TECHNICAL SPECIFICATION

ROADS, PAVING, SURFACING, SLOPE PROTECTION AND FENCING

DEP 34.13.20.31-Gen.

April 1983

DESIGN AND ENGINEERING PRACTICE

USED BY

COMPANIES OF THE ROYAL DUTCH/SHELL GROUP

PREFACE

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1. INTRODUCTION

1.1 GENERAL

This specification is a revision of an earlier publication entitled `Roads, paving and fencing', dated March 1972, which was cancelled with DEP circular 27/82. It defines minimum requirements for design and construction of the subjects referred to in (1.2).

It is intended for use in oil refineries, chemical plants, gas plants etc. related to manufacturing activities and, where applicable, in exploration and production.

Unless otherwise authorized by SIPM, the distribution of this specification is confined to companies belonging to or managed by the Royal Dutch/Shell Group, and to contractors nominated by them under cover of a secrecy agreement.

As a general rule the requirements of the national and/or local regulations shall be adhered to, but if these are less stringent than the requirements of this specification, the latter shall prevail.

Where regulations are more stringent than the requirements of this specification, the supplier and/or contractor shall inform the principal, who may negotiate with the authorities concerned, in order to obtain agreement to follow this specification as closely as possible.

Each section in this specification is self-contained. A sub-section `General minimum requirements' (1.4), which is applicable to all subjects, is followed by several sections which describe specific requirements for individual subjects.

Each section is sub-divided in the following clauses:

- detailed scope
- general description
- functional requirements
- design and materials
- construction
- references.

In certain cases, clauses are combined or omitted.

Where cross references are made, the number of the section or sub-section referred to is shown in brackets.

1.2 SCOPE

This specification covers only design and construction of:

- roads
- paving
- surfacing of unpaved areas
- cable trenches
- erosion protection of slopes, e.g. bund walls, embankments, ditches, open drains, etc.
- fencing and gates.

The earthworks described herein are limited to those above the sub-grade, so where a functional minimum requirement for a sub-base/foundation exists, it will be provided without further discussion.

Geotechnical and foundation engineering aspects, including stability of slopes, roads, bund walls, tank pits and tank pads, including their surfacing, etc., are not within the scope of this publication. For those aspects, reference is made to DEP 34.11.00.11-Gen.* and DEP 34.11.00.12-Gen.*

* In the course of preparation

Sub-grade is defined as the soil or rock generally prepared and compacted to support for example a structure, a road or a pavement system.

1.3 DEFINITIONS

General definitions

For the purpose of this specification the following definitions shall apply:

Shall and **Should** - the word `shall' is to be understood as mandatory and the word `should' as non-mandatory, advisory or recommended.

The **Principal** is the party which initiates the project and ultimately pays for its design and construction.

The Principal will generally specify the technical requirements.

The **Contractor** is the party which carries out all or part of the design, engineering, procurement, construction and commissioning for the project. The Principal may sometimes undertake all or part of the duties of the Contractor.

Technical definitions (see Fig. 1.1)

Site

Area where oil-, gas-, chemical- or coal facilities, plant complex or a terminal incl. harbour facilities is projected, comprising the total of all on-plot and off-plot areas.

On-plot areas

Area(s) (to be) occupied by utility- and processing units, including associated control rooms, electrical sub-stations, analyser houses, cooling towers, stacks, interconnecting pipe tracks, flares and plant roads.

Off-plot areas

Area(s) where administration buildings, workshops, laundries, warehouses, materials yards, storage tank compounds, pump stations, fire-fighting station, training grounds, cooling water intake station, cooling water settling ponds, cooling water discharge channels, jetties, harbour, pipe tracks and main roads are located.

Battery limit

Operational boundary of individual processing unit or utility block.

Sterile zone

Area around e.g. flares, burn(er) pits. An area designated to one kind of activity. This area should be free of other equipment and/or activities not related to the specified unit.

Laydown area

Clear areas inside battery limit reserved for laying down process equipment parts during erection in the construction phase or for maintenance overhaul.

Contractor's area

Off-plot space which is reserved for construction activities, storage of construction materials and equipment, assembly, painting, fabrication, temporary contractor's offices. Different areas might be allocated for construction and operation.

1.4 GENERAL MINIMUM REQUIREMENTS

The minimum technical requirements as laid down in this specification shall be applied in the design and construction of items as listed in (1.2).

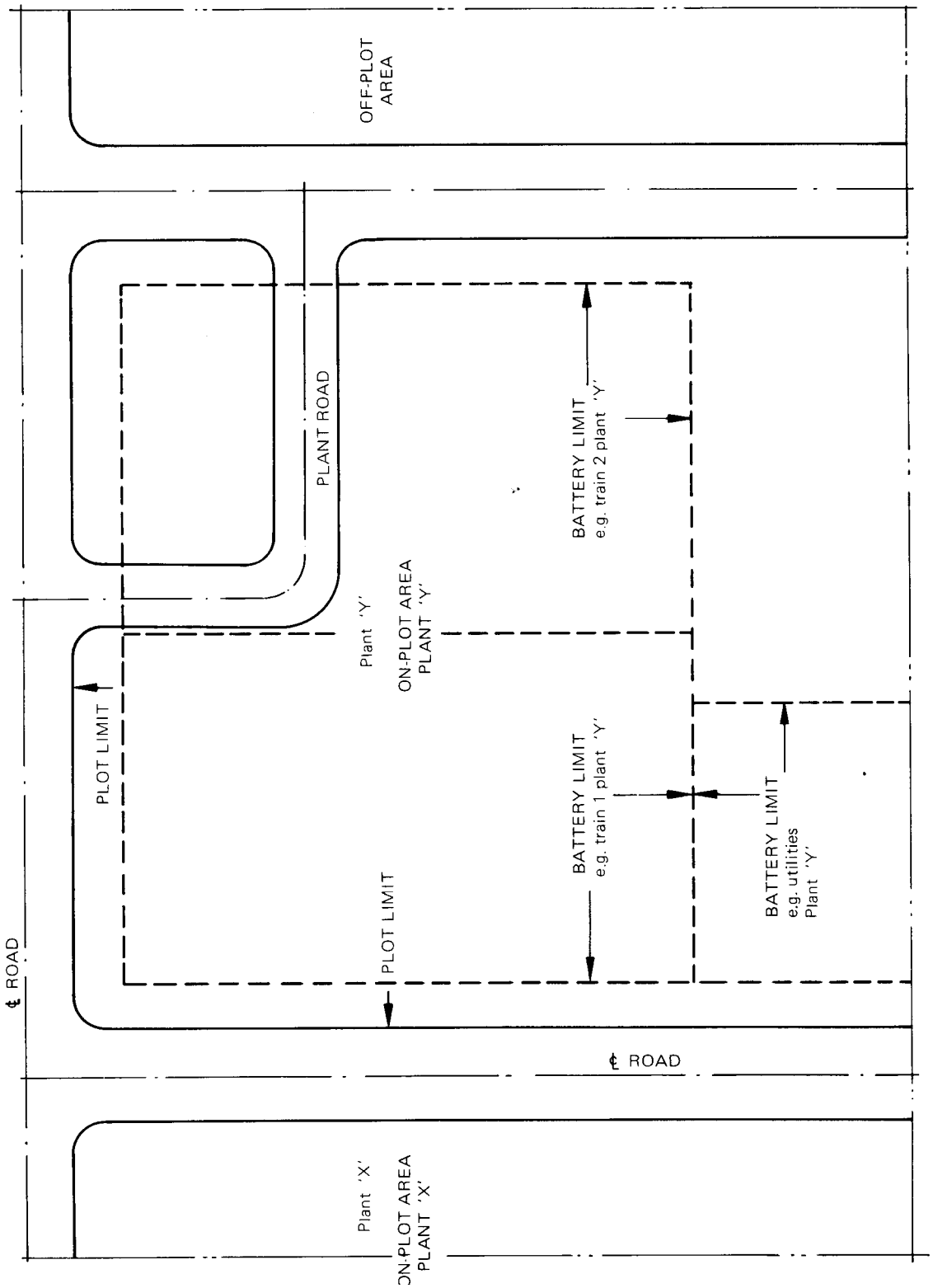
Supplementary to these requirements, the design and construction shall be in accordance with generally accepted theories, codes, methods and good working practices. Examples of acceptable codes are mentioned in this publication.

