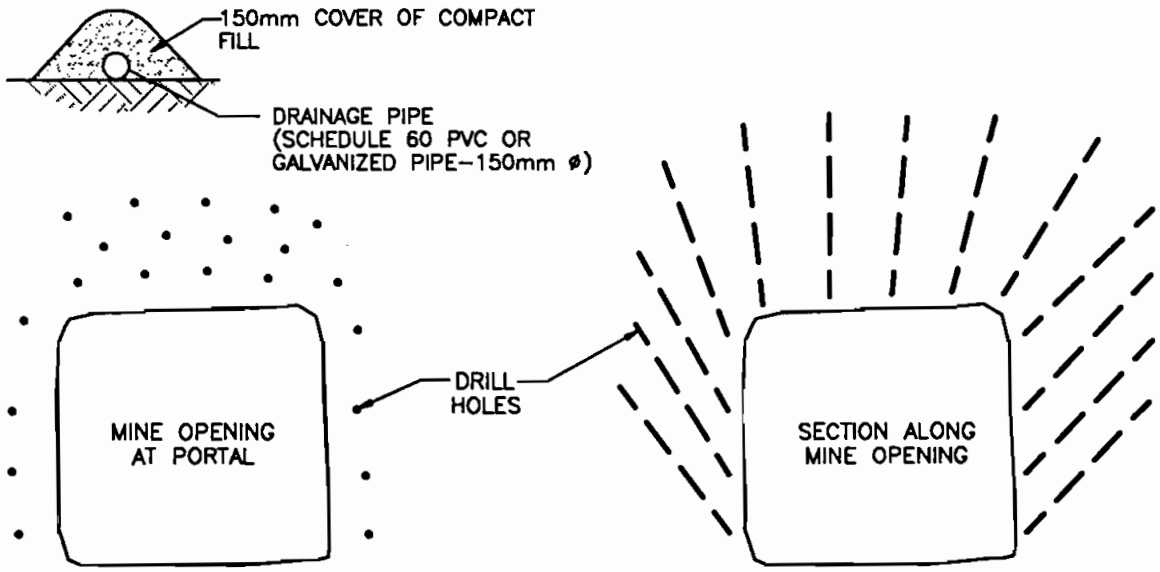
The blasting pattern should ensure that rock, weighing between 50 and 75 kg is produced throughout the extent of the blast. These large rocks will discourage people from digging through the fill to gain access into the opening. Because of settlement, it is recommended that the site be inspected 4 to 6 months after closure to ensure the blasted rock has not settled, exposing the top of the opening.

If drainage is required, a schedule 60 galvanized or PVC drain pipe should be installed prior to closure. The pipe should extend a minimum 1.5 m past both ends of the blasted rock and be covered with a minimum of 150 mm of compacted fill prior to blasting.

ADIT BLAST CLOSURE
REFERENCE DRAWING No.7



SECTION ALONG OPENING



SECTION A-A
EXAMPLE DRILL HOLE PATTERN AT PORTAL

SECTION B-B
DRILL HOLES WITHIN MINE OPENING ANGLED INTO ROCK WALLS

BACKFILL CLOSURE

Materials

Rip-Rap: A hard, durable, graded rock to minimize the creation of void spaces. The minimum diameter should not be less than 500 mm.

Rock Fill: A durable, impermeable, water insoluble, well graded, rock fill to minimize voids. The maximum size fraction should not exceed 200 mm. Waste rock from underground development is generally suitable, provided it is free from wood, debris and any chemical or hazardous materials.

Cover Soil: Overburden or local native till which is suitable to sustain vegetation.

Tool/Equipment List

Excavator or backhoe
Shovel

Installation/Construction

Vertical Shafts, Inclined Shafts, Raises and Subsidence Features

- Remove any debris and refuse from around the shaft or subsidence feature as safe conditions permit. Do not enter an abandoned mine shaft, raise or subsidence feature, although, it may be possible to retrieve some debris and refuse from the opening using a backhoe or excavator bucket.

- Place rip-rap in the bottom of the opening to a height that extends above the roof of any intersecting tunnels. Depending upon the depth of the opening, a minimum height of 4 m of rip-rap is recommended. In deep or water-filled openings, fill with rip-rap until the fill is visible from the edge of the opening.

- Fill the remainder of the opening with a graded rock fill from on-site sources if available (waste rock), or a similar rock from a local source. Place the rock fill in 600 mm lifts and compact if possible, until the fill reaches the surface. A minimum thickness of 1.5 m of rock fill is recommended.

