Design of Picton Railway Overbridge for Mine Subsidence

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Abstract

Tahmoor Coal Pty Ltd is currently replacing an existing bridge over the Main Southern Railway Line near Picton in NSW, due to proposed mining works. The new bridge is located immediately to the west of an existing brick arch bridge. The rail overbridge is an asset of Transport for New South Wales with Wollondilly Shire Council owning the connecting road. Other key stakeholders include ARTC, John Holland Country Regional Network and the Mine Subsidence Board.

The new overbridge is required because of potential subsidence impacts from scheduled longwall mining activities in the area in late 2015 which would compromise the safety of the existing bridge structure. The project also involves realignment of the road approaches and the demolition of the existing bridge. A key issue in the design was the articulation of the bridge which had to cater for large opening/closure movements and large differential vertical and horizontal movements between the two ends of the bridge. A large movement modular deck joint and large movement sliding spherical bearings were adopted to accommodate these potentially large mine subsidence displacements.

This paper discusses: project and stakeholder management; and the development of design strategies to account for the effects of potential mining subsidence movements.

Introduction

Tahmoor Colliery is located south of the village of Tahmoor approximately 80 kilometres south west of Sydney. Tahmoor Colliery is extracting coal from the Bulli Seam of the NSW Southern Coalfields.



Figure 1 - Location

Coal is extracted at Tahmoor Colliery by longwall mining. This method requires the area immediately in front of the coal face to be supported by a series of hydraulic roof supports, which temporarily hold up the roof strata and provide a working space for the shearing machinery and face conveyor. After each slice of coal is removed, the hydraulic roof supports, the face conveyor and the shearing machinery is moved forward.

When coal is extracted using this method, the roof immediately above the seam is allowed to collapse into the void that is left as the face retreats. As the roof collapses into this void, the fracturing and settlement of the rocks progresses through overlying rocks and results in subsidence of the surface area above as illustrated in Figure 2 overleaf.



Figure 2 - Cross section of a typical longwall face (Curtesy of Tahmoor Coal)

The longwalls at Tahmoor are located approximately 450 metres below the surface and the longwall panels are approximately 300 metres wide.



Figure 3 – Aerial View of Bridge Site



Figure 4 - Extract of Longwall 27-30 Subsidence Management Plan Area (Curtesy of Tahmoor Coal)

In 2008, Tahmoor Colliery started mining directly beneath the Main Southern Railway at Tahmoor. The mining schedule indicates the Picton Railway Overbridge, where Bridge Street crosses over the railway, will be affected by longwall mining around December 2015 and it was determined that the existing structure could potentially collapse during the mining operations. Therefore, it was determined that the existing bridge should be demolished and replaced with a new structure that would be capable of accommodating the possible subsidence movements to allow the continued operation of the Main Southern Railway and the traffic on Bridge Street.

Location and Setting

The Picton Rail Overbridge is located in the suburb of Picton within the Wollondilly Shire Council Local Government Area (LGA). The site is within the Tahmoor Mine Lease area above the proposed Longwall 29 alignment. The location is characterised by rural landscapes with pockets of bushland around drainage gullies. Surrounding land uses included rural residential and neighbouring commercial area.

The bridge is located on Bridge Street which links the townships of Picton and Thirlmere. The bridge crosses the dual track Main Southern Railway at rail chainage 91.010km. The existing structure has a span of approximately 10m, and is a concrete arch bridge with brick masonry spandrels. The existing vertical clearance is approximately 4.5m.



Figure 5 – Existing Bridge (Recently demolished)

The roadway immediately adjacent to the bridge consists of an S bend alignment. The existing road width is approximately 6.5m and the usable road width across the bridge is 5.2m. The approach from the north currently has a speed limit of 60kmph with an advisory limit of 35kmph. The southern approach has a speed limit of 80kmph. The southern approach to the bridge in particular is poorly aligned with a tight bend that reduces practical vehicle speeds.