Local climate, topography, soil conditions and other local requirements shall be taken into

account for design and construction as well as specific plant requirements.

Equipment, materials and working methods shall be approved by the principal.

Fig 1.1 DEFINITIONS OF TERMS USED



2. ROADS

2.1 DETAILED SCOPE

This section contains minimum requirements for permanent roads and bridges within the property/lease boundaries of an oil refinery, chemical plant, gas plant, etc. Sub-grade requirements, including stability, embankments, etc., are not included but highlighted only. For these aspects, reference is made to DEP 34.11.00.11-Gen. and DEP 34.11.00.12-Gen.

Permanent road types and minimum widths are listed below:

	Width
main roads	8 m
plant roads	4/6 m
off-plot heavy-duty roads	6 m
off-plot light-duty roads	4 m
patrol roads	3 m
maintenance tracks	to suit

2.2 GENERAL DESCRIPTION

Roads generally comprise:

- a sub-grade
- a (sub)-base
- paving.

A (sub)-base is required if the settlement behaviour and/or the bearing capacity of the sub-grade is insufficient to support the paving and traffic without excessive deformations or maintenance during the lifetime of the plant. Roads shall be of the two-lane type, except for maintenance tracks, patrol roads and other roads as specified by the principal. Each road shall be provided with road shoulders on both sides, except for maintenance tracks and patrol roads. Terms are defined and typical cross sections of roads are shown in Fig. 2.1.

Shoulders shall be able to support without damage slow-moving and parked vehicles for which the road is designed.

2.3 FUNCTIONAL REQUIREMENTS

The functional requirement for all roads/tracks is to provide:

- a safe and reliable access to all locations of the site for those transport means (cars, trucks, cranes and other mobile equipment) which are required at those locations during the lifetime of the plant
- a safe and reliable access to all installations/buildings for fire-fighting equipment and other emergency vehicles as intended to be used for the site under consideration via at least two independent routings under all conditions; see DEP 80.47.20.30-Gen.

2.4 DESIGN AND MATERIALS

2.4.1 General

Roads on which a hydrocarbon (or chemical) spillage is expected during the lifetime of the road, shall be surfaced with chemical-resistant (concrete)-type paving. For on-plot roads concrete is generally used, for off-plot roads bituminous-type flexible paving. From a civil engineering point of view a flexible-type paving is preferable under all circumstances.

Design, materials and testing procedures, etc. shall be in accordance with generally accepted standards and codes.

Crash barriers (2.4.8) shall be provided as proposed and agreed with the principal.

2.4.2 Interface site preparation

The design of the sub-grade shall be based on the result of a geotechnical (soil mechanical and geohydrological) survey, including calculations and determination of the grain-size distribution/sit content, plasticity index, friction properties and permeability. Average, high and the highest possible ground water level as well as the in-situ permeability shall also be considered.

Acceptance of the sub-grade and (sub)-base before surfacing, shall be based on the design requirements and resulting criteria. Examples of suitable tests, as far as compaction is concerned, are CBR*, plate bearing test, static cone penetration test (DCPT**) or in-situ density tests in accordance with ASTM, BS or equivalent standards.

* California Bearing Ratio

** Dutch Cone Penetration Test

Interpretation of test results shall take into consideration the maximum moisture content of the (sub)-base/sub-grade material that is considered representative for the operating situation.

Measures shall be taken to prevent intrusion of sub-grade material into the (sub)-base.

2.4.3 Heavy- and light-duty roads

Heavy- and light-duty roads paving shall be designed to the `AASHTO interim guide for design of pavement structures' or equivalent standard as acceptable to the principal. Design factors, which are prescribed by - but not quantified in - the above guide, shall be proposed to and agreed with the principal. In the case of the AASHTO publication, the design factors include:

- (normally) high ground water level
- non uniform soil support (settlement/differential settlements sub-grade)
- soil support value S (flexible paving)
- equivalent 80 kN single-axle loads
- regional factor
- modulus of sub-grade reaction value K (rigid paving)
- working stress of concrete (rigid paving).

The terminal serviceability index for heavy and light-duty roads shall be 2.5 and 2.0 resp. as defined in the AASHTO publication. The concrete working stress as defined in this publication may be derived from the standard splitting strength, see DEP 34.19.20.31-Gen.

The axle loads and arrangement of vehicle dimensions for heavy- and light-duty roads are defined in Fig. 2.2.

The road construction (i.e. sub-base and paving) shall be adequately supported horizontally either by a sufficiently paved berm or by a vertical retaining element, e.g. concrete kerb.

The roads listed below shall be of the heavy-duty type:

- main roads on site and all roads in and around processing units, utility areas and yards
- roads to and around main buildings and loading facilities
- main access roads to the site.

Light-duty roads comprise all other roads on site except:

- patrol roads (2.4.4)
- maintenance tracks (2.4.5).

Road width depends on size of heavy equipment to be transported, but shall be at least 6 m wide (access roads 8 m); light-duty roads shall be 4 m as indicated under (2.1). Road shoulders on either side shall have a minimum width of 2 m for heavy and 1.5 m for light-duty roads.

The boundary between the road and road shoulder shall be clearly marked with lines or a kerb. Openings shall secure the dewatering of the road surface.

The crown of all heavy-duty and on-plot light-duty roads shall be 150 mm above highest point of paving. The paved areas adjacent to the roads shall have a smooth transition to the edge of the roads. The slope in longitudinal direction of heavy-duty roads shall be 1 in 20 maximum and for light-duty roads 1 in 10.

Flexible pavings shall have a minimum thickness of 50 mm.

The rigid paving for heavy-duty roads shall have a minimum thickness of 250 mm and 150 mm for light-duty roads.

2.4.4 Patrol roads

Patrol roads shall be designed to accommodate under all relevant climatic conditions vehicles with a maximum weight of 5 tons. Minimum width shall be 3 metres. Maximum slope shall be 12%. Patrol roads shall be paved with a flexible-type paving.

2.4.5 Maintenance tracks

Maintenance tracks specified by the principal to facilitate access to (yet) unused areas within the property/lease boundary, shall be accessible for 4-wheel drive-type vehicles under normal weather conditions. Vegetations, peat and soft clays shall be removed. Maximum slopes shall not exceed 12%. Surfacing is not required.

2.4.6 Road crossings

Roads should cross at an angle of 90 degrees.

At road crossings the edge of the paving shall have a radius of curvature of:

7.5 m for 4-m wide roads
10 m for 6-m wide roads
12 m for roads with a width of 8 m or more.

For crossings of roads of unequal width, the narrower road shall determine the radius of the curvature.

All circular edges of a heavy-duty road crossing shall be in one horizontal plane.