- Mound the surface over the rock fill using overburden or native till to a minimum one metre height to allow for settlement, and grade the perimeter down to the original ground level at a gentle slope to allow for drainage. A minimum 2:1, horizontal to vertical slope is recommended.

- Vegetate the mounded area with a suitable vegetation cover to reduce erosion and water seepage through the backfill.

Material Quantity Estimates

To determine the fill quantities, it is necessary to know the depth and dimensions of the vertical opening. For shafts, information and plans may be available from the Nova Scotia Department of Natural Resources. For non-flooded shafts, if conditions are safe, it may be possible to measure the depth of shallow openings by lowering a measuring tape and multiply the depth by the area of the opening. For deep or flooded shafts where no information is available, it may be impossible to calculate the fill requirements. Any intersecting tunnels will also result in the requirement for extra fill.

For subsidence features, the required volume of fill will depend upon the extent of subsidence and the size and shape of the opening into which the surface is subsiding. Volumes are very difficult if not impossible to estimate in these cases. Continued subsidence may also result in the requirement to add additional fill over time. These openings typically require repeated filling and regular monitoring and inspection to check for continued subsidence.

Because volumes of abandoned mine openings are often difficult or impossible to determine, fill should always be placed into the openings in small quantities. This will ensure that the fill will not arch or bridge across the opening, resulting in unfilled areas below the blockage. Should this happen and the arch release, an open hole can suddenly appear at surface.

Adits, Declines and Slopes

- Scale down or support any loose rock above and beside the entrance or on the roof and walls of the opening as appropriate.

- Clear away any vegetation, debris and other refuse from around the entrance and/or inside the opening over the distance to be backfilled.

- Clear the floor of loose rocks and debris, and if required, install a schedule 60 galvanized steel or PVC drainage pipe. The drainage pipe should extend a minimum of 1.5 m past both ends of the backfill and be a minimum of 100 mm in diameter. Prior to backfilling, the drainage pipe should be covered with a minimum 150 mm of compacted fill.

- Construct a bulkhead inside the opening where the end of the fill is planned to provide a backstop against which the fill can be pushed.

  The bulkhead should be positioned to permit filling for a minimum of 5 m into the opening. This distance will vary based on the size and condition of the opening, the amount of fill available and the type of equipment utilized.

- Backfill the opening with a well graded rock fill to minimize voids and settlement intermixed with 50 to 75 kg boulders to discourage people digging into the backfill. The fill should be pushed along the full length of the backfilled section and to within 75 mm of the top of the opening.

