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Chapter 22
Bridges and Retaining Walls

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Revision Register

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1	-	First Issue	Steering Committee	Nov 2000
2	22.4	Removed section referring to Tunnels.	R.Pritchard	June 2006
	22.1.11	Added section on Matters for Resolution Before Design Commences.		

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Chapter 22
Bridges and Retaining Walls

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22.1 General Introduction

Bridges and tunnels are the most costly structures associated with road infrastructure in terms of unit cost per area of road carriageway provided.

However, there may be no viable alternative to using these structures in a range of circumstances.

The initial construction cost of a tunnel may be more than ten times that for a bridge at the same location (in terms of road carriageway provided) with high operating and maintenance costs. Yet a tunnel may still be the best option for the site for a range of reasons (see Chapter 23, Section 23.2).

This Chapter highlights the issues to be considered in making a decision on the appropriate type of bridge structure to be used. It also provides road design requirements and describes the characteristics of the structures.

It also describes the factors that must be considered and decided before the design of a bridge is started. This is particularly important for designers wishing to provide an alternative design for a bridge contract or for designers preparing the brief for bridges to be part of a project where design is included in the contract. .

22.2 Bridges

22.2.1. Definition

A bridge is a structure designed to carry a road over a depression or obstacle. In this

The term "overpass" is used to identify a bridge spanning another road or a railway.

Bridges are relatively expensive compared to earthworks and paving so it is important that the most cost effective solution be obtained. Specialist advice on the costs and suitable bridge solutions should be obtained.

In general, bridges have a longer economic or design life than roads. Hence, the geometric dimensions usually provide for a longer period of projected traffic growth than the initial road approaches. Alternatively, the design should allow for future widening and/or raising / lowering to accommodate expected changes in width or level.

22.2.2. The Bridge Option

The alternatives to bridges are usually culverts, floodways or tunnels depending on the circumstances. As floodways for waterway crossings provide much lower flood immunity for a road, there is no real comparison with a bridge solution and this alternative will, therefore, not be considered further in the following comparisons.

Waterways

To achieve a reasonable degree of flood immunity it is necessary to pass water under a road. Within acceptable limits for such things as afflux and potential scour, both bridges and culverts serve this purpose.

The largest standard box culvert used by Queensland Main Roads is 4200 mm x 4200 mm in size. However, in some areas of the State, where multi-cell culverts 3000 mm or higher are required, a bridge may be a cheaper alternative (the minimum span of a standard deck slab bridge being about 8 m). Further, where the natural surface at a proposed culvert base is soft and prone to settlement requiring a special design, a bridge may be less costly.

Placing culverts where there is permanent water at a site is also impractical when the cost of de-watering is considered. Environmental effects must also be considered (see below).

In tidal waterways, boats require adequate horizontal and vertical clearance and culverts are not an option.

Environmental Considerations

Traditionally, the design of both bridges and culverts considers the potential scour under and downstream of the proposed structure. These considerations are very important in minimising the environmental impact but other factors must also be considered.

For example, in some highly sensitive environmental areas, the blockage in a waterway has to be kept to an absolute minimum. In addition, the extent of works in the bed and on the banks must be kept to a minimum. In these circumstances, a bridge will provide the best solution.

A bridge also provides opportunities for suitable fauna crossings of a road and these may be suitably incorporated in bridges required over waterways. In some cases, it may be necessary to provide a bridge to allow sufficient clear opening for fauna such as koalas to cross a road. The possibility of special overpass structures to allow the passage of fauna may need to be considered.

Non-Waterway Bridges

Non-waterway crossings are usually confined to overpasses spanning other roads or railways although special cases will occur (e.g. fauna crossings, preservation of special features).

Bridges are almost always used for these purposes but other solutions may be suitable in certain cases. Commercially available products such as concrete arches and multi-plate steel culverts may be adequate for short spans.

In any case, the commercial concrete arches have to be structurally designed and the limitations placed on their use by the manufacturers of both products must be strictly observed.

Bridge or Tunnel?

Choosing between a bridge and tunnel requires consideration of a range of factors of which cost is only one. It is often the case that the choice will be made on the basis of factors other than cost.

The cost of a tunnel is invariably much higher than a bridge alternative, particularly when operational and maintenance costs of tunnels are included. Other factors (see Chapter 23, Section 23.2) must dominate the cost factor for this choice to be made.

22.2.3. Bridge Types

There are four basic types of bridges, namely:

- beam bridges;
- truss bridges
- arch bridges; and
- suspension bridges.

Table 22.2.3 sets out typical spans used for the different bridge types. These spans should be taken as guidelines only since the actual span adopted for a particular bridge will depend on the circumstances of that structure.

Table 22.2.3 Typical Bridge Spans

Type of Bridge	Span Minimum (m)	Maximum Economic Span (m)
Timber girder	-	12
Timber truss	12	24
Steel girder	15	20
Steel plate girder	20	45
Steel trough girder	20	80
Steel truss	30	Over 220
Steel box girder	50	Over 300
Steel arch	60	Over 550
Cable-stayed steel girder	150	Over 600
Steel cantilever truss	150	Over 600
Suspension	250	Over 1500
Concrete slab	6	8
Concrete deck units	6	16*
Concrete type III prestressed girder and insitu deck	22	26
Super tee	30	35
Concrete arch	30	390
Cable-stayed concrete girder	40	Over 600
Concrete bowstring arch	20	75
Prestressed concrete box girder	30	Over 200

* Called Prestressed Concrete Deck Units in Queensland where experience shows that 25m can be achieved economically and 30m units have been used.

Source: Modified from "Civil Engineering Construction" - Antill, James M, Paul W.S. Ryan, and Graham R. Easton (Sixth Edition).

Beam Bridges

Beam bridges form a very high proportion of the total number of bridges built throughout Queensland because they are often the most cost effective bridge structures. Types include:

- simply supported girder bridges;
- cantilever girder bridges; and
- continuous girder bridges.