2.4.7 Bridges, culverts and pipe crossings underneath roads

Design considerations for this specification are limited to those which interfere with road design. The following axle loads shall be allowed for:

- heavy-duty roads
  A tandem axle load of 150 kN at the front of a car combined with an axle load of 150 kN at the rear, see Fig. 2.2.
- light-duty roads
  2 axles of 50 kN each, 2 wheels at a distance of 2 m, axle to axle distance 3 m, see Fig. 2.2.

- a minimum distance of 0.5 m shall be provided between (pipe) bridges, pipelines, crossings, etc.

Special load requirements for specific (future) duties, including construction requirements, shall be considered separately.

2.4.8 Crash barriers

Crash barriers shall be applied where considered essential to protect personnel and/or equipment and piping. For example road crossings over and under pipe(t)racks, roads close to pipe(t)racks, roads adjacent to (steep) slopes, T-junctions, (sharp) bends.

The preferred crash barrier system consists of I-beams, steel supports embedded in the soil at 3 m distances to carry a guard-rail of 0.75 m minimum height. The steel should be galvanized.

The system shall be able to absorb impact energy by deformation without collapse.

2.4.9 Exceptional transport on existing roads

Transport vehicles carrying exceptionally heavy equipment shall be chosen as extreme loading conditions in the design of roads (including culverts and bridges). If these are not acceptable, an adequate solution shall be agreed with the principal.

2.4.10 Drainage

The drainage of roads comprises surface run-off and sub-surface drainage systems.

2.4.10.1 Surface drainage

The road surface shall have a minimum lateral slope of 1:50 to provide proper drainage under all weather conditions. Ditches and collectors along the roads shall form an integral part of the surface drainage system of the site. For surface drainage system, reference is made to DEP 34.14.20.31-Gen.

Open ditches and channels along roads in on-plot areas shall be concrete-lined. The need for lining of ditches and channels along other roads depends on the possibility of spillages and erosion sensitivity of the (sub)soil.

2.4.10.2 Sub-surface drainage

The subsoil under the road paving system shall be well drained.

The distance between underside paving and (normal) high ground water level shall be not less than:

main roads	0.75 m/1 m
plant roads	0.50 m/0.75 m
off-plot heavy-duty roads	0.50 m/0.75 m
off-plot light-duty roads	0.50 m/0.75 m
patrol roads	0.30 m/0.50 m

In the event of a rocky sub-grade the highest ground water level shall be taken as the rocky sub-grade level. This applies only when the distance between rock level and underside paving is less than above specified values.

The necessity of a permanent sub-surface drainage system shall be investigated to ensure

- the control of the ground water level with regard to the above stated minimal distances
- a proper drainage of the subsoil under and adjacent to the road.

The influence of unlined drain ditches, lined drain ditches and channels with weep holes on the ground water table shall be taken into account.

The risk of clogging of a system should be minimal.

2.4.10.3 Roads crossing (natural) drainage systems

Roads often interfere with the natural drainage of areas or existing drainage systems. If so, the (natural) drainage shall be restored, e.g. by means of culverts, ditches, rerouting of water courses, etc. Design shall be based on extreme conditions, e.g. rainfall (intensity of a storm with a recurrence period of 30 years) and, if appropriate, on the result of a hydrological survey.

(Rain)water from outside the fence shall be diverted in consultation with the principal to prevent its (uncontrolled) passing through the site.

2.5 CONSTRUCTION

It shall be ensured at any time that all parts of a site are accessible.

In a large-size construction project, it is recommended that a traffic flow scheme is developed, indicating the routes to be used by the individual (sub)-contractors.

Where practicable, construction roads shall coincide with the location of permanent roads in order to improve the permanent road sub-grade.

Materials used for the construction of (sub)-base shall be well-graded, well draining and easy to compact.

2.6 REFERENCES

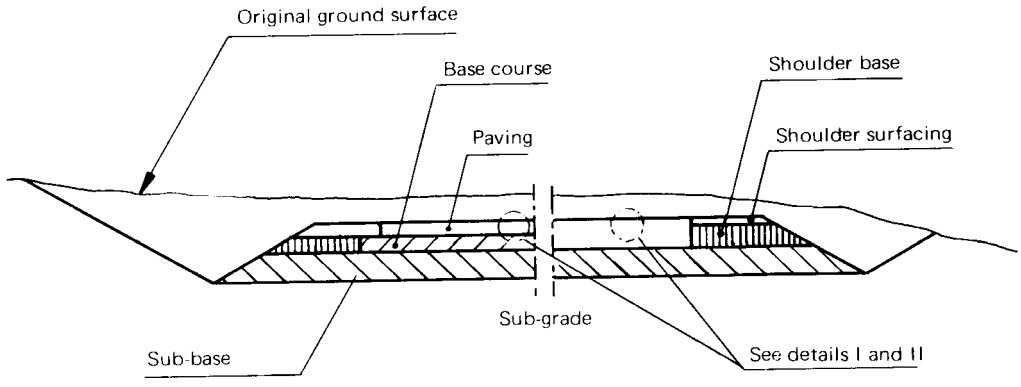
Site preparation and earthworks	DEP 34.11.00.11-Gen.*
Geotechnical and foundation engineering	DEP 34.11.00.12-Gen.*
Refinery drainage systems	DEP 34.14.20.31-Gen.
Reinforced concrete foundations and structures	DEP 34.19.20.31-Gen.
Trucks and trailers for fire fighting	DEP 80.47.20.30-Gen.

* In the course of preparation

AASHTO interim guide for design of pavement structures

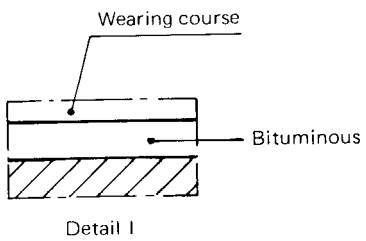
Issued by
the American Association of
State Highway and Transport Officials.
341 National Press Building.
Washington, DC 20045, USA