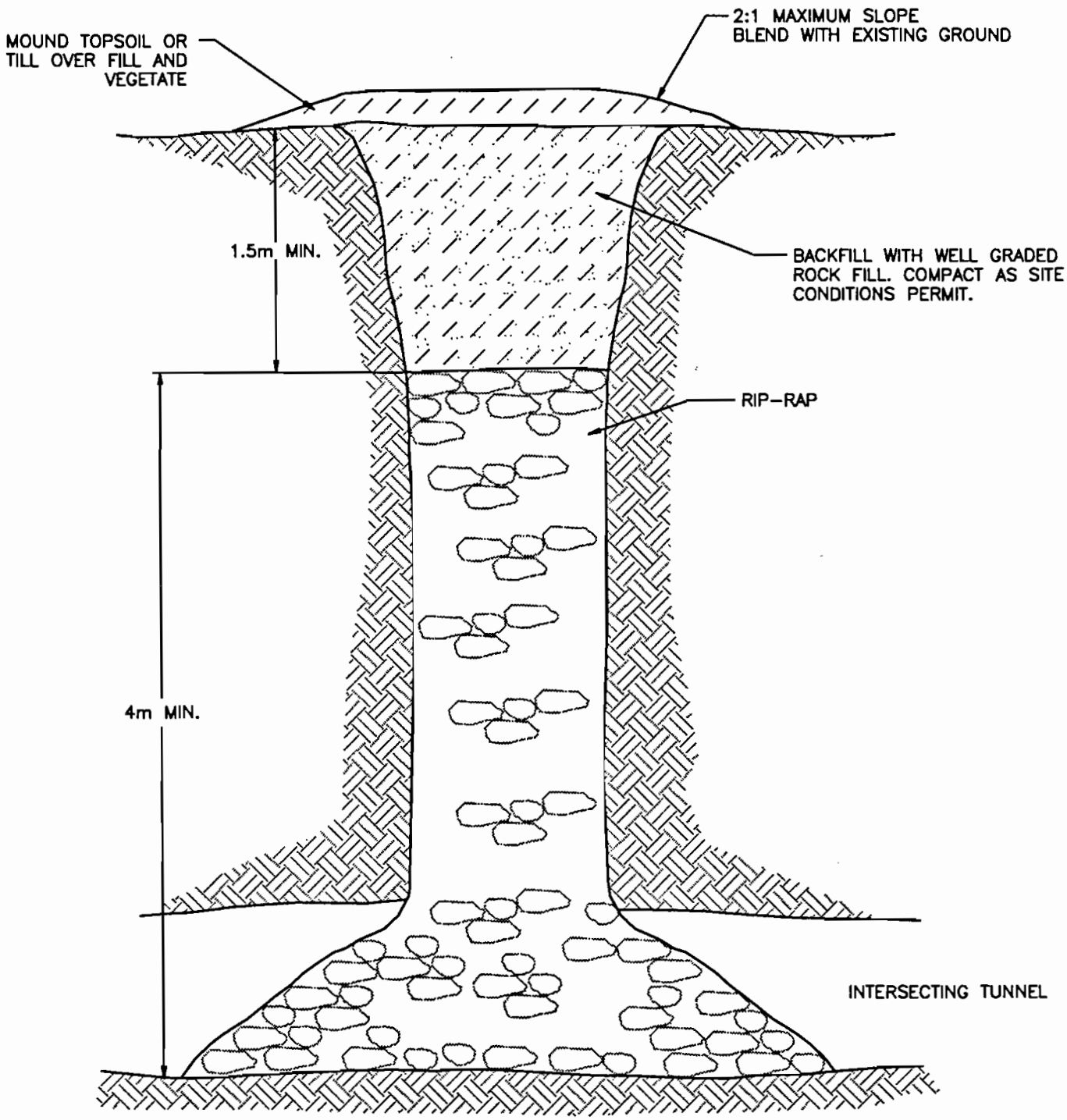
  Once backfilled, the fill should be extended past the entrance of the opening for a distance which is at least two times the height of the entrance of the opening. Fill should also extend over the top of the entrance a minimum of one metre to compensate for settlement. The fill used to seal the entrance should also be well mixed with 50 to 75 kg boulders to reduce erosion and discourage people from digging into the backfill.

- The fill outside the entrance should be covered with rip-rap to reduce erosion or alternatively with native till to permit revegetation. To reduce the impact of erosion the slope of the fill should not exceed a 2:1 slope.

Material Quantity Estimates

Fill quantities can be determined by multiplying the length of opening to be filled by the average area of the opening, plus the amount of fill required to seal the entrance.