These are illustrated in Figure 22.1(a)

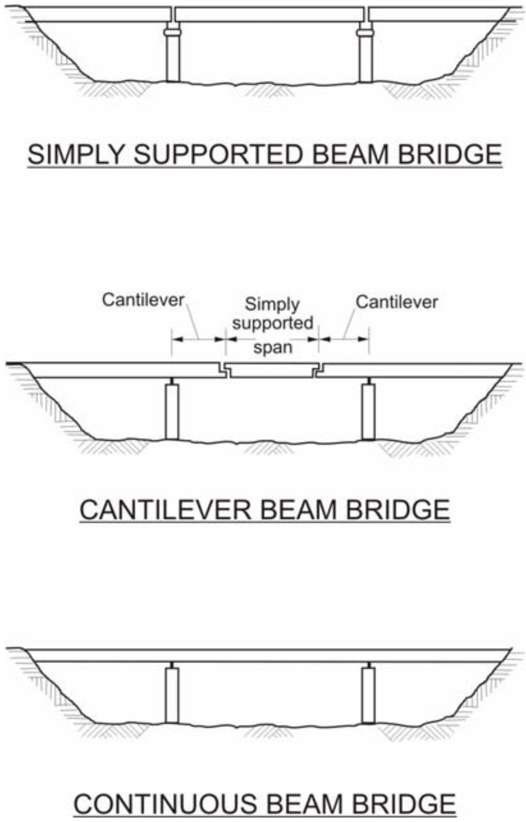

Figure 22.2.3 (a) Beam Bridges

Beams can be I or T shaped, hollow circular voided or hollow rectangular box(es), as shown in Figure 22.2.3(b)

It should be noted that the spans given in the notes below are provided as a guide only and spans outside the ranges indicated may be possible. Specialist advice is required for spans outside these ranges.

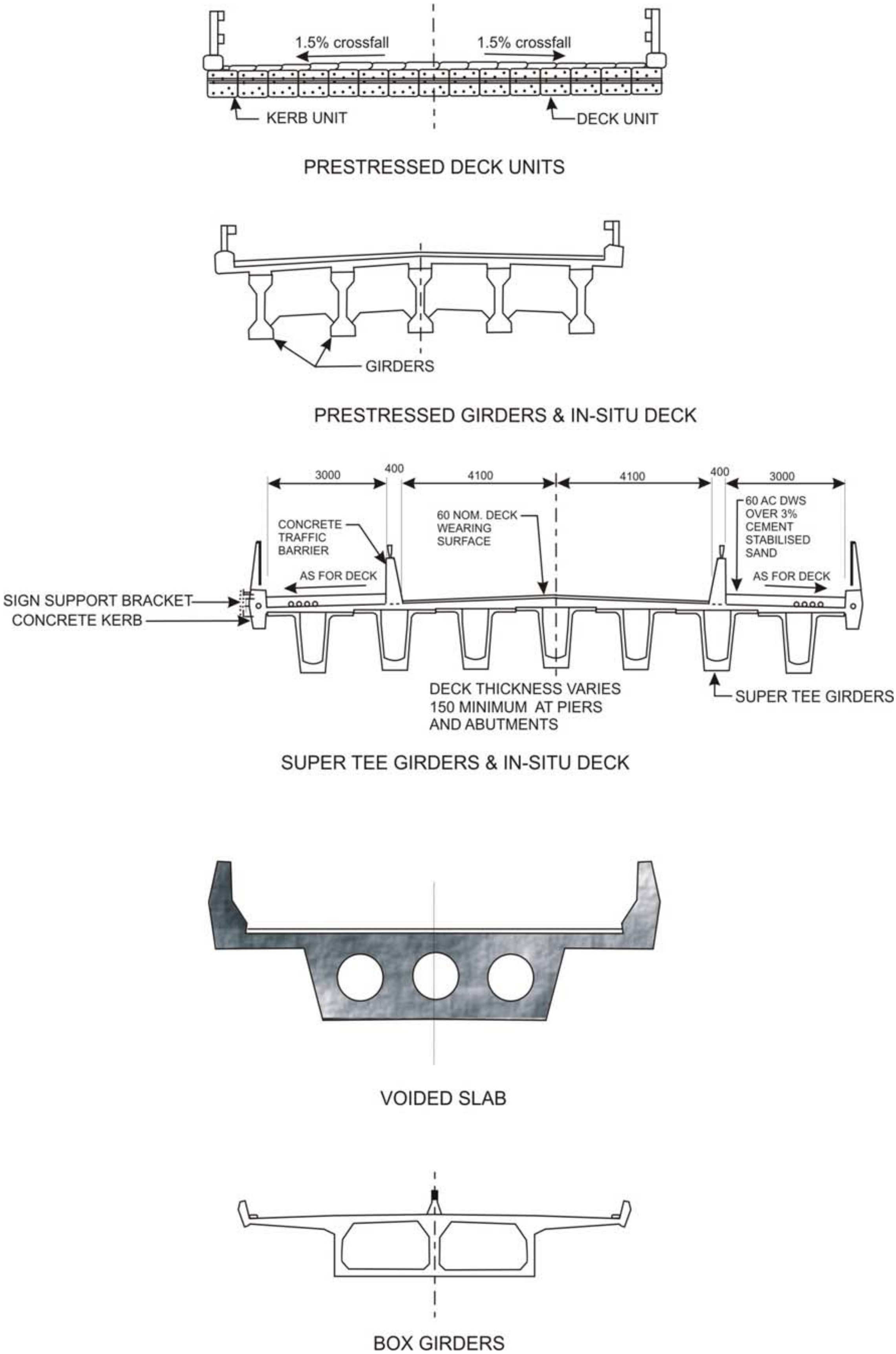

Figure 22.2.3(b) Beams can be I or T shaped

Prestressed Concrete Deck Units

Prestressed Concrete Deck Units are used in nearly all of the smaller span bridges in Queensland. The range of spans constructed is usually 8 to 22m, although spans up to 30m have been used where traffic conditions demanded the fastest possible construction methods.

The nominally 600mm wide prestressed units are post-tensioned transversely after erection and an asphalt deck wearing surface placed on the top. The need to waterproof the deck has led to increasing use of a concrete deck on deck unit bridges. In these cases transverse post-tensioning is omitted.

For bridges on a skew greater than 40°, load transfer becomes more complex as the skew increases and additional detailing is required.

Concrete decks may also be used where Asphalt Concrete is not readily available as a Deck Wearing Surface or where an aggressive environment is present.

Prestressed Concrete Girders (I Beams)

These types of girders are commonly used in spans 26m to 32m and require a cast-in-situ concrete deck.

Super Tee Girders

These prestressed concrete girders are also appropriate for spans 26m to 35m.

When constructed they have a centre void as shown in Figure 22.2.3(b) There are small recesses at the top of these voids to hold floor formwork for the concrete cast-in-situ deck.

Voided Slab Beams

Voided slab beams are prestressed or reinforced concrete cast-in-situ beams, which are most suited to curved roadways such as ramps.

The circular voids reduce the weight of the girders with consequent reductions in loading and reduced cost.