Fig. 2.1 CROSS SECTIONS OF ROADS

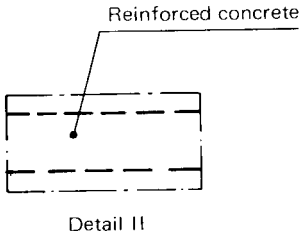


Flexible **Rigid**

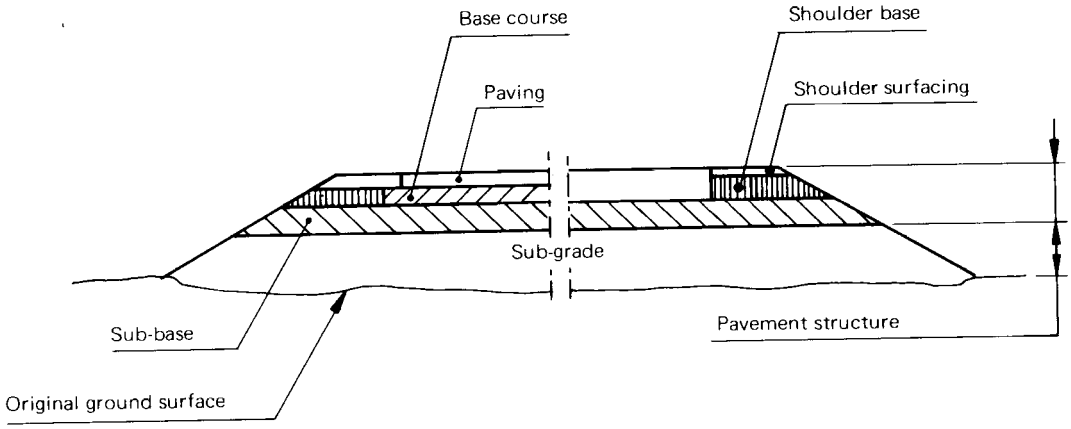
Typical cut section



Flexible paving



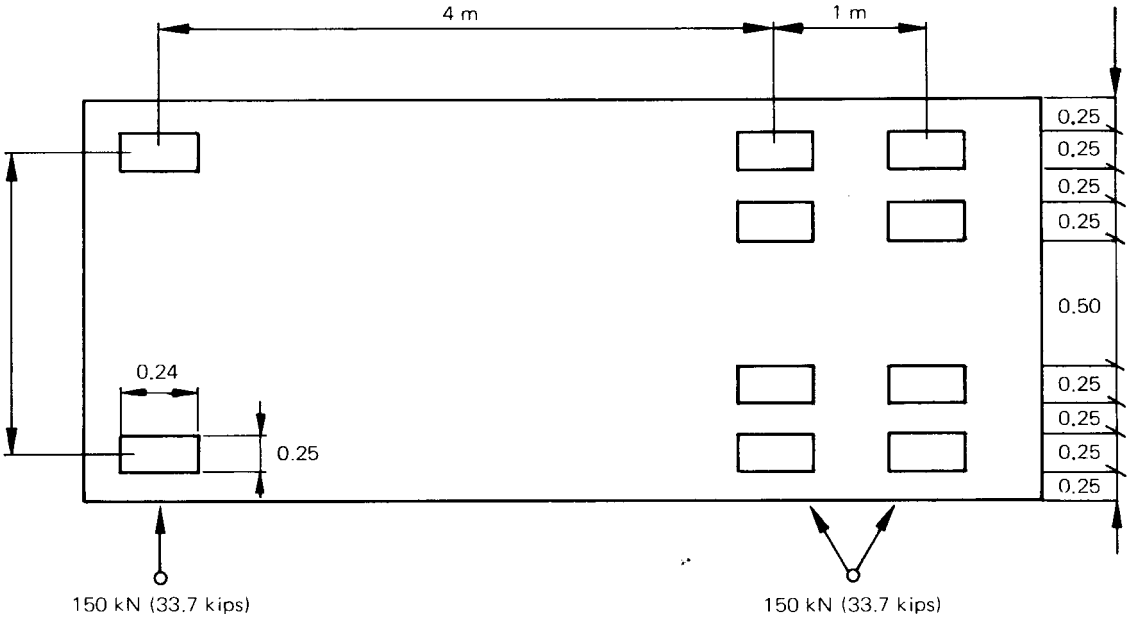
Rigid concrete paving



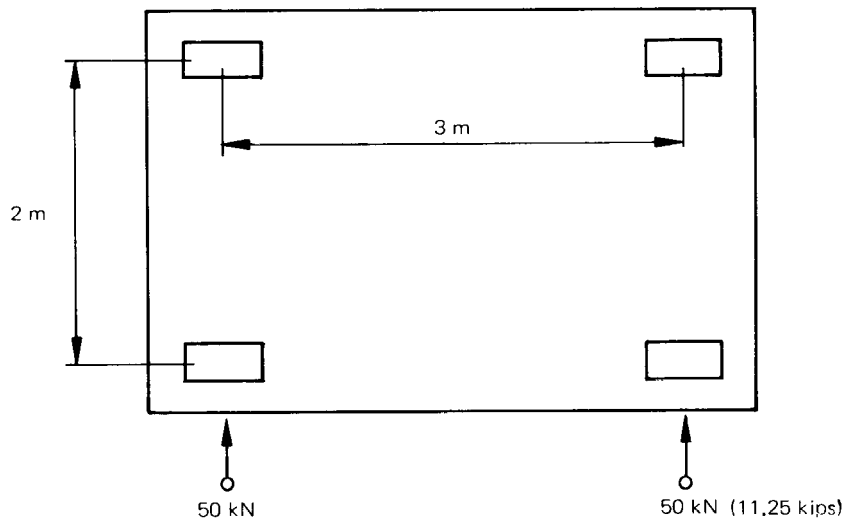
Flexible **Rigid**

Typical fill section

Fig. 2.2 AXLE LOADS AND VEHICLE DIMENSIONS



On heavy-duty roads



On light-duty roads

3. PAVING

3.1 DETAILED SCOPE

This section describes the minimum requirements for paved areas, e.g.

- plant areas
- material yards
- cleaning yards
- parking areas
- pump slabs
- parts of on-plot pipe(t)racks which contain flanged connections, valves or sampling points.

Paving is generally limited to those parts of a site where spillage of chemicals or hydrocarbons from (mis)operations and maintenance cannot be excluded, or where loads other than personnel on foot shall be accommodated.

3.2 GENERAL DESCRIPTION

Paving consists of a reinforced concrete layer i.e. the pavement slab which rests on the sub-grade prepared during the site preparation. A sub-base to support the paving may be required depending on the sub-grade. Typical cross sections of standard light- and heavy-duty paving are shown in Fig. 3.1. The paved areas are divided into slabs separated by expansion joints. Prevention of chemical spillage or hydrocarbons into the subsoil through the joints may be necessary.

In areas where light-duty paving is sufficient without the probability of a spillage, tiles or bricks may be acceptable.

3.3 FUNCTIONAL REQUIREMENTS

Functional requirements for paving areas are:

- provision of reliable and easy access of personnel and equipment for construction, operation and maintenance
- provision of a foundation base for light equipment, such as sheds, racks, ladders, stairs, pipe supports, etc.
- protection of the soil and the ground water against a spillage of chemicals incl. hydrocarbons
- prevention of erosion of the soil
- routing of spillages (water, chemicals, oil, gas) to sumps and drains.

3.4 DESIGN AND MATERIALS

3.4.1 Paving classification

Paving is classified as follows:

- light-duty paving (standard)
- heavy-duty paving (standard)
- special paving.

3.4.2 General

The application of standard light- or heavy-duty paving is preferred. Only if functional requirements (3.3) cannot be met by standard paving, or when special paving shall be designed specified by the principal.

3.4.3 Site preparation interface

Reference is made to DEP 34.11.00.11-Gen. and DEP 34.11.00.12-Gen.

The sub-grade shall be prepared prior to the construction of the sub-base and the paving. If required, the prepared sub-grade shall be tested to verify whether e.g. the compaction satisfies the requirements. Suitable tests are plate-bearing test, in-situ density tests, shallow

DCPTs, CBR, etc., in accordance with ASTM, BS or equivalent standards.

Measures shall be taken to prevent intrusion of sub-grade material into the (sub)-base layer(s) of the pavement structure.

3.4.4 Calculation method

Paving slabs shall be designed in accordance with accepted rational methods, e.g. modified Westergaard's formulae. The minimum axle loads are defined in Fig. 2.2.

A modulus of sub-grade reaction is normally used to represent all soil supporting the concrete paving slabs. To determine or to verify the modulus, the standard plate bearing test, with a 762 mm (30 in.) diameter plate, shall be used. For other diameters or methods the results shall be corrected to obtain a value comparable with the standard method.

The calculated concrete tensile stresses shall be lower than the working stress for the selected concrete grade. The working stress shall be taken as 75 times the concrete flexural tensile strength. It depends on the height of the test sample and is defined by AASHTO T-97.The flexural strength can be derived from the standard splitting strength, see DEP 34.19.20.31-Gen.

The function of steel wire fabric reinforcement is to prevent uncontrolled cracking due to stresses resulting from sliding of the slab and not to contribute to the actual tensile strength of the paving. When the contribution of the reinforcement is considered this shall be based on the linear elastic stress theory.

The design of the wire mesh shall take into account the maximum friction forces due to sliding. The forces are dependent on slab base friction and weight of the slab only.

