

Road design

History of road design

Roads are essential for connecting people to their daily activities. In doing so, roads inevitably pass through a number of human and physical environments and, as such, must be carefully planned and designed.

The Romans were the first real road designers. They designed and constructed the first organised road system in Europe which was in use for almost 2000 years. Some parts are still in use today as secondary roads. These roads were very important in maintaining both the stability and expansion of the Roman Empire; not too dissimilar with the role of roads today in contributing to economic growth and quality of life.

The early roads of Queensland's first settlers were poorly planned and designed. When the need for a road was identified, it typically followed the trails or tracks produced by drays and bullock teams. The introduction of road authorities heralded a new approach to road design, with the Main Roads Commission established in Queensland in 1920. Today, road design is a detailed process of selecting elements that, when combined, make up the end product – the road.

Steps in the designer process

Before undertaking a project, the department's planners and designers:

- engage widely with stakeholders to determine their needs and identify potential issues
- adopt a holistic approach to planning and design to achieve an appropriate balance between competing factors (such as funding, volumes of traffic, types of traffic)
- visit the project site before completing the planning and design phase to ensure that the proposed design is practical for the site
- ensure parameters of the design elements are appropriate for the:
 - future operation of the road
 - function of the road
 - safety of road users
 - outcomes expected from the project.

Planners and designers pay particular attention to the long-term vision for the road network, and make an objective assessment of the affordable standard appropriate to various links in the road network. Link strategies for a given road define the proposed road standard in accordance with that road's investment strategy. Things considered include the requirements for specific traffic needs – for example, B-Doubles, road trains, levels of access, flooding immunity and travel speeds.

Role of the designer

Designers don't just design the road. Design is a complex process undertaken by technical professionals. Our designers must know the effect of combining design elements under different circumstances, and be able to apply sound judgment and experience in reaching the appropriate design.

Our designers look at:

- drainage design – storm water runoff and local planning authority requirements
- roadside design – everything related to the areas between the outside edge of the shoulder or kerb and the roadside reservation boundary, such as median strips, road furniture (for example, bus shelters), roadway lighting, pedestrian facilities, bicycle facilities, landscaping and noise barriers
- geotechnical design – such as earthworks design, construction materials and environment issues
- intersection, interchanges and rail crossing design – a critical component as these are locations where a high percentage of accidents occur
- geometric design – such as coordinated road alignments, adequate cross sections, sight distances and features that allow the safe operation of the traffic at the required speed
- environmental constraints and the impact of the road on the environment, both physically and operationally.



Context sensitive design

Roads are one element of the transport system which functions in natural and built environments to meet the needs of a range of stakeholders. Road design does not happen in isolation of this, but is sensitive to the context in which the road will operate.

Careful consideration is given to:

- the need and purpose of a road project
- safety
- mobility
- preservation of scenic, aesthetic, historic, environmental and community values.

Importantly, Queenslanders are part of the design process through the identification of their needs and expectations and commenting on planning and design elements.

The department undertakes context-sensitive design to give flexibility to independent designs tailored to particular situations. Context-sensitive designs harmoniously combine good engineering practice with the natural and built environments within the constraints and parameters of the project.

Fitting the road to the terrain

A visually attractive and physically unobtrusive road is one that blends well with the environment. A general rule for designers is to follow the natural contours of the land, using graceful and gradual horizontal and vertical transitions, and aligning the road to natural features such as mountains and rivers.

The use of continuous liberal curves is preferred to long-tangent and short-curve design. In flat, open terrain, long straight road stretches are common, but generally there is advantage in avoiding excessive lengths of straight road. A gently curving design always helps to keep the 'operating conditions' under control, and at the same time affords scope for easier fitting of the road to the terrain.

An added benefit of this type of road design is the enhancement of safety by:

- drivers being more aware of their speed
- drivers making better assessment of the distances and speeds of other vehicles
- reducing headlight or sun glare in appropriate circumstances
- reducing driver boredom and fatigue.

Designing curves for safety



Cant, camber or superelevation is the difference in elevation of two road edges. Designers ensure that a curved road is sloped so it is higher on the outside of the curve.

Superelevation allows part of a vehicle's weight to assist in maintaining a circular path. It reduces the required amount of side friction between the tyres and road surface when driving a circular path. This is important for the safety and comfort of all road users.

The amount of superelevation depends mainly on the operating speed of the curve and curve radius, with more superelevation applied on tighter curves. However, with the need to drain water off the road surface there is a minimum amount of superelevation applied to all curves.

Factors limiting how much superelevation to use include:

- stability of high laden commercial vehicles
- stability of loads on trucks
- tendency of the rear wheels of slow moving vehicles to track towards the centre of the turn
- appearance, particularly in flat terrain and urban areas
- effect on out-of-control vehicles leaving the inside of the curve
- tendency of vehicles to slide on the road surface in frost/icy conditions.

If the section of road includes a bridge, intersection or level crossing, then superelevation is more difficult to design and construct.

Designing intersections

An intersection is a location at which two different traffic streams cross or merge. Intersections are a normal part of any road system. Where a significant number of intersections occur, they are the major determinants of traffic flow and capacity of the entire road network. They are also a source of significant accident risk.

Two basic types of intersections are designed.

- At-grade intersections.
- Grade-separated intersections (also known as ‘flyovers’, interchanges or overpasses).

At-grade intersections are those where roads meet or intersect at the same level. They are generally controlled by traffic islands, give-way signs, stop signs, traffic lights or roundabouts.