Box Girders

Prestressed concrete box girders are used for longer spans, from 40m to 260m in Queensland, although much longer spans have been used elsewhere in the world.

Depending on the depth of the box, there may be a single "rectangular" void rather than the two voids shown in Figure 22.2.3(b) An asphaltic concrete deck wearing surface is placed on the box girders.

Truss Bridges

Truss bridges have been used for longer span bridges in steel. Each truss is an independent frame, and these frames are connected together by the floor system at the level of the lower chord, and lateral bracing between the upper chords, or vice versa. Steel truss bridges usually require falsework for erection; or they may be launched from the ends; or they may be floated into position and lifted onto the piers.

Major examples of this type of bridge in Queensland are the Burdekin River Bridge between Ayr and Home Hill, and the Story Bridge in Brisbane. The Story Bridge over the Brisbane River is a steel truss cantilever bridge with a main span of 281.7m. It was completed in 1940.

Truss bridges are not commonly used in Queensland at this time - more economical solutions are usually available.

Arch Bridges

The shape of an arch bridge may be semi-circular, elliptical or parabolic.

Masonry, concrete and steel have been used.

Concrete arches are sometimes used, particularly as short overpass bridges over road and rail and as crossings over small waterways. Longer arch bridges are not commonly adopted for straightforward applications but may be the most cost effective solution for some special cases. Short spans using precast products often provide a good solution where the area spanned has to remain untouched.

The longest concrete arch in Queensland is the William Jolly Bridge over the Brisbane River, with a main span of 72.6m completed in 1932.

Suspension and Cable-stayed Bridges

Cable-stayed traffic bridges become economical only for larger spans of approximately 250 metres or more. Cables provide intermediate support for the beams, thus avoiding additional piers and achieving longer clear spans.

Suspension bridges are only economical for very large spans to a maximum of up to 2 km.

Figure 22.2.3(c) gives examples of a suspension bridge and a cable-stayed pedestrian overpass.

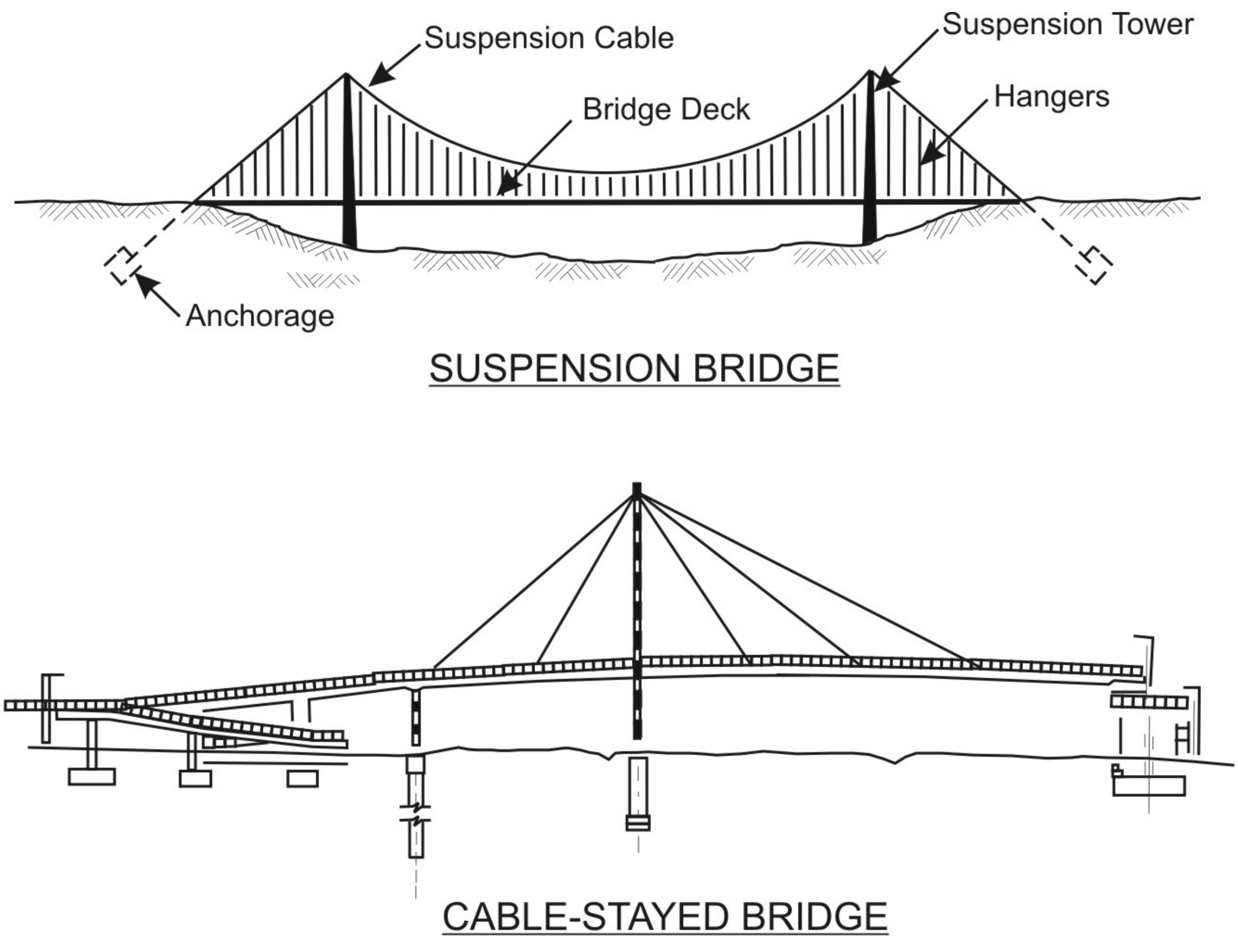

Figure 22.2.3(c) Suspension Bridge & Cable Stayed Bridge

22.2.4. Horizontal and Vertical Alignment for Bridges

In the planning of bridges, the road alignment is usually selected and the bridge location and alignment designed to fit the road. The detailed planning and costing of the bridge is then carried out. However, where significant cost savings may be available if a different bridge solution is adopted, the road alignment may need to be adjusted accordingly. Early specialist advice is required.

Where there may be significant differences in alternative alignments, the issues described in the following sections, 22.2.5 to 22.2.9, should be considered.