Apart from the sub-grade reaction the consequences of (short- and long-term) settlements and differential settlements shall also be taken into consideration.

Locations of contraction/expansion joints shall be selected similarly to and together with slab reinforcements to prevent uncontrolled cracking as a result of shrinkage, thermal expansion/contraction, natural changes in moisture content and other conditions (acceptable tensile strain .015 percent).

Special paving may be required to support higher loads or to satisfy additional requirements. The design principles shall be the same as described above. Alternative methods shall require principal's approval.

3.4.5 Standard light- and heavy-duty paving (See Fig. 3.1)

Standard light- and heavy-duty paving shall be made of grade 25 concrete in accordance with DEP 34.19.20.31-Gen. and shall suit local soil conditions, e.g. application of a special cement type.

For light-duty paving the layer thickness shall be 100 mm and the minimum reinforcement, one layer of 7 mm steel wire fabric 200 x 200 mm, material A 193 in accordance with BS 4483 or equivalent.

For heavy-duty paving the layer thickness shall be 150 mm and the minimum reinforcement, two layers of 7 mm steel wire fabric 200 x 200 mm, material A 193 in accordance with BS 4483 or equivalent.

3.4.6 Expansion and contraction joints

Expansion joints shall be provided between two adjacent slabs. Generally, no dowels are required and the joint comprises a gap of sufficient width to cater for local temperature differentials. It shall be filled with an elastic joint filler and sealed with a chemical-resistant sealant.

Contraction joints shall be spaced not more than 10 m apart. Maximum slab size shall be 20 x 20 m^2.

3.4.7 Drainage

For drainage aspects, see DEP 34.14.20.31-Gen

Paving shall have a minimum slope of 1:100 with the exception of paving under e.g. LPG spheres, furnaces, which shall slope 1:50.

3.5 CONSTRUCTION

A sub-base shall have a minimum thickness of 250 mm and shall be made of well draining, well graded, uniformly compacted, granular material.

Waterproof building paper, polyethylene sheeting or equivalent material shall be laid before placing the reinforcement and pouring the concrete to prevent absorption of water into the base. This material shall be thoroughly clean.

The concrete shall be thoroughly densified applying a vibrator or other suitable equipment.

After pouring and finishing, the concrete shall be prevented from drying for at least seven days. The minimum of 7 days curing may be achieved by application of a curing compound.

Steel reinforcement shall have a minimum cover of 40 mm and if only one layer is required this shall be placed at 0.6 times the slab thickness above the bottom satisfying the cover requirements.
For aggressive environments (chemical attack), an increased cover is required and shall be agreed with the principal.

Minimum acceptable concrete grade is 25. See DEP 34.19.20.31-Gen.

3.6 REFERENCES

Site preparation and earthworks	DEP 34.11.00.11-Gen.*
Geotechnical and foundation engineering	DEP 34.11.00.12-Gen.*
Refinery drainage systems	DEP 34.14.20.31-Gen.
Reinforced concrete foundations and structures	DEP 34.19.20.31-Gen.

* In the course of preparation

Steel fabric for the reinforcement of concrete	BS 4483

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2 Park Street, London W1A 2BS,
England

AASHTO interim guide for design of pavement structures

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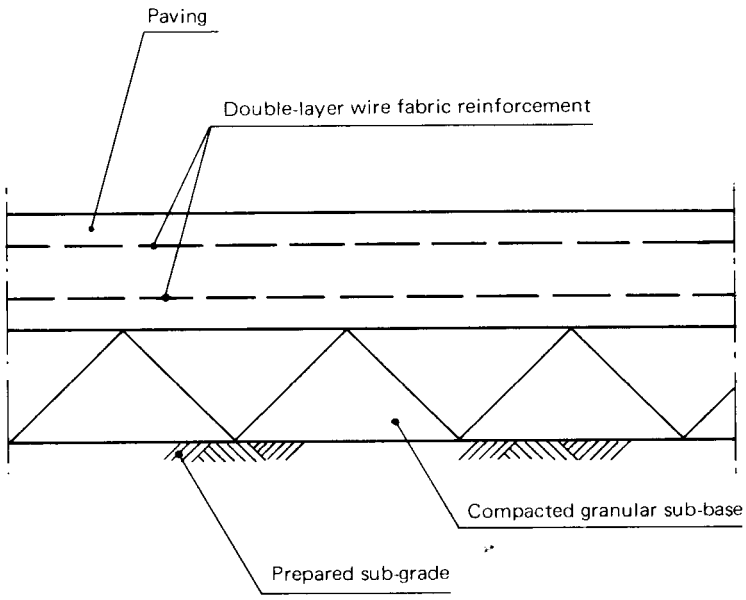
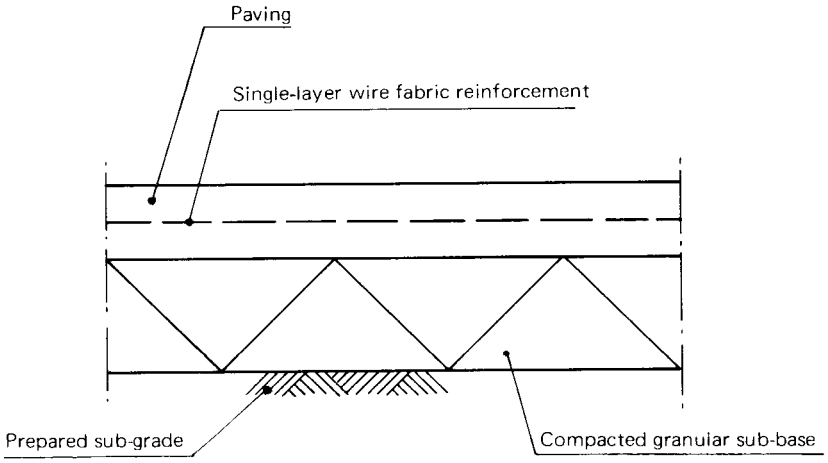
State Highway and Transport Officials,
341 National Press Building,
Washington, DC 20045, USA

Fig. 3.1 SECTIONS OF STANDARD PAVING



Typical section heavy-duty reinforced concrete paving



Typical section light-duty reinforced concrete paving

4. SURFACING OF UNPAVED AREAS

4.1 DETAILED SCOPE

This section describes minimum technical requirements for the surfacing of those areas within the boundary fence, which do not require paving.

These areas are generally limited to those parts of a site where no hydrocarbon (chemical) spill is expected, and where the surface normally does not need to support loads other than personnel on foot.

Examples of these areas are:
- the zone between inner and outer fence
- flare and liquid burner areas, except the plots where equipment is located
- administration and other landscaped areas
- off-battery areas which are not used (future construction, safety zones, etc.)
- tank pits excluding areas around (and underneath) pressurized gas storage which shall be paved
- off-battery pipe(t)racks which contain no flanged connections, valves or sample points.

4.2 FUNCTIONAL REQUIREMENTS

Surfacing of unpaved areas shall fulfill to:
- prevent soil erosion by wind and water
- be able to support people on foot and light vehicles i.e. land rover type
- keep the subject area clear of undesirable vegetation.

4.3 DESIGN

The surfacing shall be durable and shall have minimal maintenance requirements. In the case of a fire it shall be preferably inert or self-extinguishing. The ground water shall not be polluted, if necessary, a drainage system shall be provided for.

Unpaved areas may be classified into 2 categories:

1. **Low-fire hazard,** e.g.:
   - neutral zone between fences
   - unused off-plot areas
   - off-plot pipe(t)racks which contain no flanged connections.

