The Design and Construction of Maylands Recreational Shared Path Bridges over an Environmentally Sensitive Wetland with Water-Filled Clay Pits

Andreas Kerkovius, Connell Wagner Pty Ltd, Perth

SYNOPSIS
The Maylands Recreational Shared Path (RSP) is a recreational and commuter cycling & pedestrian path located along the western foreshore of the Swan River between Banks Reserve and Bardon Park.

The design had to deal with very difficult ground conditions along the Swan River flood plain, and crossing of sensitive wetland areas with two bridge crossings requiring 25m spans over existing water filled clay pits.

The bridge designs required an innovative approach that mitigated the environmental and visual impact on the wetland, and the adjacent residential views and security. To provide an aesthetic design for the bridge deck, and to clear the water surface to allow natural light under the deck, the developed deck elevation comprises a variable depth, composite steel and concrete twin girder deck with a very thin central span section. This solution required the adoption of an integral structure with a piled counter-balance abutment to resist the substructure loads, and to enable a slender superstructure design. Construction principles from large bridge construction were employed for this scaled down very slender single span solution.

The design and construction of the Maylands RSP, was one of the most difficult RSP path projects attempted in the Perth Metropolitan area, however, due to a very good working relationship between designer and contractor, and the strong support of the client, all issues were overcome and a functional and aesthetically pleasing infrastructure project has resulted. The bridges have been constructed with minimal impact on the wetlands, providing an attractive crossing of the clay pits, meeting the environmental and heritage requirements for the sensitive river foreshore development.

This project was adjudged a winner of the CCF EarthAwards 2007.

1. PROJECT OUTLINE

Location & Background
The Maylands Recreational Shared Path is a cycling and walking path located along the western foreshore of the Swan River between Banks Reserve and Bardon Park in the Perth suburb of Maylands.

This recreational shared path (RSP) has been an integral part of the long term strategy for developing cycle paths within the Perth Metropolitan area. Over the last twenty years, it has been the missing link in the planned bike path from the Perth
CBD to Midland along the western shoreline of the Swan River. The construction of this section of path has been problematic because of the path location in respect to the Swan River flood plain, the general topography of the path alignment between Banks Reserve and Bardon Park in Maylands and the general ground conditions within this planned cycleway alignment.

In 2000, initial concept work was started on the proposed alignment for the Maylands RSP. In 2004, a final alignment was selected, which was generally located within the Swan River flood plain, but which required the inclusion of 2 bridges along the alignment to bridge old clay pit ponds within a significant wetland area. The chosen alignment also required both aboriginal and environmental clearances to be obtained, plus the management of acid sulphate soils that existed along the Swan River foreshore. (refer to Photo 1 & Figure 1)

Photo 1: Maylands Recreational Shared Path – Banks Reserve End (Downer EDI Works)

The concept alignment selection and consultation process proved to be a reasonably arduous exercise, and once detailed design had commenced, the difficulty status of this project grew. Design was undertaken through 2004, based on Austroads guidelines for cycleway design. The main issues in the design process were the atrocious ground conditions that needed to be accommodated along the chosen alignment and the fact that the route was within the Swan River flood plain, presenting associated scouring and flooding issues that needed to be accommodated within the design. The whole RSP route required extensive foundation treatment, alignment design through wetland areas that were physically impossible to survey at the time of design, and the development of 2 bridge designs, each requiring a 25m clear span over existing water bodies. These bridge designs required an innovative approach to achieve the 25m span requirement with an
economical but aesthetic design for the bridge, with a very slender and shallow bridge profile.

**Environmental constraints**
The pathway alignment over the wetland area and ponds was selected following an extensive community consultation and evaluation process of several options, which focussed on the potential environmental impact of the pathway. The pathway alignment had to address a number of constraints, including:

- Minimize impact on wetlands,
- Retain the ecological function and integrity of the wetlands,
- No separation of the wetlands from the Swan river,
- Removal of endemic weeds,
- Retain key native vegetation,
- Aboriginal Heritage Act clearance regarding piled bridge foundations.

Based on the environmental values, and an impact and risk assessment, the chosen alignment was located along the western fringe of the wetland at Banks Reserve, spanning two water-filled, clay pit ponds (Figure 1). Before works commenced, the site constraints and potential environmental issues were identified and outlined in an Environmental Management Plan.

Figure 1: Layout plan
Social Benefits for Community
A condition of the project was that it met the Swan River Trust Policy EA4 ‘Land use and development’ which states: “The Swan River Trust will seek to ensure that land use and development on or adjacent to the river maintains and enhances the river environment”.

The project demonstrates the possibilities of infrastructure development as a dramatic enhancement of an area that was once a rubbish dumping area, with dilapidated clay pits and dense exotic vegetation impassable on foot, to achieve the environmental and community connection to the Swan river foreshore while creating recreational and commuting options between Perth and Maylands and beyond to Bassendean.