Where there is only scope for relatively minor changes, selection of a suitable horizontal and vertical alignment at the bridge site can provide savings in design and construction time and costs. Examples are:

- Bridges are easier to design and construct on straights and grades rather than on horizontal and vertical curves. Variable – vertical curve bridges are more difficult to construct than vertical grade bridges.
- Carrying superelevation for the full length of a bridge avoids a superelevation change on the structure.
- Bridge alignment preferably should be on a single vertical or horizontal geometric element (e.g. horizontal geometry modified such that the bridge is fully on a curve) to simplify design and construction.
- A larger radius vertical curve than the minimum required over a bridge may result in overall cost savings, because a cheaper type of bridge may be able to provide the required offset from the tangent to the vertical curve. For example, a larger radius curve may allow the use of shorter span deck slabs with the offsets taken up in the deck wearing surface. Larger span concrete girders require the offset to be taken up in the cast-in-situ deck and kerbs and this costs more.

A further consideration is the drainage of the deck surface. A suitable gradient on the bridge will generally simplify the drainage of the surface and may be essential to avoid aquaplaning problems. In any case, careful attention to the drainage of the surface is required and appropriate measures to accomplish satisfactory drainage must be adopted.

22.2.5. General Appearance Considerations

Bridges can be a dominant feature of the landscape, even when small and particularly when the viewing positions are advantageous. In other circumstances, the close proximity of the bridge to a driver or pedestrian will invite close scrutiny.

The overall form of the bridge will determine its general appearance. Details of the design will have an effect on the perception of its attractiveness. Such issues as overall proportions, relative size of members, slenderness ratios and the like will be important.

On long bridges, it may be necessary to adopt a long vertical curve over the length of the bridge to ensure an appropriate appearance. All major bridges should give consideration to this feature. Details of the vertical curvature will depend on the type, size, location and other features of the bridge. A holistic approach must be taken to the design of the bridge and its relationship to the surrounding environment.

Overpass structures with open-end spans are more attractive than solid abutment types. They provide a sense of openness and freedom as opposed to enclosure and restriction. For the same reasons, overpasses with no pier in the median are usually more attractive. However, omitting the central pier may be too expensive and impractical in many cases.

It is advisable to obtain specialist architectural advice at the early stages of the design to ensure that the bridge will have a satisfactory appearance. This does not necessarily mean that the bridge will cost more.

It is necessary that the appearance and function of the bridge are maintained over the life of the facility. These can be marred by staining caused by the flow of water over the faces of the elements of the structure.

Consequently, control of drainage and seepage through joints is essential. In particular, seepage must be prevented from flowing through and over the face of abutments and piers where staining becomes an eyesore for passing motorists and other users.

Particular attention to the drainage behind abutments is required. Water must be captured and drained to points away from the face of the abutment or spill-through, preventing it passing over the surface of any part of the structure.

Design of the elements to collect and carry the water from the bridge must be an integral part of the design of the bridge, not an add-on. It is important that the drainage elements required fit in with the structure and do not detract from its appearance. Pipes that transfer water from the collection point to the discharge location should be hidden. Photographs of inappropriate design illustrate some of the problems.

While control of drainage in this way is essential for bridges over roadways, it is good practice to apply this discipline to the design of all bridges.

Graffiti also detracts from the appearance of the structure. Refer to the Road Landscape Manual (Queensland Main Roads, 1998).

22.2.6. Bridges Over Waterways

Considerations for bridges over waterways include those in the following sections.

Clearances and Bridge Heights

Chapter 7 provides details of clearance requirements for bridges.

New bridges are invariably designed to a standard equal to or higher than that of existing bridges, in terms of total waterway area and heights.

An extremely rare occasion may arise where a span or spans shorter than existing ones may be justified in non-tidal streams, but never in tidal waters. However, even in this case, the total waterway area of the bridge would not be smaller than that of the existing bridge. In other words, a new bridge has flood immunity at least equal to, and usually higher than, that of an existing bridge and provides at least the same clearances for boats.

In tidal waters, the Environmental Protection Agency must approve the bridge spans and vertical clearance for boats (including yachts, if relevant). The Agency must also approve the final design drawings. (Previously known as Section 86 approval under the Harbours Act 1955, and preserved under Section 236 of the Infrastructure Act 1994.)

Any need for fenders to absorb impact by boats on piers must be considered in clearance calculations.

For major structures over non-tidal water, approval may be required from the Department of Natural Resources in the future.

Stream Width

It is usually desirable to have one large crossing of a stream rather than a number of smaller ones over its tributaries.

At a comparatively narrow section of a stream, a shorter and generally less expensive bridge may be built.

A narrower cross-section usually indicates that the banks are more stable and resistant to change and erosion by flood waters.

Higher stream velocities and, perhaps, greater movement of the stream bed also need to be evaluated for these sections.

A further consideration is the environmental impact of the structure. It is often preferable that the existing bed not be disturbed or that certain parts of the bed be left undisturbed by the construction. In these cases, the span lengths and positioning of the piers and abutments may have to be adjusted to suit.

Environmental Requirements

In addition to the overall impact of the structure (see above), runoff from the bridge deck will have to be controlled where it would otherwise impact on a sensitive environment. In these cases, it is necessary to collect the water and distribute it to a sedimentation basin, or other treatment area, before being discharged.

Using scuppers and discharging directly into the stream may be acceptable in some cases. Specialist advice will be required to determine the appropriate solution.

The design of the bridge may require consideration of fish movement in the stream and fauna movement along the banks. These issues should be addressed as early in the process as possible to ensure the most appropriate and economical solution is reached. (Refer also to Chapter 3 and the references therein.)

Native title requirements must be considered when locating a bridge over a waterway and in establishing pier and abutment positions.

Further, issues of cultural heritage must be resolved before proceeding. Sites may have archeological significance and special measures to accommodate these may be the appropriate solution.

Foundations

Generally where rock is at or near the surface, a less expensive bridge substructure may be built at the site.

By restricting a channel (e.g. having a shorter bridge) higher velocities will result through the structure. Hence with firm foundations, a shorter and less expensive bridge may be built without scouring at the site of the bridge.

However, this can affect the overall hydraulic gradient of the stream with resulting compensating scouring at downstream bends of the stream. Changing the characteristics of the stream must be done with caution and generally avoided.

Stream Stability

There is a tendency for scouring to take place on the outside of a bend in a stream. This natural tendency may not be attributable to the presence of a bridge at all, but difficulties may arise if a bridge is sited in such a location.

It is preferable that a bridge be sited on a straight stretch of a stream with uniform cross-sections throughout. Even so, care must be taken in determining the length of the bridge to avoid changing the stream characteristics and adversely affecting downstream scour (see also "Foundations" above).