   Slow-growing grass is generally preferred. If an acceptable safety distance exists to the nearest fire hazard area, the principal may approve other forms of vegetation. For gardens and landscaping, requirements shall be specified by the principal.

2. **Fire-hazard,** e.g.:
   - flare and open fire areas
   - off-plot pipe(t)racks which do contain flanged connections, valves or sampling points, e.g. manifolds
   - areas around processing units.

   Pipe tracks shall have a 75 mm thick gravel cover.

   In all on-plot areas inert material, e.g. gravel is required in a layer thickness of at least 50 mm. Measures shall be taken to minimize growth of vegetation.

   Off-plot areas shall preferably be covered with slow-growing grass. Other types of surfacing, e.g. gravel, shall require principal's approval.

4.4 MATERIALS

Inert materials as mentioned in (4.3) shall be durable under local conditions. Crushed, sound rock, coarse gravel, sand-cement mixes and blast furnace slag is generally acceptable.

5. CABLE TRENCHES

This section is limited to general civil engineering minimum requirements only.

Cable trenches shall have a minimum depth of 600 mm for 1 layer of cables to a maximum of 1000 mm for 3 layers of cables. Trenches shall be filled with graded, non-angular, well draining, compacted sand free of sharp particles, e.g. sieved. Salty sand shall not be used unless specifically approved by the principal.

In paved and unpaved areas, cables shall be shielded by cable tiles at a depth of at least 350 mm below final grade. Under concrete paving no cable tiles are required.
In paved areas, trenches which need to remain accessible shall be covered with removable concrete panels. Panels shall be designed to the same standard as the surrounding paving.

If trenches in paved areas need not remain accessible, the permanent paving should be continuous.

The location of trenches shall be clearly indicated on the surface, by colour code in paved areas and by signs in unpaved areas.

Instrument trenches shall always cross at 90 degree angles with power and lighting cables. For the upper one a `bridge' comprising a concrete bottom slab supported on the walls of the lower trench shall be constructed to facilitate excavation of the lower cable trench.

Instrument trenches shall be apart minimum 0.6 m and maximum 2 m for at least 10 percent of the distance over which they run in parallel with trenches for power cables and lighting.

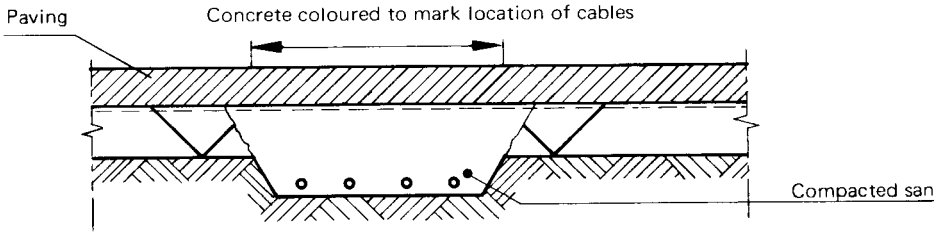
The bottom of trenches should be above the permanent ground water table.

The cables shall have a minimum distance of 0.3 m to buried pipelines. In the case of hot lines the pipe shall be insulated to limit the temperature at the outside to 60 °C maximum.

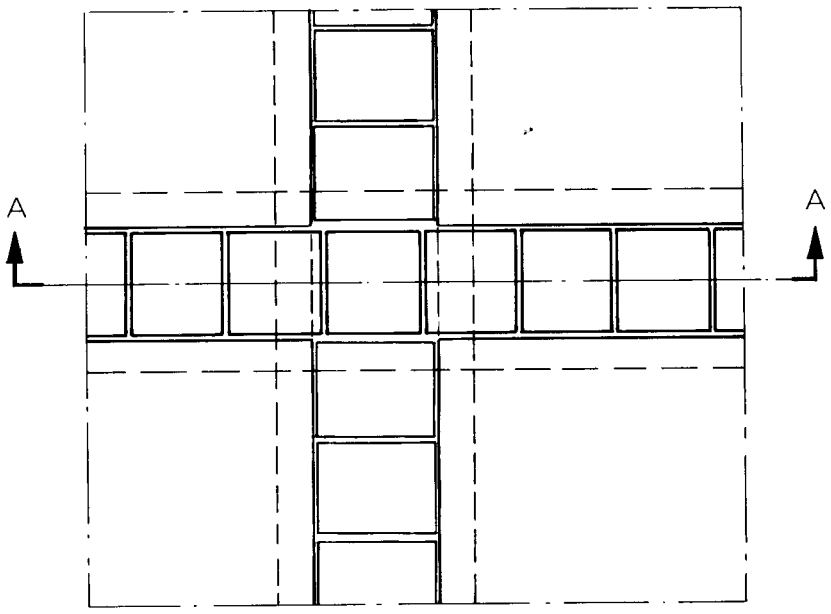
Cables should cross underneath buried pipelines.

Typical cross sections and lay-outs are shown in Fig. 5.1.

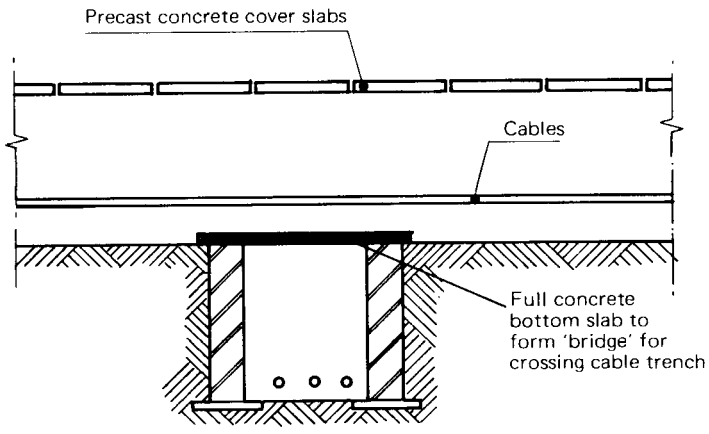
Fig. 5.1 CROSS SECTIONS AND LAY-OUT OF CABLE TRENCHES



Permanently covered cable routing



Top view of crossing cable trenches



Section A – A

6. EROSION PROTECTION OF SLOPES, EMBANKMENTS, DITCHES, OPEN DRAINS, ETC.

6.1 DETAILED SCOPE

The scope of this section is limited to erosion protection aspects.

Stability, settlement behaviour and construction of slopes, bund walls and embankments are covered in DEP 34.11.00.11-Gen. and DEP 34.11.00.12-Gen.

For ditches and open drains only material, design and construction aspects of the protective surface layer are considered.

Design and capacity requirements for drainage systems are covered in DEP 34.14.20.31-Gen.

6.2 GENERAL DESCRIPTION

Examples of erosion protection layers are:
- concrete slabs or blocks, mortar
- flexible asphaltic, bituminous products, e.g. sand bitumen mix
- impermeable polyethylene (or equivalent) clothing, anchored with tiles, brickwork, rock, etc.
- layer of (crushed) rock, gravel, tiles and brickwork, if required in combination with filter cloth
- grass.

A filter cloth shall be applied if a wash out of sand or sandy material is expected under the erosion protection layer (e.g. brickwork, joints of slabs, cracks in the protection layer, etc.) The possibility of cracking should also be considered.

6.3 FUNCTIONAL REQUIREMENTS

Slopes for example bund walls, cuts, embankments, open drains and ditches shall be protected against erosion and subsequent damage and failure on a micro scale as a consequence of wind, water, and spillages.

Protection against failure on a macro scale (slope stability) can be initiated but is not a function of erosion protection and not considered in this specification.