Grade-separated intersections occur when intersecting roads are separated in level so they do not disrupt the flow of traffic on one another when they cross. This is achieved by building bridges over, or tunnels under, the crossing site.

When the intersection allows turning movements from one road to another, an interchange is formed. These are the highest form of intersection treatment. When fully developed, all at-grade crossings are eliminated and interaction between traffic streams takes place by merging, diverging or weaving.

Designers look at:

- visibility at the location of the intersection so drivers can read signage, locate points of conflict with other users and determine how to proceed
- ensuring general intersection geometry is suitable for the dimensions, acceleration and deceleration, and tracking capability of vehicles
- using design geometry to effectively position vehicles in the intersection, so drivers are easily visible to each other
- promoting safety by keeping intersections as simple as possible, reducing and separating points of potential conflict for the driver, and controlling operating speeds
- having a “forgiving” intersection design to deal with possible incorrect judgements made by drivers
- providing for cyclists and pedestrians, including those with special needs
- ensuring consistent treatment along the route so drivers who are unfamiliar with the location can make intersection decisions quickly and accurately
- providing layouts for emergency and oversize vehicles to effectively negotiate the intersection.

Balances and checks

Safe road design is the over-arching priority, ensuring safer transportation for motorists, cyclists, pedestrians and adjacent communities.

Road design involves considering aesthetic, scenic, historic, cultural and physical aspects of places that help give communities their identity and sense of place.

Designers also consider the provision of existing and future services (such as overhead/underground power and phone cables, sewerage, gas and water pipes), legislation, relevant Australian Standards, guidelines in the department’s Roads Planning and Design Manual and many other comprehensive supporting documents.

The result – a well designed road that balances a myriad of aspects!

Building a road

There can be considerable lead time needed before roadworks begin. The process of road building involves several steps.

Concept

The concept stage can happen many years ahead and may involve working with local government, planning authorities, industry and communities, and in some cases the federal government.

Planning (usually three to five years for major projects)

Once the decision has been made to build a road, planners then look at the best location. Considerations include the cost and amount of land needed and the effects the road will have on the community and business. Planners also prepare environmental impact statements that show how the road may affect the environment and communities.

Design Development (usually one to two years for major projects)

This stage decides the size, type and location of the road. Traffic volumes, the type of road (for example, national highway, arterial road) and the landscape (urban, remote, hilly, flat, soil type) are considered at this stage.

Construction (anywhere between one and four years for major, complex projects)

The first step is site preparation and involves clearing any buildings and vegetation. Topsoil may be used in landscaping activities later. Pavement is then laid. First, a sub-base (crushed rock cement or gravel) is laid. Then the base is laid (crushed rock, concrete or a mixture of both). Finally, there is the wearing course or surface.

In the construction stage, road workers erect speed and roadwork signage and barriers to ensure the safety of motorists and workers. They also undertake landscaping activities and spray line-markings.

Even with the best of planning, there are many reasons why roadworks can be delayed. These include property resumptions, funding availability, weather conditions and availability of materials.

Managing the road asset

As with all structures, Queensland roads are not designed or constructed to last forever. Just like the vehicles that travel on them, roads experience wear and tear over time with prolonged use, heavy loads and natural impacts such as flooding and high temperatures.

In managing this important community asset, there are a number of aspects to consider. For example, there is a need to balance economic, social and environmental outcomes over the expected life of the road.

To do this, data on the road asset is routinely collected and analysed. Data includes the type and nature of vehicles using the road, the traffic volumes and increases, and the purpose the road is most frequently used for, for example, freight or tourism. Road and bridge condition data is also monitored and analysed to develop a program of priority projects and maintenance.

As a road asset manager, we engage regularly with our stakeholders (such as local councils, community members and various industry representatives) to identify their priority issues and manage their expectations. The outcome for Queenslanders is a better road system.

Maintaining the road asset

The department uses three categories to describe road maintenance activities - routine maintenance, programmed maintenance and road rehabilitation.

Routine maintenance covers:

- upkeep of roads
- maintenance of the road shoulder and sub-grade
- maintenance of side drains and other ancillary works
- repair of pot holes and localised failures.

Programmed maintenance covers activities similar to that for routine maintenance, but scheduled within a program of projects for delivery.

Examples of programmed maintenance are:

- bitumen reseals
- gravel re-sheeting of unsealed roads
- thin asphalt overlay
- replacement of defective bridge members
- painting steel bridges.

Rehabilitation is performed primarily to provide a better ride and improve the structural adequacy of the road pavement.

Rehabilitation works include:

- reworking or strengthening of bases or sub-bases
- asphalt overlay of greater than 75mm depth
- bridge refurbishment to original condition
- re-decking timber bridges.

Protecting the road asset

The current road network is a result of ongoing investment over many decades. A large proportion of the network was built to cater for the needs of the time. Meeting the current and emerging demands such as larger vehicles, higher speeds and increasing expectations for safety and comfort, is an ongoing challenge. Protecting Queensland's largest community asset is a top priority for the department.

Our Roads Implementation Program 2009-10 to 2013-14 details a five-year rolling program of capital works and maintenance across Queensland. The program ensures roads and bridges are built and maintained to safety standards and to meet increasing expectations.

To protect the asset, a lot of planning goes into the program to balance capital investment with maintenance. There are many competing priorities within the budget allocated to roads.

Maintenance is undertaken at an optimum time to maximise the performance of the asset and to minimise the costs over the life of the road. Funding decisions give priority to maintenance and rehabilitation. The strong emphasis placed on maintenance ensures improved road user safety and community stability and vitality, especially in Queensland's more remote areas.



Bitumen spraying



Road paving

For more information:

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