A Dry Site

Many of the creeks and rivers in Queensland flow for only a few months of the year. Where isolated pools of water exist in the "dry" season in some streams, costly construction can be avoided by shifting the bridge site to a dry part of the stream.

A Skew Crossing

The bridge piers should be aligned to the natural skew of a stream to avoid deflection of flows resulting in scours.

Savings can be made in the cost of design and construction by having skews no greater than 30° where standard precast, prestressed concrete deck and kerb unit superstructures are proposed.

Whilst greater skews are possible, the detailing of the bridge becomes more difficult and expensive. Specialist advice is required.

Future Dams and Weirs

During the economic life of a bridge, the possibility of future dams, weirs, barrages, canals and other large hydraulic works should be investigated.

Future large dams may cause extensive relocation of bridges and other transport infrastructure

Cross Section

Cross section requirements are given in Chapter 7 - Cross Section. Guidelines for adopting full carriageway widths on "short" bridges are also provided in that chapter.

Horizontal clearances (as relevant to bridges discussed in this Section) to roadway elements are as discussed in Section 22.2.7.

Span Lengths

Span lengths will be determined by a range of factors including:

- stream size;
- bank stability;
- relative costs of superstructure and sub-structure; and
- economy.

Standard prestressed concrete deck units with spans up to 25m are the most economical types of superstructure used in Queensland. Their superstructure depth is also smaller giving less obstruction in waterways than other types with larger spans.

They may also be erected quickly without the need for cast-in-situ decks that are required for larger span bridges.

In general, the longer the span, the greater the superstructure cost per square metre of deck area provided.

Bank stability during construction and in service is an important consideration in determining the location of the abutments. Designers should seek specialist advice on how to preserve bank stability before finalising abutment locations.

22.2.7. Bridges over Roadways

Bridges over roadways include overpasses over roads, bikeways and pedestrian paths. The factors discussed in Section 22.2.6 for bridges over waterways apply in most cases to bridges over roadways.

Horizontal Clearances

The elements of the bridge structure (parapets, piers, abutments and associated barriers) must be located to provide appropriate horizontal clearances from roadway elements.

Horizontal clearance must allow for the following factors:

(a) pavement width;

(b) shoulder width or edge clearance;

(c) pier protection barriers (including allowance for deflection of flexible barriers);

(d) curve widening;

(e) sight lines; and

(f) future works e.g. additional lanes, footpath, bikeways etc.

Values of horizontal and vertical clearances to be provided are given in Chapter 7, Cross Section.

In addition, it is necessary to ensure that the appearance of the structure is attractive for the users of the facility over which the bridge passes. The aesthetics of the structure and its surroundings is a matter of design and the appropriate specialists should be consulted as necessary to achieve a satisfactory result.

Drainage Control

Drainage of water from the elements of the structure (deck drainage, flow through joints and abutments) must be controlled in a positive way and the outlets carefully designed in accordance with the environmental management plan. Uncontrolled flow of water from and through the bridge will also have an adverse effect on the appearance of the structure (see Section 22.2.5).

22.2.8. Bridges over Railways

Advice on vertical and horizontal clearances for bridges over railways, and future duplication or electrification should be obtained from the Manager Civil Engineering in Queensland Rail (see Chapter 7). In addition, the piers for these bridges must be solid.

22.2.9. Pedestrians and Cyclists

Detailed discussion of the needs of pedestrians and cyclists is included in Chapter 5. In addition, cross section standards are also included in Chapter 7. The information listed below can be obtained from these sources as well as the Bridge Design Code (Austroads, 1992).

- footpath width on bridges (Chapter 5, Section 5.4 and Chapter 7, Section 7.10).
- widths, gradients and clearances of pedestrian bridges and subways (Chapter

5, Section 5.4 and Chapter 7, Section 7.10).

- widths, gradients, and clearances of bikeways on bridges (Chapter 5, Section 5.4 and Chapter 7, Section 7.10).

22.2.10. Public Utility Plant (PUP)

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Where Public Utility Plant has to be accommodated on bridges, it is preferred that it be located under the footway. Appropriate ducting should be provided and should be accessible from the surface, possibly by way of removable panels.

For some major services, special arrangements to carry the required plant across the bridge below the superstructure, or on the outside of the superstructure may be needed. This will have to be designed as part of the structure with appropriate fixing methods. The effect on the appearance of the bridge must be considered.

22.2.11. General Design Requirements

Design Standards

The design of bridges must be in accordance with the Australian Standard AS5100 – 2004 Australian Standard for Bridge Design. Any errors or anomalies in the Australian Bridge Design Code should be discussed with the Principal Engineer (Bridge Design) for clarification or for amendment to the code. All design criteria for bridges designed for the Main Roads road system should be approved by the Principal Engineer (Bridge Design) before any design is carried out.

Whereas earlier editions of the Australian Bridge Design Code were essentially administered by the infrastructure owners and applied to their own bridge assets, an increasing number of bridges are being built under the design and construct and/or maintain-operate principle. Contract documentation for these methods of procurement of bridges, which rely on references to the Australian Bridge Design Code, has been compromised by the number of matters in the Code which require resolution by the owner before commencing the design process. In AS 5100 – 2004, all matters requiring resolution by the owner are listed in Appendix A of Part 1 to enable owners to ensure all relevant matters related to a project are resolved and determined prior to acceptance of tender.

Matters for Resolution before Design Commences

The following shall be confirmed as accepted by the relevant authority or owner of a bridge or associated structure before commencing the design process:

Issue	Applicable to Project
AS 5100.1 Scope and general principles	
a) Application of the provisions of this Standard to the design of modifications to existing bridges (see Clause 2)	Bridges over 100m span will have additional special criteria. Modular expansion joints to conform to RTA Specification 316.
Design life of ancillary elements (see Clause 6.2) that can be easily removed and replaced	Design life means 95% of bridge exceed the nominate design life. Light poles, signs on side of bridge and cantilever signs 40 years Full width gantry signs 100 years Bearings 100 years Noise barriers refer Main Roads Specification MRS 11.15
Use of non-linear analysis methods (see Clause 6.4)	Non-linear analysis not permitted as primary design method. Program must be tested and certified.
Other effects, including load effects, to be considered regarding specific additional conditions and requirements (see Clause 6.8)	Some special cases may be required. Discuss with Main Roads.
Bridge waterway requirements (see Clause 7.1)	Job specific. Refer hydraulic brief. In general, velocities must be kept close to natural velocities.
Determination of environmental requirements including requirements of the waterway authority (see Clause 8)	Drainage from deck on case by case. In general, water to discharge through scuppers unless over road or railway.
Geometric requirements for all bridges (see Clauses 9.1, 9.2 and 9.3)	Safe design speed → min radius as required by rail or waterway authority and Main Roads. Geometry should conform to the Road Planning Design Manual and Austroads Road Design Guide.
Geometric arrangement of railway bridges (see Clause 9.2)	As required by rail authority
Road bridge carriageway widths (see Clause 9.4)	In accordance with AS 5100
Edge clearances from the edge of the traffic lane to the face of the safety barrier (see Clause 9.5)	In accordance with AS 5100
Horizontal clearances to substructure components of bridges over roadways (see Clause 9.6)	Job specific
The minimum vertical clearance of structures over roadways (see Clause 9.7)	Minimum clearance on stand alone footbridge 6.0m. Job specific requirements may override Table 9.7
Vertical and horizontal clearances for bridges over railways (see Clause 9.8)	As required by rail authority.
The superelevation and widening of the deck surface of a bridge on a horizontal curve (see Clause 9.9)	Job specific
Geometric requirements for walkway and pedestrian bridges (see Clauses 9.10 and 9.11)	Minimum clearance on stand alone footbridge 6.0m
Dimensional requirements for pedestrian subways (see Clause 9.12)	1:33 for disabled access – varies with length
Determination of barrier performance level and barrier type requirements (see Clause 10.2)	Job specific

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Issue	Applicable to Project
Acceptance criteria for bridge traffic barriers (see Clause 10.4)	Principal Engineer (Bridge Design)
Specification of performance levels for traffic barriers including bridge rehabilitation (see Clause 10.5.1)	Minimum level for barrier is “Regular” to AS 5100.2. However higher barrier may be required on tight radius and to conform to railway authority requirements.
The need and provision of special performance level barriers (see Clause 10.5.6)	Minimum height 1.4m. Risk analysis to be undertaken.
The height and profile of parapet type barriers (see Clause 10.6.1)	1.1m
Geometric requirements for post and rail type barriers (see Clause 10.6.2)	In accordance with Clause 10.6.2
The extent of transition of the road approach barrier system to the bridge barrier (see Clause 10.6.3)	In accordance with Main Roads Standard Drawings
Performance levels for collision protection (see Clause 11.1)	As per AS 5100
Requirements for protection of bridge supports from road traffic collision (see Clause 11.2)	A concrete conforming to the geometry of Figure 7.22 of the Road Planning and Design Manual.
Requirements for protection of bridge supports from railway traffic collision (see Clauses 11.3.1, 11.3.2, 11.3.3 and 11.3.4)	In accordance with railway authority requirements
Requirements for protection of bridge supports from ship collision (see Clause 11.4)	Job specific, normally controlled by pier positioning
Requirements for protection barriers for bridges over electrified railways (see Clause 12.2)	In accordance with rail authority
Requirements for protection screens to prevent objects falling or being thrown from bridges (see Clause 12.3)	In accordance with rail authority
Requirements for the attachment of and design loads for noise barriers on bridges (see Clause 13)	Job specific
Drainage requirements for bridge approaches (see Clause 14.1)	Job specific
Attachment of utility services on structures (see Clause 16)	Job specific

AS 5100.2 Design Loads	
Varying loads on the basis of engineering measurements and calculations (see Clause 1)	Design code: AS 5100: 2004 Significant variation from code SM1600 HLP 400 position diagram Design speed Fatigue criteria *(for Concrete Railway Bridges, Steel Bridges)* Pedestrian load Collision load Wind speed Flood data (velocity, level) Earthquake zone Differential settlement (If Applicable) Barrier performance level Construction method (When Required)

Value of γ_g for large segmental cantilever construction for the case when dead load reduces safety (Table 5.2)	Job specific
Value of γ_{gs} to be applied to the nominal superimposed dead load (see Clause 5.3)	2.0
Specification of heavy load platform design load (see Clauses 6.2 and 6.3)	HLP 400. May be higher on specific heavy load routes.
Requirement for design loads and load factors if road bridges are to carry tramway or railway traffic (see Clause 6.4)	Job specific
Number of lanes to be included for braking force and calculations (see Clause 6.8.2)	As per code. Taking into future redevelopment.
Number of stress cycles for fatigue load calculation (see Clause 6.9)	As per code
Design vehicle load for walkway (Clause 7.1)	20kN
Requirement for design for crowd loading (see Clause 7.1)	Job specific. May be higher than Code where crowd loading expected. Or 5 kPa over whole span, with crowd loading for special events.
Design loads for railway bridges and bridges carrying light rail and the like (see Clause 8.1)	As specified by relevant authority
Dynamic load allowance for specific structures, track standard and train speeds (see Clause 8.4.7)	As determined by rail authority
Need for protection beams to protect superstructures of low clearance bridges (see Clause 10.3)	As per Table 10.3
Risk analysis and redundancy levels for determination of alternative load path (see Clause 10.4.2)	As determined by rail authority
Need for and determination of collision loads on support elements (see Clause 10.4.3)	As determined by rail authority
Other design requirements for collision loads from railway traffic (see Clause 10.4.6)	As determined by rail authority
Determination of traffic barrier design loads (see Clause 11.2.2)	Minimum regular. Higher level if determined by risk study.
Determination of effective heights of traffic barriers (see Clause 11.2.3)	In accordance with As 5100.
Barrier anchorage requirements (see Clause 11.2.4)	Other method must be approved by Main Roads
Requirement for pedestrian barrier design for crowd loading (see Clause 11.5)	Panic load in high profile locations
Criteria for dynamic analysis (see Clause 12.2.3)	Determined on job specific basis
Need for assessment of vibration behaviour for railway bridges (see Clause 12.3)	As required by rail authority
Classification of bridges and associated structures that are essential to post-earthquake recovery (see Clause 14.3.2)	Type III includes major stream crossing including Gateway bridge, Captain Cook bridge, Burnett River, Fitzroy river, Burdekin river and any major road where there will be a major deviation. Type II are overpasses as per 14.3.2.
Identification of an requirements for earthquake design for bridges identified as particularly important (see Clause 14.4.1)	Bridge specific requirements
Any changes to the importance level for noise barriers (see Clause 24.2	Refer Main Roads Specification MRS 11.15