In the case of the accidentally contamination of a drainage system, the cover layer of open drains and ditches shall protect the subsoil against pollution by hydrocarbon/chemical products.

6.4 DESIGN

Erosion protection systems shall be selected to cope with all requirements under all conditions.

Erosion protection systems (e.g. concrete slabs, blocks, etc.) shall be sufficiently supported to prevent sliding downward, e.g. as a consequence of temperature movements, own weight, etc.

6.4.1 On-plot areas

6.4.1.1 Inside battery limits

Inside battery limits all slopes, bund was, embankments, open drains and ditches, shall be lined with concrete in accordance with DEP 34.19.20.31-Gen.

The special requirements of pouring these relatively thin slabs shall be observed in addition to those specified in the DEP publication referred to.

The minimum layer thickness shall be 80 mm, reinforced with wire mesh 7 mm diameter at 200 x 200 mm fabric or equivalent.
Slabs shall have a maximum size of 5 x 5 m.

Slopes higher than 1 m, shall be provided with drain points to eliminate water/liquid pressure build up. Wash out of soil through the drain points shall be prevented.

Erosion of soil through joints between panels, see Fig. 6.1, shall be prevented, e.g. by application of strips of suitable filter cloth. Long-term behaviour (e.g. danger for gradual clogging) shall be taken into consideration.

6.4.1.2 Outside battery limits

Grass shall not be used as an erosion protection for flare areas, major pipe tracks, pump pits, etc., to reduce fire hazards.

In areas where hydrocarbon/chemical spill is remote i.e. those areas where an accidentally oil-contaminated drainage system is installed, all erosion protection systems, except grass are acceptable.

For concrete panels the minimum requirements described in (6.4.1) are applicable.

Drain points, as specified in (6.4.1), are also required for flexible erosion protection systems.

For water-tight and low permeable erosion protection layers, the drainage aspect as mentioned above (i.e. drain points) shall be considered.

In areas where the occurrence of a hydrocarbon/chemical spill is not remote, and for drain channels of the accidentally contaminated drainage system, either concrete slabs as per (6.4.1) or (for major drains) an impermeable sealing membrane shall be used to at east 0.5 m above design water level.

The design shall take into account the highest possible ground water level in combination with the minimum water level in the drain.

6.4.2 Off-plot areas

In all areas not covered by (6.4.1), grass is recommended.

6.5 MATERIALS

Materials shall be consistent with the relevant ASTM standard or the equivalent accepted by the principal. For concrete and cement mortar, see DEP 34.19.20.31-Gen. and BS standard or accepted equivalent.

6.6 CONSTRUCTION

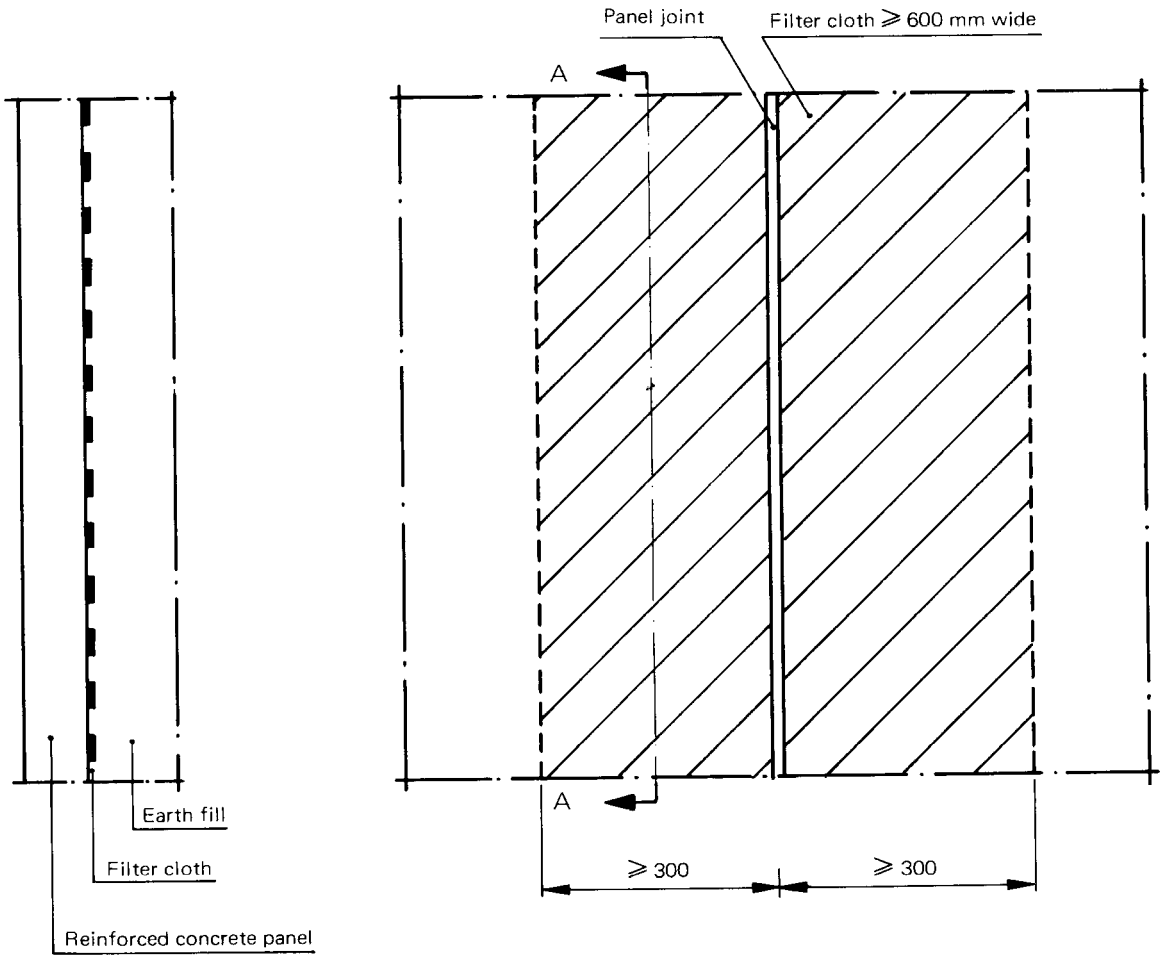
Slopes shall be compacted and trimmed adequately before installation of erosion protection layers to prevent local failure. Working methods shall be agreed by the principal.

6.7 REFERENCES

Site preparation and earthworks	DEP 34.11.00.11-Gen.*
Geotechnical and foundation engineering	DEP 34.11.00.12-Gen.*
Refinery drainage systems	DEP 34.14.20.31-Gen.
Reinforced concrete foundations and structures	DEP 34.19.20.31-Gen.

* In the course of preparation

Fig. 6.1 JOINT IN SLOPE PROTECTION PANEL



Section A – A **Front view**

7. FENCING AND GATES

7.1 DETAILED SCOPE

This section covers the minimum requirements for permanent fences and gates. The design of temporary fencing shall be agreed with the principal.

7.2 GENERAL DESCRIPTION

7.2.1 The preferred system

The preferred system consists of the following components:
- all posts for line, corner, end and pull with a buried concrete footing and inclined top
- bracing
- chain link fence fabric
- barbed wire
- tension wire
- gates.

Typical versions of the preferred system are shown in Fig. 7.1

7.2.2 Alternatives

Alternatives to the preferred system may be considered provided they satisfy the requirements under (7.2) and (7.4).

7.3 FUNCTIONAL REQUIREMENTS

7.3.1 Fences

A system of fence(s) and gate(s) shall be erected close to and entirely within the property - or lease - limits of a site, e.g. refinery, chemical plant or any other specified facility.