In the context of preserving the wetlands and existing amenities and views of the river, key natural elements were preserved, such as the fringing vegetation, wetland fauna and flora, and existing natural habitat for waterbirds. Safe and environmentally appropriate access to the foreshore environment has created a greater appreciation of the Swan river and recreational activity and connectivity.

Photo 2 : View over wetlands & water-filled claypits
2. BRIDGES OVER WETLAND PONDS AT BANKS RESERVE

The design and construction of the Maylands RSP, was probably one of the most difficult cycle path projects that has been attempted in the Perth Metropolitan area. Considerable challenges were encountered through the whole design and construction process, but due to a very good working relationship between Connell Wagner and the contractor (Downer Works EDL), and the strong support of the client (Department for Planning and Infrastructure), all problems were overcome and a functional and aesthetically pleasing infrastructure project has resulted.

The key technical issues for the bridge crossings that had to be addressed are:

- Water filled clay pits with unknown edge conditions,
- Acid sulphate soil conditions – avoid disturbance & exposure,
- Soft, saturated soils to 8 to 10 m depth, (wetlands, floodplain)
- Large spans over water, \( L = 25 \) m between abutments,
- Composite beam \( L/d \sim 36 \) for midspan region, beam pinned at \( ¼ \) span transition / splice to taper cantilever to abutment,
- Single span fixed into counter-balance abutments with piles to transfer forces to founding layer (compression under permanent loads),
- Screw piles for tension capacity under live loads (vertical - rear end),
- Screw piles to mitigate ASS issues during installation.

Geotechnical

The results of the geotechnical investigation indicated that subsurface conditions are variable at the proposed bridge sites. The CPTs carried out encountered soft to firm peat materials to 1.5-2.5m depth, overlying stiff to very stiff clay to 6-11.5m over medium dense/stiff silty sand/sandy silt.

Due to the presence of soft soils in the top 1.5 to 2.5m, a shallow foundation system was not deemed to be adequate and a pile foundation system was adopted to transfer bridge loads to deeper bearing strata and also support any uplift load by skin friction.

In order to mitigate the effects of excavated acid sulphate soils, a screw pile solution was adopted, which avoided the need for soil removal during the pile installation.

Bridge Description

The crossing of the Banks Reserve wetland area required the bridging of two water-filled clay pits fringing the western edge of the wetland along the base of a raised bank (refer Figure 1). A gas main easement is located along this edge, and the bridge design and construction was required to mitigate any potential impacts of the RSP on the pipeline. The adoption of screw piles avoided vibration or noise impacts during construction on the residents and the gas pipeline.

The RSP alignment and geometry required keeping a low profile in this area, and to maintain clearance over the water for water birds and tidal flow conditions from the
Swan River. Consequently a very shallow bridge deck was desirable, able to span 25 m across the water bodies to abutments at the pit edges. (Photo 3)

The bridges over the water-filled clay pits each comprise a single 25 m span between abutments. In order to achieve a slender deck with sufficient clearance to the water surface, a haunched, composite steel girder with concrete deck slab solution was developed. This enabled the adoption and a deck span/depth (L/d) ratio of 36 for the span region, increasing with the haunch to L/d = 20 at the abutment. This haunched deck presents an aesthetic visual profile over the water with an environmentally compatible footprint. (Figures 2 & 3)

The decks are integrally fixed with the abutments, with the abutments acting as counter balances to the span loading, relying on the piling arrangement and abutment counterweight to provide the resistance to the span loading.

The abutments comprise a box type structure with longitudinal rib walls that align with the deck girders to transfer the forces to the foundation piles.

The box is filled with compacted sand before the top slab pathway is cast to join monolithically with the deck. The hogging moments are transferred from the fixed beam ends to the abutment wall beam through the composite deck slab and the prestress tie bars used to stress and fix the beam end to the abutment wall.
Figure 2: Bridge Plan & Elevation

Figure 3: Bridge Typical Section at Abutment
Superstructure Structural System

The deck comprises a composite steel girder with concrete deck slab, 3000 mm wide between kerb faces. The deck depth varies with tapered haunches and a constant depth central span section.

The steel girder comprises a fabricated steel, tapered I-beam section from the abutment (h=1200 mm) to roughly the ¼ span (h=500 mm), being near the location of point of contraflexure. The central span section comprises a standard I-beam, 500 mm deep. Cross-bracing between the two beams was provided for the construction phase to provide stability and dimensional control to the sections being erected.

The tapered beam sections at each abutment were accurately positioned and aligned with shims between the beam ends and the abutment wall face, and the central span section was bolted to the tapered section ends. The beam ends were stressed to the abutment face with stress bars after the gap was grouted with a high strength, shrinkage compensating grout prior to the deck slab construction to create the structural continuity between the girder and the abutment.

