PIPELINE SYSTEMS

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M-Lock® Bridge System

Technical Guide

PIPELINE SYSTEMS

M-LOCK®
Complete Bridge System

GENERAL

The M-Lock® Bridge System is a proprietary product manufactured and sold by Rocla using standard components, to suit the requirements of AS5100 and Australian Road Authorities.

A bridge design consists of many issues, many of which are unique to each site, such as:

a. Road alignment and geometry
b. Span configurations
c. Hydraulic aspects
d. Geotechnical issues
e. Type and number of piles
f. Live vehicle loads and barrier requirements
g. Configuration of abutments and wingwalls

When considering all these issues, the M-Lock bridge system is offered as a solution available to the bridge designer and certifier. Rocla offers the product pre-cast, and will not supply reinforcement details, but will certify that the components of the bridge are structurally adequate to comply with the requirements of AS5100, when constructed in accordance with our recommendations. The bridge designer will still need to certify that all the other aspects are adequate for the service levels required by the road, and that the piles and bridge layout are adequate for the site.

In summary, each bridge is different, and it is the certifier's job to ensure that the solution, which may include standard M-Lock® components, is appropriate for each site.

OVERVIEW

This document presents an overview of the development of the Rocla M-Lock® Bridge System. It also describes how this bridging system is ideally suited for the construction of small to medium span bridges in remote areas and in areas where a locally skilled labour force or construction plant is not readily available. An overview of the typical components used in the system, togetherwith the typical construction sequence, will be given, emphasising the relatively short construction periods required.

The document outlines the versatility of the M-Lock® Bridge System with examples of its use in the following situations:

- Road bridges
- Sub-division bridges
- Pedestrian bridges
- Utility bridges

This document also describes the M-Lock® Bridge System's optional extras. These are additional to the basic system and include: provision for utility ducts, footways, kerbs, alternative barrier types and an asphaltic concrete wearing course.

INTRODUCTION

The M-Lock® Bridge System is a modular system that comprises precast reinforced concrete elements, designed to be rapidly assembled with minimal need for skilled labour and on-site work. The precast elements typically comprise piles, headstocks, end protection beams and planks. The M-Lock system is ideally suited for low traffic volume bridges in remote rural areas but it has also been successfully used for sub-division bridges, pedestrian bridges and utility bridges.

The system is essentially based on a product that was initially produced by Rocla in the US, performing successfully there since 1952. When introduced into Australia, the system was modified to suit the Australian marketplace's specific requirements, particularly the difference in design loadings and material specifications between the US and Australia.

The first Australian M-Lock bridge was constructed in 1995 over Ohio Creek at Walcha in New South Wales. Since then, over 230 bridges have been constructed in Australia using the system.

FIG. 1: OHIO CREEK, WALCHA NSW

DESIGN DEVELOPMENT

In 1995 Cardno was appointed by Rocla to re-engineer the standard US system and to produce designs for standard span lengths of 7m, 9m, 10m and 12m with widths varying from 4 planks wide (single carriageway) to 9 planks wide (3-lane carriageway).

Cardno developed different precast concrete piling systems to suit the varying sub-surface conditions that may be encountered at bridge sites. These piling systems comprise driven piles and socketted piles.

The bridge planks were designed to be bolted to the headstocks; should the bridge become submerged during a flood event the bridge deck will not be washed away. Air release holes were detailed in the planks to minimise uplift forces due to buoyancy.

The standard designs were used successfully until 2000, when the new SM1600 live loading was introduced. This loading was subsequently adopted by the current Australian Standard, AS5100 “Bridge Design” which replaced the Bridge Design Code 1996. With the advent of the more onerous SM1600 loading, Cardno undertook modifications to the standard M-Lock components so that the designs were structurally compliant with the new loading.

In 2005 Cardno was commissioned by Rocla to design standard components for 15m span bridges. The 15m span plank is deeper than the other standard spans; headstocks were designed for use in multi-span bridge applications that incorporate both 15m spans and shorter span lengths.