The system shall be designed to prevent unauthorized entry into the site by persons who are not equipped with special means to force such an entry.

The system may consist of a single or double fence, the outer fence with a 45-degree outward inclined top 0.7 m long. It may include maintenance tracks or patrol roads as specified by the principal.

NOTE: The top of the outward inclination shall be within the property limits.

The system shall also facilitate discovery by the plant security officers of any trespassing. Hills and gullies along the fence line shall be levelled off as far as practicable. Fences shall have a minimum of bends.

The system shall not inhibit the natural dispersion of gas leakages on site.

7.3.2 Gates

The number of gates shall be minimum.

Gates shall be an integral part of the fence and shall be of a similar design, e.g. height, strength, etc.

7.4 DESIGN REQUIREMENTS

7.4.1 General

Site preparation works, prior to the erection of fences, shall fulfill the following requirements
- Embankments, which may result from the requirements under (7.2.1), shall not extend beyond the property (lease) limits.
- Embankments shall be stable and have a slope of maximum 1 vertical to 1.5 horizontal. Adequate erosion protection shall be applied.
- Embankments shall have a compaction of 85% modified AASHTO minimum (ASTM method D-1557 or AASHTO method T-180).

- Embankments shall have a minimum shoulder of 0.5 metre between the fence foundation and the outside embankment slope.
- Embankments slopes, etc., resulting from site preparation works shall allow a clear view from the patrol road/maintenance track towards the area outside the fence. Exceptions shall be agreed by the principal.

7.4.2 The (preferred) fence

The fence shall be designed to withstand any load which may occur (such as gale wind loads, temperature expansion from extreme climatic conditions, etc.).

The vertical part of the fence (and gates) shall be min. 2 m high and the gap between the fence and the ground shall at no place exceed 0.1 m.

The concrete footing of a fence post shall extend at least 0.6 m into the ground, and shall have the same weight as the post with a minimum of 250 N.

Both cast in situ and precast concrete footings are acceptable.

Metal parts (except the fabric) shall not be in contact with the soil.

Gates shall be of the swinging type unless otherwise specified by the principal.

7.4.3 Drainage crossings

At crossings of the fence with water courses or culverts, a removable bar screen shall be installed for security reasons.

7.5 MATERIALS

The material choice shall be based on local availability and minimum maintenance and low capital costs.

Galvanized (or aluminium-coated) steel, aluminium and concrete are generally acceptable. PVC-coated chain-link fabric and tension wire may be used.

Materials shall be durable in view of the climatic conditions, soil conditions, and with the plant atmosphere.

Materials for assembled components shall be compatible and not lead to contact corrosion.

7.6 TIMING OF CONSTRUCTION

The construction of permanent fences and gates shall precede all other construction activities unless otherwise agreed by the principal. In the latter case a temporary fencing system shall be considered.

7.7 REFERENCES

The ASTM and other standards referred to below shall be used to supplement requirements in (7.1) to (7.6).

AMERICAN STANDARDS

Zinc-Coated Steel Chain-Link Fence Fabric	ASTM A 392-81
Aluminium-Coated Steel Chain-Link Fence Fabric	ASTM A 491-80
Moisture-Density Relations of Soils and Soil-Aggregate Mixtures	ASTM D 1557-78
Chain Link Fencing	ASTM F 552-78
Installation of Chain-Link Fence	ASTM F 567-78
Fence Fittings	ASTM F 626-79

Poly (Vinyl Chloride) (PVC)-Coated Steel Chain-Link Fence Fabric	ASTM F 668-81
Strength Requirements of Metal Posts and Rails for Industrial Chain Link Fence	ASTM F 669-81

Issued by
American Society for
Testing and Materials,
1916 Race Street,
Philadelphia, Pa. 19103, USA

BRITISH STANDARD

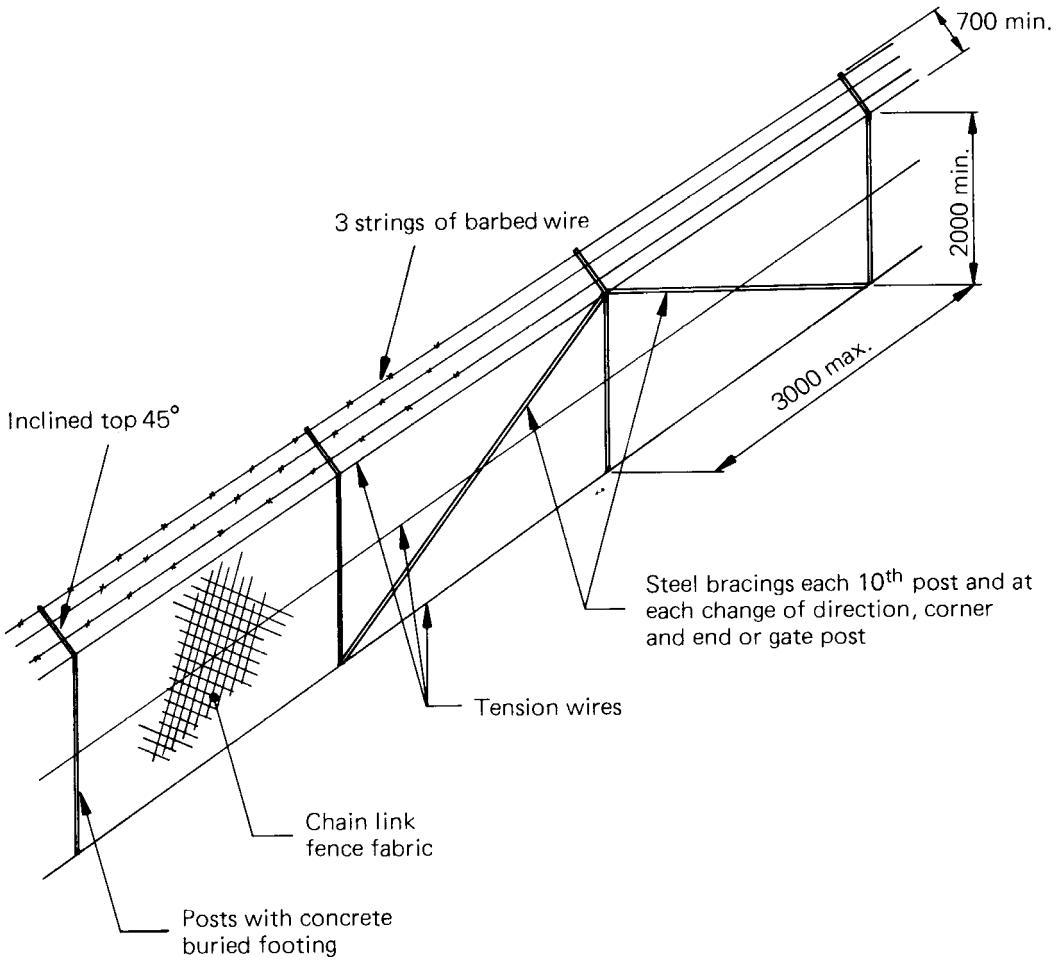
Fences (i.e. industrial security type)	BS 1722

Issued by
British Standards Institution,
2 Park Street, London W1A 2BS,
England

AASHTO interim guide for design of pavement structures etc

Issued by
the American Association of
State Highway and Transport Officials,
341 National Press Building,
Washington, DC 20045, USA

Fig. 7.1 FENCE


700 min.
2000 min.
3 strings of barbed wire
Inclined top 45°
3000 max.
Steel bracings each 10th post and at each change of direction, corner and end or gate post
Tension wires
Chain link fence fabric
Posts with concrete buried footing