Figure 6 – Aerial View of Existing Bridge (Recently demolished)

Design Development

A number of options were previously considered including: strengthening of the existing bridge; and replacing the existing bridge on a new alignment to ease the existing poor S bend curve. However based on cost estimates and potential impacts to rail traffic, it was decided to replace the existing bridge by construction a new bridge adjacent on roughly the same perpendicular alignment. A key objective in choosing this option was to minimise costs for road realignment and to enable the bridge to be constructed without impacting on the existing bridge use until the new structure was commissioned.

Road Alignment

Bridge Street is a local road connecting the townships of Picton and Thirlmere. Traffic along Bridge Street consists largely of local vehicles with limited heavy vehicle traffic. The overbridge currently only allows for one vehicle to cross at a time due to the narrow width, with the current load limits preventing trucks using the bridge.

The existing road alignment at the bridge site features a sharp S Bend and is considered to be sub-standard in accordance with current Design Standards. The site and economic constraints prevent the provision of a compliant road alignment. However, the proposed alignment is a significant improvement relative to the existing situation.

The new bridge will result in a wider carriageway and the inclusion of a pedestrian walkway over the bridge. As a result of the proposed works the bridge will now allow oncoming light vehicles to cross the bridge at the same time. Additionally, the improved structural integrity of the bridge would allow trucks that are currently restricted by load limits to traverse the bridge. Therefore, the traffic flows will be improved as a result of the proposed works

Bridge Design

Based on site constraints, constructability, economics, aesthetics, environmental issues, health and safety considerations and the availability of materials the proposed replacement structure will be a 25m span bridge, formed of precast, prestressed concrete 'Super T' girders with an insitu reinforced concrete deck supported on reinforced soil wall abutments.

A design strategy was adopted whereby the main elements of the bridge articulation were designed to accommodate all conceivable types of mining induced ground movement of the worst credible magnitude without intervention or adjustment.

The bridge design allows for 5.4m clearance over the rail track which is a departure from the minimum vertical clearance of 7.1m required by ARTC standards. However, the bridge is designed that it can be raised in the future to 7.1m to allow for potential double stacking.



Figure 7 – Proposed Works

Stakeholders and Approvals Process

This project is understood to be unique in NSW, whereby a private company: finances; designs; and constructs a state owned bridge, carrying a council road, over an interstate operated railway. This led to some complex discussions over who was responsible for approving the various aspects of the project. The various parties involved and their determined responsibilities are described below:

Tahmoor Coal

Tahmoor Mine is an underground coal mining operation situated in the Southern Highlands Region of New South Wales. Tahmoor Coal is the proponent for the scheme as it is their planned mining operations that have the potential to adversely affect the existing surface infrastructure, and therefore are required to undertake works to ensure the safety and service of the existing infrastructure is not compromised.

Transport for NSW (TfNSW)

TfNSW are the land owner of the railway bridge and the rail corridor.

In accordance with the State Environmental Planning Policy (Infrastructure) 2007 (ISEPP) and the Environmental Planning and Assessment Act 1979 (EP&A Act), the works were approved under Part 5 of the EP&A Act with TfNSW acting as the determining authority.

Australian Rail Track Corporation (ARTC)

ARTC lease the railway track from TfNSW and are responsible for the management of the Rail Network and the management of the railway infrastructure maintenance.

For this project, it was determined that ARTC would be responsible for approving the Structural Design of the Bridge. ARTC were responsible for ensuring the proposed works were constructed to a suitable standard and with minimal impact on the use of the MSR line.

Wollondilly Shire Council (WSC)

WSC is the owner of the adjoining roads and were consulted to ensure that the proposed amendments to the road would meet Council requirements and the current and proposed usage of the road. In principle, support for the proposal and lands owners consent has also been sought from Council for the works.

Mine Subsidence Board (MSB)

The MSB is a service organisation operating for the community in coal mining areas of NSW and manages the scheme of compensation as provided for in the Mine Subsidence Compensation Act. The Act also gives the Board the responsibility of reducing the risk of mine subsidence damage to properties by assessing and controlling the types of buildings and improvements which can be erected in Mine Subsidence Districts.