The deck slab comprises precast u-shaped panels, 2500 mm long, with a cast in situ overlay to achieve a 180 mm thick concrete slab acting compositely with the steel beam. The edge kerbs are cast monolithically with the precast unit, resulting in a trough shape for casting of the in situ topping.

The beam elements and precast units were lifted into place with a large mobile crane, positioned on an access path on the western bank, having a reach sufficient for placing panels at the far abutment.

A difficulty encountered during the set-up of the precast units on the steel beams involved some casting tolerances and shrinkage distortion of the units. This was largely overcome by aligning the units to a ‘best fit’ with packing spacers and sealing the gaps prior to casting the in situ concrete to prevent grout leakage.

The integral nature of the design avoids the need for expansion joints and bearings, thereby improving the overall bridge durability and reducing inspection and maintenance requirements for these elements.

An embedded approach slab is provided to mitigate potential differential settlement between the flexible path approaches and the rigid abutment. The approach slab provides a suitable transition onto the bridge for cyclists, minimizing the approach sag and ‘bump’ onto the bridge deck.

Galvanized steel safety railings are provided along the edge kerbs with a top rail height of 1300 mm above walkway slab level to allow for cycle use in accordance with AS 5100. The safety railing comprises panels of multiple vertical balusters spaced at 130 mm clear spacing with a top rail, which are fixed to the outer kerb edge of the deck slab.

Lighting is provided at each of the abutments using architectural posts and lamps to enhance the appearance of the bridge.
Sub-structure Structural System
The abutment comprises a 6000 long x 1500 high, reinforced concrete box, with thick longitudinal walls aligned with the steel girders. Embedded stress-bars create fixity between the girders and the abutment. The moment and shear forces are transferred via the walls to the piles. The front piles are raked to provide longitudinal restraint and carry most of the compression loads, while the rear piles are vertical to balance the dead loads, but provide a tension restraint under live loads.

The box is filled with compacted sand fill to provide additional ballast for counter-balancing the continuity moment transferred at the deck / abutment connection.

The piles comprise 114 mm dia steel tube screw piles with concrete fill. The wall thickness includes provision of a sacrificial thickness for potential acid sulphate attack within the subsoils.

Construction
Final design approvals were obtained in 2005 and the project was tendered and awarded to Works Infrastructure in August 2005.

Construction of the RSP path and bridges commenced in the middle of the wet winter months. The site conditions and wet weather provided challenges for the construction crew especially for heavy construction plant, where a 24T excavator almost disappeared into the Swan River flood plain. Soft river materials, natural ground streams, acid sulphate soils, reeds and impassable vegetation, protected vegetation and wildlife were some of the issues faced by the construction team.
A key aspect of the construction to minimize the impact on the wetland environment was the construction sequence, which included a stayed support system during the assembly and installation of the steel girders. The staged construction of the composite concrete deck limited the deflections and stresses of the deck span region. (Photo 4)

The use of precast deck units enabled the use of mobile cranes, with a reach capable of placing the units from access points clear of the sensitive wetland environment, and avoided the need for formwork on the steel girders over water. (Photo 5)

**Construction Sequence**
The bridge was constructed in the general sequence as indicated in Figure 4 and as noted below:

1. Installation of abutment piles and construction of abutments including filling of void with sand,
2. Connection of tapered beam sections to the abutments using a stayed support system,
3. Placement of the central span beam onto the taper beam ends and establish continuity,
4. Removal of stay system and placement of precast deck panels onto tapered beam section and casting of concrete overlay to establish composite section over the abutment region,
5. Placement of precast panels on remaining span section and casting of concrete overlay to establish composite section,
6. Completion of the deck features.

**3. SUMMARY**
The Maylands bridges over the wetland clay pit ponds provide a key link to the recreational shared path along the Swan River foreshore. The crossing of the water-filled pits was achieved with an innovative structural solution to the site that met the community, environmental and stakeholder expectations, and now presents a popular recreational and commuter path between Perth and Bassendean.

The project delivery was dictated by:
- Very difficult site conditions – probably the most difficult RSP construction in the Perth Metro area,
- Significant clear bridge spans over wetland claypits,
- Very soft and saturated Swan River floodplain,
- Privacy and security concerns of residents,

This was achieved by:
> Extensive Community & Stakeholder consultation,
> Environmentally sensitive design & technical innovation,
> Construction management to industry best practice.
Acknowledgement
The permission granted by the Department of Planning and Infrastructure to publish the information contained in this paper, and the support of Connell Wagner to present it at this conference, is gratefully acknowledged.

Figure 4: Bridge Construction Sequence