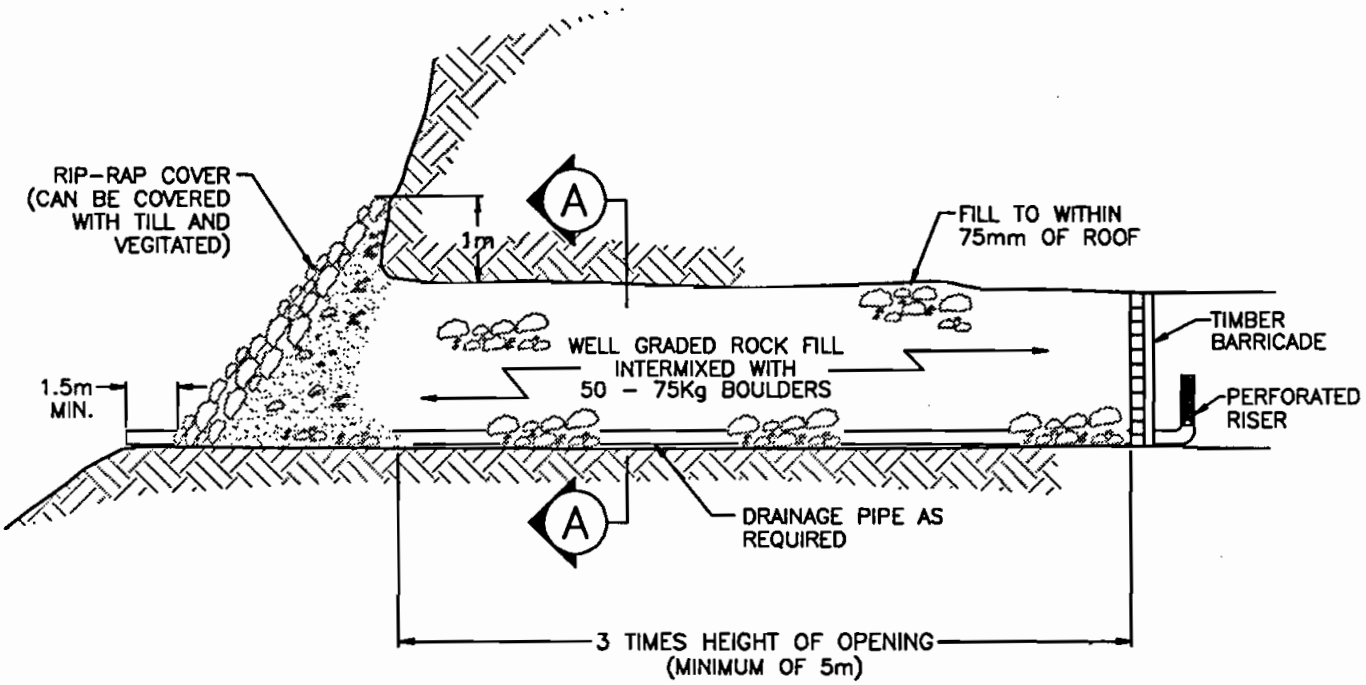
SHAFT BACKFILL ENCLOSURE
REFERENCE DRAWING No.8



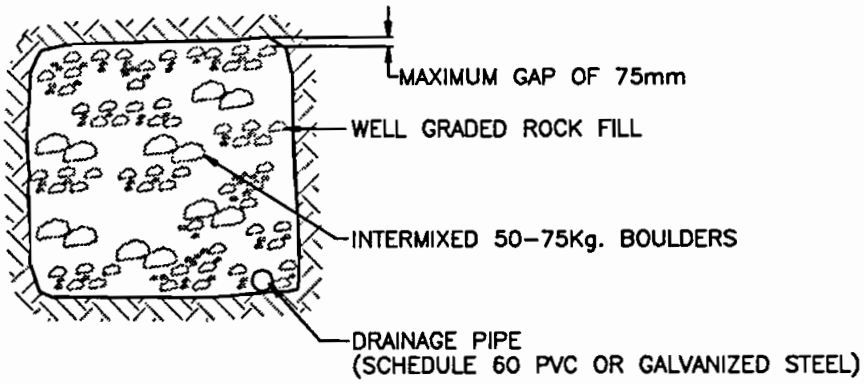
NOTE:

1. REMOVE ANY WOOD, TIMBER, DEBRIS AND REFUSE FROM SHAFT OPENING AS SAFE CONDITIONS PERMIT USING AN EXCAVATOR OR BACKHOE BUCKET.
2. DO NOT ENTER AN ABANDONED SHAFT, RAISE OR SUBSIDENCE FEATURE TO RETRIEVE ANY MATERIALS.

ADIT BACKFILL CLOSURE
REFERENCE DRAWING No.8A



SECTION ALONG OPENING



SECTION A-A
ABANDONED MINE OPENING FILLED WITH
WELL GRADED ROCK FILL

BAT GRATE

Materials

Steel: Frame - 75 mm X 75 mm X 6 mm inch angle iron

Grates - 600 mm long by 20 mm diameter steel rod or rebar

Tool/Equipment List

Wrenches, hammer
Welder and cutting torch

Fabrication

The bat grate should be fabricated from angle iron and steel bars to create a sequence of 75 mm high by 600 mm long openings which will extend from the ceiling to the floor of the mine opening. The grate should be constructed by welding the steel rod or rebar at 100 mm centers, to a vertical angle iron frame. The two sections of angle iron should be positioned parallel, 600 mm apart.

Installation

- The bat grate should be installed within an opening cut into a steel grate closure frame. The bat grate must be installed in a vertical orientation, such that the steel bars or rebar extend horizontally. The bat grate should be welded into the steel grating frame, although it could also be bolted into position. If bolts are used the nuts should be rounded or the threads damaged to prevent removal.

- Paint the steel bat grate and any other bare steel with a zinc-rich protective paint.