FIG. 2: WENTWORTH BRIDGE - BEFORE

FIG. 3: DURING CONSTRUCTION

ADVANTAGES OF MODULAR BRIDGES

There are many advantages with using a modular bridge system including:

1. **Precast construction** – Because the components are manufactured at a purpose built precast yard both quality and tolerance can be tightly controlled. In WA, Rocla has a precast facility in the Perth suburb of Cloverdale.
2. **Steel moulds** – Rocla’s moulds for the standard precast components are fabricated in steel. The use of steel provides greater re-use than conventional timber moulds; in the long-term it is better for the environment.
3. **Environment** – Disturbance to a bridge site is typically limited to minor earthworks at the abutments and the drilling of holes for precast socketted piles. Construction work areas and compounds are minimal in size as few materials need to be stored on site (precast components are generally installed on the day they are delivered) and relatively few items of plant and tool s are required.
4. **Plant** – Typically the only major pieces of plant required to build this type of bridge are a drilling rig for the pile holes and a mobile crane for installing the precast components.
5. **On-site labour** – Because the bridge components are precast, skilled tradespersons such as carpenters, steel fixers and concrete gangers are not required on site. This is of particular importance in rural locations where there is likely to be a shortage of skilled labour.
6. **Ready mixed concrete** – Because there is no need for in-situ concrete, the proximity of concrete batching plants for the timely delivery of fresh concrete is not an issue.
7. **Speed of construction** – Typically a single span bridge can be constructed in a period of 15 working days. When an existing bridge is being built on the same alignment as the existing due to geometric or land constraints, the quick construction time minimises disruption to road users.
8. **Span over span construction** – Bridges can be constructed by reaching out with plant for piles and precast components such that plant need not work in creek or river beds.
9. **Asphalt topping** – An asphalt topping is not necessary, unless required for aesthetic purposes. This helps keep down the construction cost which may be of particular concern for bridges along unsealed roads in a rural area, where the cost of getting a paving machine and the asphalt to site would be prohibitively high.

BRIDGE COMPONENTS

The M-Lock bridge system comprises the following typical precast components;

- **Piles**
- **Headstocks**
- **Planks**
- **End Protection Beams**

The precast piles are typically centrifugally spun piles with an outside diameter of 585mm for the socketted pile application or 400mm square reinforced concrete piles for the driven application.

The type of pile used will depend upon the subsurface conditions. Socketted piles are primarily used where rock is encountered and precast square piles are used where there is no rock or it is impractical to provide socketted piles. Socketted piles have protruding reinforcement for the pile/headstock connection, whereas the precast square piles need the upper section of concrete to be broken back to expose the pile reinforcement for the pile/headstock connection.

Headstocks are available for a range of bridge deck widths and incorporate voids to accommodate the protruding pile reinforcement. Headstocks are manufactured either with a 2% two-way crossfall or straight. Ferrules are cast in to the top face of the headstock to allow hold down bolts for the planks and end protection beams to be screwed in.

The planks have an inverted "U" profile, are 1.2m wide and are structurally designed for SM1600 traffic loading in accordance with AS5100. For span lengths up to and including 12m the depth is 620mm and for the 15m spans the depth is 800mm. The planks are bolted down to the headstocks and bolted to the adjacent planks using hot-dip galvanised components.

End protection beams are provided at the abutments to protect the end face of the planks from possible damage from traffic. They also prevent soil spilling onto the bearing shelf which may impede rotation of the planks when subjected to traffic loading.

CONSTRUCTION

A typical construction sequence for an M-Lock® Bridge System is as follows:

1. **Site preparation** – Some earthworks are generally necessary to prepare the ground for the abutment headstocks and the piles. Where scour protection works are required to the side slopes and around the piers the ground needs to be prepared for this.

2. **Boring pile holes** – For a typical bridge with socketted piles, the pile positions are surveyed and then boring of the pile holes can commence. The standard pile is a centrifugally spun pile with an outside diameter of 585mm and the pile holes are oversized at 750mm diameter to facilitate easy installation and to take up any out of tolerance with the pile holes. The depth of the holes is dependent upon the design loading on the pile and the geotechnical conditions at the site. The geotechnical conditions and the level of the water table may require temporary steel casing to support the pile hole prior to installation of the pile. Generally the boring will involve socketting into bedrock material; the depth of embedment will be dependent upon the strength of the rock. When piles are installed with a rock socket the exact depth can be calculated to suit the length of the piles and therefore no trimming of the piles is required.

3. **Installing piles** – The precast concrete piles are lifted and inserted into the prebored holes and are supported in their correct line and level. Once they are lined and leveled the annulus between the wall of the pile hole and the pile is backfilled with a compacted lean sand/cement mix. The pile void is usually backfilled with stabilised sand.

4. **Placing headstocks** – The precast headstocks are lifted onto the piles. Voids are provided in the headstocks so that the protruding reinforcement from the piles fits into the voids. Once the headstock i s lined and levelled, the voids are filled with grout to provide a structural connection between the piles and the headstock.