It is noted that this site is located on the border, but just outside of a Mine Subsidence District and therefore did not require approval under the Act.

<u>Cardno</u>

Cardno was commissioned by Tahmoor Coal to provide overall design services for Picton Railway Overbridge. Their scope of work included: bridge design; design for subsidence; geotechnical investigation; road realignment design; drainage design; topographical ground survey; public utilities design; construction staging; cost estimates; technical construction specification; planning approvals; environmental assessment; risk management; maintenance manual and construction stage support.

Mine Subsidence Engineering Consultants (MSEC)

MSEC are experts in the field of predicting, assessing and monitoring of the effects of subsidence caused by the longwall mining of coal. MSEC provided Cardno with predictions for the possible ground movements at the bridge site and agreed suitable parameters to be adopted for the bridge design.

<u>GHD</u>

GHD undertook the engineering proof check of the bridge design and provided construction surveillance services to satisfy ARTC's requirements.

Robson Civil Projects

Robson Civil Projects undertook the Construction of the Works.

Design Description

Configuration

The bridge over Main Southern Railway (MSR) at Bridge Street is 26.8m long and consists of a single span with no skew. The bridge design allows for 5.4m clearance over the rail track which is a departure from the minimum vertical clearance of 7.1m required by ARTC standards. However, the bridge is designed that it can be raised in the future to 7.1m to allow for potential double stacking.

The 5.4m clearance is greater than that provided by the existing bridge.

The bridge has a constant longitudinal grade of 4% fall to the south east abutment. The carriageway is 8.0m wide comprising 2 x 3.5m traffic lanes and 2 x 0.5m road shoulders. A 1.85m wide walkway is provided to the east side of the bridge with a 1.5% one-way crossfall. A 3% two-way crossfall is provided to the carriageway.



Figure 8 – Bridge Elevation

Superstructure

The superstructure comprises 5 Nos. 1000mm deep precast, prestressed concrete Super-T girders which act compositely with a cast in situ reinforced concrete deck slab of minimum thickness 180mm. Transverse reinforced concrete diaphragm cross beams are provided at each end of the Super-T girders. A 500 mm deep notch is provided at the ends of each pre-cast Super-T girder to facilitate the construction of diaphragm cross beams are designed to accommodate the forces from jacking of the superstructure during future bearing replacement.

The carriageway portion of the deck surface is topped with a waterproof membrane and asphalticconcrete wearing surface with a total thickness of 75mm. The wearing surface protects the structural concrete surface from abrasion and environmental exposure.

The external traffic barrier on the bridge is a medium performance level traffic barrier comprising a 650mm high concrete parapet with twin steel rails, with an overall height of 1300mm. The concrete part is constructed using precast concrete panels which also provide the bridge fascia. The precast concrete fascia panels are fixed to the deck slab with an in-situ concrete stitch pour. The inner face profile matches the RTA Standard Type MAO barrier shape. One 100mm diameter conduit is cast into each external barrier for services. The barriers, with the same internal and external profile, extend onto the wingwalls, beyond the ends of the bridge.



Figure 9 – Cross Section of Deck

Substructure

The abutments comprise reinforced concrete pad footings supported on the fill behind a reinforced soil wall. This foundation type was adopted mainly due to the large mining subsidence movement. The piled foundation was determined not suitable for the bridge as the vertical mining movement and ground stains can disrupt founding material, withdraw end support and cause shear failure. Most of the grand strains and vertical curvatures will be absorbed by the flexible reinforced soil foundation before being transferred to the bridge pad footing. Reinforced soil wall (RSW) straps are provided behind the abutments as a restraint for longitudinal bridge loads. This arrangement will ensure that the abutments are longitudinally restrained.