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AS 5100.3 Foundations and soil-supporting structures	
Design requirements for foundations for overhead wiring structures (see Clause 2)	Refer relevant authority design criteria.
Detailed method and formulae to be used for the design of geotechnical or structural elements (see Clause2)	Job specific approvals only.
Supervision of site investigation (see Clause 6.1)	Geotechnical engineer unless specified otherwise.
Extent and coverage of preliminary and design investigation (see Clause 6.1)	Unless job specific requirement
Minimum number of bore holes (see Clause 6.2)	One per pier/abutment
Selection of the geotechnical strength reduction factors (see Clause 7.3.4)	As per AS 5100
Requirements for consideration of future development (see Clause 7.8)	Job specific when specified
Other durability criteria (see Clause 9.1)	Job specific
Use of treated and untreated timber (see Clause 9.2)	Not permitted for bridges
Requirements for prevention of corrosion of reinforcement (see Clause 9.3)	Consult rail authority for electrified lines, other areas seek expert advice.
Acceptance of rates of corrosion for steel surface (see Clause 9.4)	Adopt AS 5100 unless better site data provided.
Requirements to minimise corrosion effects of stray currents (see Clause 9.3)	Consult rail authority for electrified lines, other areas seek expert advice.
Acceptance of slip factor coatings (see Clause 9.5)	Refer MRS 11.67
Durability requirements of other materials (see Clause 9.6)	Job specific
Design requirements for durability of materials used in shallow foundations (see Clause 10.3.6)	As per AS 5100
Requirements for structural design and detailing for shallow footings (see Clause 10.4)	As per AS 5100
Requirements for materials and construction for shallow foundations (see Clause 10.5)	As per AS 5100
Use of timber piles (see Clause 10.3.1)	Temporary works only
Requirements for durability of materials used (see Clause 10.3.4)	As per AS 5100
Requirements for structural design and detailing for construction of piles (see Clause 11.4)	As per AS 5100
Requirements for materials and construction for pile (see Clause 11.5)	As per AS 5100
Requirements for testing of piles (see Clause 11.6)	Dynamic testing in accordance with MRS 11.68
Design requirements for durability of anchorages and anchorage components (see Clause 12.3.6)	As per MRS 11.03
Requirements for materials and construction for anchorages (see Clause 12.4)	As per AS 5100
Requirements for method of installation and on-site assessment tests for anchorages (see Clause 12.6.1)	As per MRS 11.03
Proof load test for anchors (see Clause 12.6.2)	As per MRS 11.03
Requirements for anchorage acceptance tests (see Clause 11.6.3)	As per AS 5100

Requirements for design of retaining and abutments (see Clause 13.1)	As per AS 5100
Acceptance of geotechnical strength reduction factor for retaining walls and abutments (see Clause 13.3.1)	As per AS 5100
Design requirements for durability (see Clause 13.3.5)	As per AS 5100
Requirements for structural design and detailing for retaining walls (see Clause 13.4)	As per AS 5100
Requirements for materials and construction for retaining walls and abutments (see Clause 13.5)	As per AS 5100
Approval of drainage system (see Clause 13.6)	As per AS 5100
Requirements for the design of buried structures (see Clause 14.1)	As per AS 5100
Design requirements for the durability of materials (see Clause 14.3.3)	As per AS 5100
Requirements for structural design and detailing for buried structures (see Clause 14.4)	As per AS 5100
Requirements for materials and construction for buried structures (see Clause 14.5)	As per AS 5100
AS 5100.4 Bearings and deck joints	All bearings and deck joints
No entries	
AS 5100.5 Concrete	
Acceptance of the use of new or alternative materials and methods of design or construction (see Clauses 1.5.1 and 1.5.2)	Subject to approval by Main Roads
Design requirements of lightweight structural concrete (see Clause 1.5.4)	Not permitted
Minimum cover at post-tensioning anchorages (see Clause 4.10.2(e))	No reduction permitted
Requirements for control of cracks in columns and tension members (see Clause 10.1.4)	Must comply with 8.6
Determination of proof test load (see Clause 17.3)	Case specific, to be approved by Main Roads
AS5100.6 Steel and composite construction	
Requirement for members and materials for new and unusual bridge types (see Clause 1.1.2)	To Main Roads approval
Design requirements for structural elements using non-ferrous metals (see Clause 1.1.2)	To Main Roads approval
Requirements for steels for machined parts and for uses in other than structural member elements (see Clause 2.2.4)	To Main Roads approval
AS 5100.7 Rating of existing bridges	
Application of performance load testing results to determine the rated load (see Clause 5.4.4)	Only with approval of Main Roads

Conditions for amending the dynamic load allowance (see Clause 5.5.1)	Only with approval of Main Roads
Approval to the use of a reduced live load factor for load capacity rating of a bridge (see Clause 5.5.2)	Only with approval of Main Roads
The load factors to be used when rating a bridge (see Clause 6.1)	Only with approval of Main Roads
Approval to modification of load factors for serviceability limit states (see Clause 6.2)	Only with approval of Main Roads
Approval to modification of load factors for ultimate limit state (see Clause 6.3.1)	Only with approval of Main Roads
Approval to the use of a live load factor which is less than the design value (see Clause 6.3.2)	Only with approval of Main Roads
Use of modified live load factors based on probability of overloading (see Clause 6.3.3)	Only with approval of Main Roads
Conditions for use of load factors for specific loads (see Table 6.3)	Only with approval of Main Roads
Approval to the determination of ratings for fatigue (see Clause 7)	Only with approval of Main Roads

Additional Requirements

Further design considerations include:

- insitu concrete strength;
- height of balustrades;
- heavy load platform loads;
- pedestrian railing design loads;
- relieving slabs;
- bearings and bearings replacement;
- deck joints; and
- painting.

Relieving slabs are required for all bridges. Where the approach pavement is concrete or there are settlement issues, the longitudinal dimension of the relieving slab must be not less than 5m to accommodate the paving machine.

The number of expansion joints should be minimised in the design process to reduce maintenance costs.

Designers should refer to AS 5100 – 2004 and to the Principal Engineer (Bridge Design) for details of these issues. In some cases, the requirements of the AS5100 – 2004 have to be varied in accordance with the decisions of the Principal Engineer (Bridge Design) and they must be consulted before the design criteria are decided.

22.3 Retaining Walls

Retaining walls are used in the following typical locations:

- urban locations where the availability of land to accommodate earth batters is restricted;
- steep sidelong country to hold fill or control landslides;
- earthworks adjacent to a stream to prevent erosion or fill spilling into a creek; and
- bridge abutments and wings.

22.3.1Selection of Wall Type

Factors that may influence the selection of the type of retaining wall for a site are:

- cost;
- available clearance to boundary fence, stream etc.;
- safety - the exposed face should not be unduly hazardous to an impacting vehicle;

- foundation conditions;
- maintenance - ease and access;
- suitability for use adjacent to footways and pavements;
- compatibility with adjacent wall types; and
- appearance.