FIG. 4: PLACING PRECAST HEADSTOCK

5. **Preparing headstock for planks** – To prepare the headstock for the planks, an elastomeric bearing strip i s laid down where the planks will bear onto the headstock. This elastomeric bearing strip allows the planks to rotate at their ends when they are subjected to traffic loading. The planks are held down onto the headstocks with bolts that are screwed into ferrules that are cast into the headstock. These bolts are screwed into the ferrules with holes provided in the bearing strip to allow the bolts to pass through.

6. **Installing planks** – The precast planks are lifted into place starting from the centre plank and working outwards, the vertical bolts are used as a guide for placement of the planks and checks are carried out during the operation to ensure that the planks are both parallel to each other and are seated correctly. The vertical bolts are tightened and the recess for the bolt hole is then filled with grout. Bolts that connect adjacent planks are installed and tightened.

FIG. 5: INSTALLING PRECAST PLANKS

7. **Grout shear key** – The longitudinal gap between adjacent planks (the shear key) is filled with grout to achieve a smooth running surface for traffic.

8. **Place end protection beams** – The vertical bolts, which anchor the end protection beam to the headstock with ferrules that are cast in the headstock, are screwed into the headstock and the end protection beams are lifted into place. The vertical bolts are tightened and the recess for the bolt hole is then filled with grout.

M-LOCK® APPLICATIONS

The M-Lock® Bridge System was originally developed for rural road applications. However, the system is also used in a variety of other applications where low-cost bridging and speed of construction are of importance to the client. These applications have included:

- **Sub-division bridges**, where the developer usually requires quick access to areas of land ear-marked for development;

FIG. 6: TYPICAL SUB-DIVISION BRIDGE

- **Pedestrian bridges**, usually in urban areas where it is important to minimise disruption to both residents and road users from construction activities, and noise pollution etc.;

FIG. 7: TYPICAL PEDESTRIAN BRIDGE

- **Utility bridges** where the M-Lock planks are used in an inverted arrangement and modified by the removal of the end diaphragms to carry large diameter utilities up to 750mm in diameter.

M-LOCK® EXTRAS

As the M-Lock® Bridge System has evolved over the years, a number of "optional" extras have been made available to the standard system. These extras include the provision for utility ducts under the bridge. To accommodate the utility ducts the end diaphragms of the planks are modified to provide a cut-out in the end diaphragms. Because the utility duct must pass between the pair of plank hold-down bolts, the size of utility duct that can be accommodated in this manner is limited to a maximum diameter of 300mm. Pipe hangers are provided along the length of the plank to support the duct.

Pedestrian footways can be provided on M-Lock bridges, however, the standard Thrie beam traffic barrier must be replaced with a barrier that is both suitable for vehicles and pedestrians. In accordance with the Bridge Design Code, AS5100, pedestrian barriers must be at least 1100mm high and have vertical balusters with no climbing footholds - where cyclists may use the footway the height increases to a minimum of 1300mm. The M-Lock planks are supplied with protruding reinforcement to provide a suitable construction joint between the planks and the footway. Utility ducts may be provided in the footway. The inclusion of footways is a common feature on sub-division bridges.

The cast surface of the planks is generally used as the running surface for traffic, particularly in rural areas. In urban areas, where the application of an asphaltic concrete wearing surface is deemed necessary for aesthetic purposes, this surfacing can be applied to the top surface of the planks. However, the surfacing needs to be laterally restrained and this is achieved by providing kerbs and/or footways.

For typical rural road bridges a Thrie beam barrier is bolted to the outside face of the edge planks. The Thrie beam barrier is suitable as a low performance traffic barrier in accordance with AS5100. However, alternative barrier types can be accommodated such as when footways or cycleways are provided. In these situations the preferable arrangement is to have a traffic barrier to segregate the traffic from the footpath and provide lightweight pedestrian barriers at the edges of the bridge.

Castellated kerbs are used in certain situations where traffic volumes are low, the bridge is not too high and the site meets the risk assessment criteria detailed in the Bridge Design Code. The castellated kerb units are precast with voids in them so that they can be placed over reinforcement protruding from the planks and the voids are then filled with grout. Castellated kerbs are ideally suited for bridges that are prone to submergence as typical traffic barriers are susceptible to flood damage and may need to be repaired or replaced following flood events. Castellated kerbs require minimal maintenance and thus keep down the whole life cost of the bridge.

Castellated Kerbs

FIG. 8: BEFORE FLOOD EVENT

FIG. 9: DURING FLOOD EVENT

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