Articulation & Deck Drainage

The superstructure is articulated as a simply supported bridge with each end of the Super-T girders supported on bearings. As shown in Figure 10, in the longitudinal direction, the bridge is fixed at abutment B. A large movement Modular expansion joint is used at Abutment A. A strip seal expansion joint is used at Abutment B. The super structure is supported on individual spherical bearings. The Bearings at Abutment A have the same movement capacity as the modular expansion joint. The articulation has been selected primarily to accommodate the mining movements. The design movement capacity of the elements are given in Table 1.

The longitudinal drainage runoff is contained within the shoulders and collected by the road drainage at abutment B.



Figure 10 - Bridge Articulation

Element	Opening	Closing	Vertical Rotation	Horizontal Rotation
Modular Expansion Joint (Abutment A)	185 mm	535 mm	+/- 0.03 rad	+/- 0.01 rad
Strip Seal Joint (Abutment B)	82 mm	43 mm	-	-
Free Floating Bearing (Abutment A)	185 mm	535 mm	+/- 0.03 rad	-
Free Floating Bearing (Abutment B)	28 mm	28 mm	+/- 0.03 rad	-
Traffic Barrier Connector	120 mm	100 mm	-	-
Cover Plates	100 mm	230 mm	-	-
Safety Screen	55 mm	20 mm	-	-

Table 1 – Movement Capacity of Elements

Bearings

The bridge bearing layout is shown in Figure 11. The bearings used are individual spherical bearings. Both Pot bearings and spherical bearings were considered in the concept design stage. Pot bearings use an elastomeric disc confined inside the pot to provide the rotational capacity. The standard pot bearings on the market normally have a rotational capacity of 0.02rad. In order to accommodate the 0.03rad design rotation, a custom design pot bearing with a thicker and larger elastomeric disc will be required. This will increase the bearing size, weight and cost significantly. The spherical bearing on the other hand has a different working mechanism. Its rotational capacity is provided by a joint action. The convex upper part is sliding inside the concave lower part. The interface is a lubricated robust low friction sliding sheet. This joint action facilitates bearing rotations about every axis. The same design rotation was achieved by a much smaller and hence cheaper spherical bearing. The smaller size and weight of the spherical bearing made the detailing and construction easier.

The use of spherical bearing is becoming more popular thanks for the development of new sliding materials. These bearings have been used on the recently completed Urban Superway Project in Adelaide, and the Hunter Expressway project in NSW. It is proposed that this form of bearing will be included in the upcoming new edition of the Bridge Code AS5100 Part 4.

At abutment A, the girders are supported on free float bearings. Lateral restraint of the superstructure is provided by a reinforced concrete shear key constructed between two of the Super-T girders. Sliding bearings are provided between the abutting surfaces to minimise the transfer of longitudinal friction forces through the restraint. These sliding bearings comprise stainless steel plates attached to the concrete shear keys and elastomeric pads with low friction PTFE surfacing attached to the girders. At abutment B, the two outer girders each side are supported on free float bearings. The centre girder is supported on a fixed bearing. The fixed bearing acts as the lateral restraint of the superstructure at Abutment B and the longitudinal restraint of the superstructure under design ultimate braking loading. This bearing configuration allows the bridge superstructure to move freely in the bridge span direction and also rotate around the middle bearings at each abutment.



Figure 11 - Bearing Layout

Modular Expansion Joint

A modular expansion joint is used at abutment A. This type of expansion joint is normally used on long span bridges with large longitudinal movements. It's selected for this short bridge due to the large mining subsidence movements. The joint consists of a number of lamella beams, which are supported and sliding on the longitudinal support beams. There are several longitudinal support beams across the deck to support the joint. The longitudinal beams are fixed on one end. The free end travels inside the box to provide the design movement. The gap between the lamella beams can be fully closed and opens up to 80mm. the movements of the lamella beams relative to each other and along the support beams are regulated by control springs. The gap is sealed with an elastomeric gland to make the system watertight.

The modular joint adopted for the bridge has been designed to accommodate the ultimate mine subsidence movements predicted for the bridge. Hence no replacement is required during the design life of the joint.