Specialist structural and geotechnical advice should be obtained before deciding on the design of retaining walls.

Allowable retaining wall clearances to railway lines should be obtained from the Manager, Civil Engineering - Queensland Rail and Chapter 7.

22.3.2 Wall Types

Examples of the most common wall types are illustrated in Figure 22.3.2(b).

Types 1 to 7 are presented without explanation since they are well known.

The contiguous pile wall in Figure 22.3.2(a) is a retaining wall that may also form the wall of a tunnel. It is described in 22.4.3 as part of a cut-and-cover tunnel.

For relatively shallow bridge abutments where the height from the road surface to the toe is not more than 3.0m, a mass concrete or grouted rubble masonry wall without spread footings is common.

The vertical face of the wall is on the stream or low road side under the bridge. As the embedment below natural surface is shallow, it should only be used where scours would not be significant.

Bridge spill-through types are shown on Standard Drawing 1117 (1/00). These are used for the higher abutments or where significant scours are expected.

Where reinforced soil walls are used at the abutments of a bridge, the sillbeam abutment must be supported on a sub-structure independent of the reinforced soil wall.

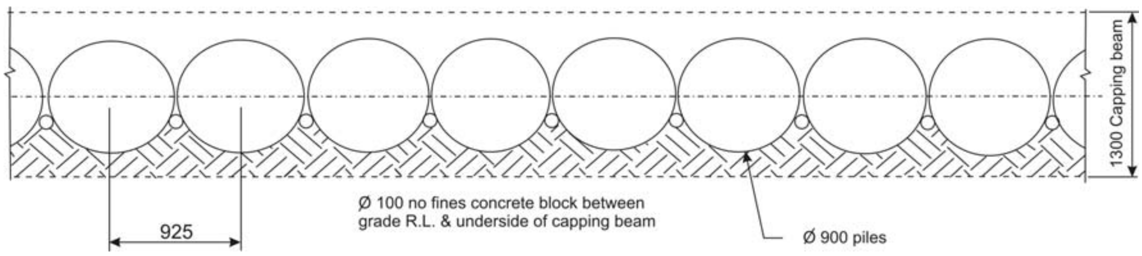

Figure 22.3.2(a) Contiguous pile wall

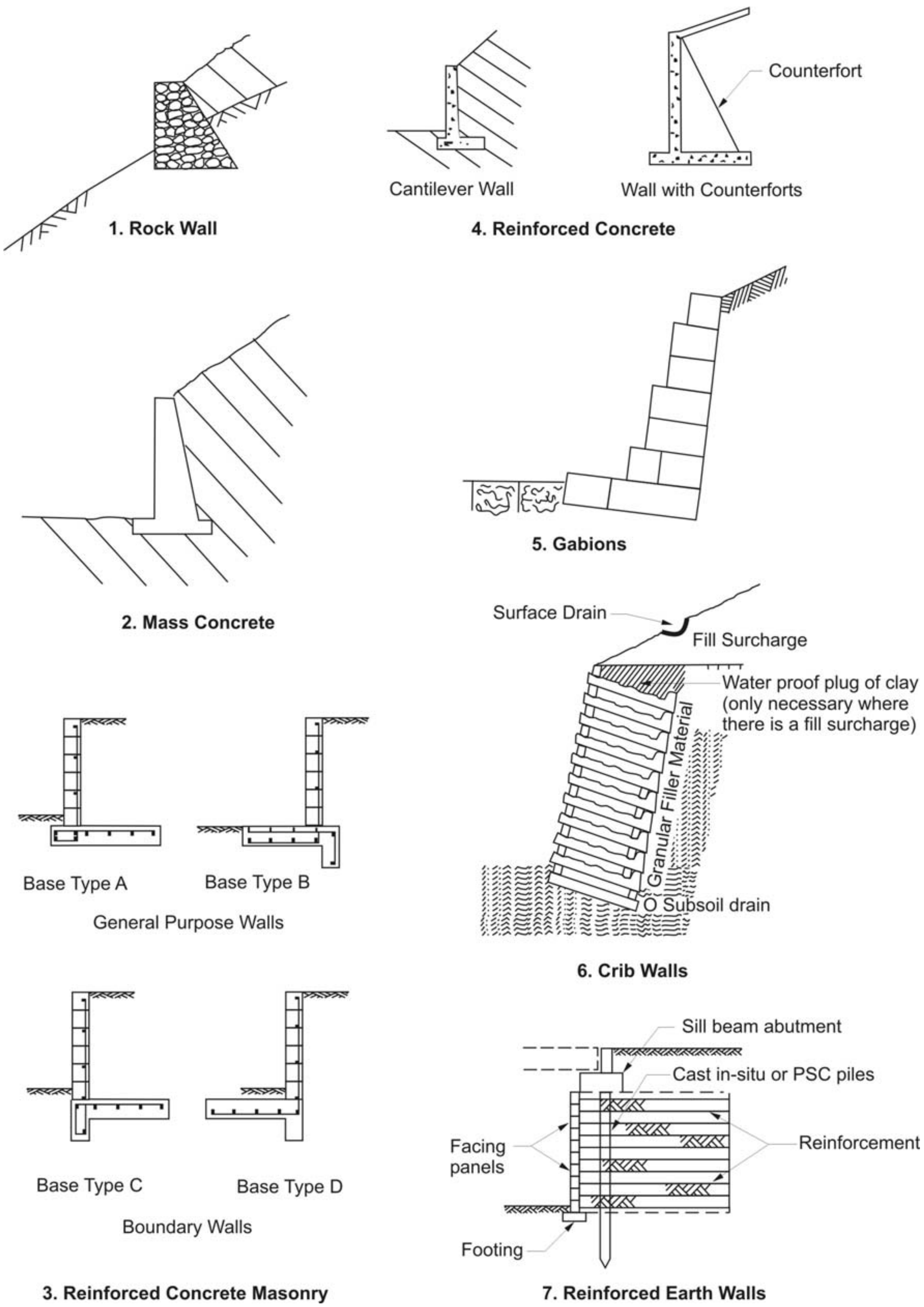

Figure 22.3.2(b) Examples of the most common wall types

References

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Relationship to Other Chapters

- Cross-references to Chapters 5 and 7 occur throughout;
- Detailed geometric elements must be derived from the relevant chapters;
- This document serves as a template for Chapters of the Road Planning and Manual. Some basic instructions follow.