Strip Seal Joint

A strip seal expansion joint has been selected at abutment B. Even though the bridge superstructure is longitudinally fixed at abutment B. An expansion joint is still required due to mining movement and live load. As shown in Table 2, the rotation of the bridge superstructure under the lateral movement between abutments leads to closing of the joint on one end and opening on the other end. Furthermore, the deflection of the superstructure under live load leads to rotation in bearings and opening in deck joints.

Approaches

Approach slabs are not provided as they are known to be liable to mask any voids or disruption of the fill behind the abutment and increase the difficulty of remedial work for bridges liable to mining subsidence.

Mine Subsidence

The bridge has been designed to accommodate subsidence effects as a result of longwall mining in the area. The predicted ground movements, with various probabilities of exceedance, have been provided by Mine Subsidence Engineering Consultants (MSEC). A design strategy has been adopted that the main elements of the bridge articulation, deck joints and bearings, have been designed to accommodate all conceivable types of mining induced ground movement of the worst conceivable magnitude without intervention or adjustment. The magnitude of the movements that have been allowed for in the design of the main elements have a probability of occurrence of significantly less than 0.05%. A small number of components – Safety Screens, Steel Traffic Barriers and Barrier/Footway Cover Plates – have been designed for smaller magnitude movements which have a probability of exceedance of between 1% and 0.05%. The probabilities relate to the likelihood of exceedance only during the period of longwall mining.

Subsidence movement scenario	Predicted Movements		
	1% Probability	0.05% Probability	Ultimate
Closure between abutments	80 mm	230 mm	500 mm
FREE END ORIGINAL STRUCTURE			
Opening between abutments	35 mm	70 mm	150 mm
Lateral differential movement between abutments	40 mm	80 mm	150 mm
STRUCTURE		400 mm cr	
	50 mm	iou mm	400 mm or 10mm/m whichever is greater

The predicted mining movements are given in Table 2.

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Table 2 - Predicted Mining Movements

Design Loads

Road Traffic Loads

The bridge structure has been designed for SM1600 loads and associated dynamic load allowance factors in accordance with AS5100.2 Section 6. The number of design lanes is 2 with accompanying lane factors adopted of; 1.0 for lane 1 and 0.8 for lane 2. A dynamic load allowance of 0.3 has been adopted of the critical M1600 load.

Braking effects of traffic have been adopted in accordance with AS5100.2 Section 6.8.2. The longitudinal braking force from single vehicle stopping FBS=720kN SLS has been found to be more critical than FBM and adopted for the design.

Heavy Load Platform Loading

The bridge structure has not been designed for Heavy Load Platform loading as instructed by the client.

Fatigue Load Effects

The fatigue design traffic load and the number of fatigue cycles are determined in accordance with AS5100.2 Section 6.9. The fatigue design traffic load adopted is 70% of a single M1600 moving traffic load, without UDL. A load factor of 1.0 and dynamic load allowance of α =0.30 were adopted. The number of fatigue stress cycles considered was 450 x 2 x 10⁴ x 23 - 0.5 x 0.5 = 938,314 cycles.

Since the number of cycles is greater than 500,000, the design complies with additional design requirements in accordance with Clause 2.5.2 to 2.5.6 of AS5100.5.

Traffic Barrier Loading

Medium Performance Level traffic barrier loading has been adopted for barriers on bridges and approach embankments.

Collision Loads

The bridge is designed for a 500 kN ultimate load acting at any direction to bridge superstructure. The railway is in a cutting, and the abutments are set back from the rock face. Hence, train impact to the bridge substructure and reinforced soil wall is not considered.

Earthquake Forces

Earthquake loads have been calculated in accordance with AS5100.2 and AS/NZS1170.4-1993. The earthquake load case is considered as an extreme event and applied at the ULS.

The railway overbridge is considered as a Type II bridge for earthquake design in accordance with AS5100.2-2004. The bridge earthquake design category is a function of the acceleration coefficient and the site factor (refer to AS5100.2-2004). An acceleration factor (a) of 0.09 is adopted in accordance with Section 2.3 of AS/NZS1170.4-1993. Based on the ground condition, a site factor of 1.0 is adopted. The bridge is analysed with a response factor (Rf) of 2.0 in the lateral and longitudinal directions. The earthquake design category for the bridge is summarized below:

- > Site Factor (S): 1.0
- > Bridge Class Type: II
- > BEDC: 1

The Bridge Earthquake Design Category adopted is BEDC-1. As the span exceeds 20m, the effects of horizontal earthquake forces have been considered in accordance with Clause 14.4.3 of AS5100.2. The total horizontal design earthquake force is calculated as H^*u longitudinal = H^*u transverse = 215kN.

Wind Loading

Wind loading has been considered as per requirements of AS5100.2 and AS/NZS 1170.2-2011. The following design parameters are used in determining the wind loads.

- > Region: A2
- > Design Wind Speed: 37 m/s SLS (1/20 years), 48 m/s ULS (1/2000 years)

Thermal Effects

The effect of temperature has been assessed in accordance with AS5100.2 Section 17 with the following parameters:

The bridge is located in Region II, Coastal and less than 1000m height above sea level.

The minimum and maximum shade air temperatures adopted are -5 °C and 45 °C.

The minimum and maximum average bridge temperatures adopted are 3 °C and 49 °C.

An average bridge temperature of 18 °C is adopted for assessing variations in bridge temperature.

A temperature gradient of 18 °C is adopted for assessing differential temperature effects.

Structural Analysis

The bridge superstructure was modelled as a grillage using the software SAM to obtain design actions and deflections in the superstructure due to live loads (SM1600) and superimposed dead loads such as barrier in-situ concrete, raised walkway in-situ concrete and asphalt (see Figure 12). This model was used to determine the transverse distribution of these loads to the girders, bearings and substructure. The torsional stiffness was reduced in each ULS model in accordance with Section 7.2.5 of AS5100.5 to take account of cracking at ultimate.



Figure 12 - Grillage Model of Superstructure in SAM

The abutments consist of reinforced concrete sill beams supported on reinforced soil embankment. The sill beams are analysed as pad footing using spreadsheets and hand calculation.

For localised bridge elements, InfoCAD was used to model the local effects and obtain design actions. An example is the traffic barriers which have been modelled in InfoCAD using a combination of plate elements for the concrete portion and beam elements for the post and rails to obtain the design actions at the connection to the deck (see Figure 13).



Figure 13 - InfoCAD Model of Traffic Barrier

Maintenance

The new bridge has been designed for a 100 year Design Life, in accordance with AS5100 Bridge Design. However, as with all bridges, there are a small number of elements (e.g. bearings, deck joints and steelwork coatings) which have a shorter minimum design life and may require maintenance or replacement during the life of the bridge.

The minimum design life of various elements of the bridge are summarised in Table 3.

Asset element/Sub-element	Minimum Design life (years)
Permanent Structural Elements	100
Spherical Bearings	40
Bridge Joints – Joint sealant	15
Bridge Joints – Expansion joint rubbers	35
Safety Screens – Protective Coating	15
Asphalt Wearing course	40
Traffic Barrier Railings – Protective coating	20

Table 3 - Design Life of Elements

The deck joints and bearings used on this bridge, which can accommodate the large ground movements, are complex devices that are designed and manufactured by a specialist supplier. These elements have special inspection and maintenance requirements that are specified by their manufacturer.

As the bearings may need to be replaced during the design life of the bridge and in accordance with the RMS Bridge Policy Manual, the bridge has been designed to allow the bearings to be readily replaced. Replacement of the bearings requires the bridge deck to be jacked up by only a small amount and the bridge may remain open to traffic during this operation.

A Maintenance Manual has been prepared to:

- 1. Provide information about the expected design life of each of the bridge elements, thereby indicating which elements may require replacement or maintenance during the 100 year design life of the bridge;
- 2. Provide special instructions from the manufacturer for the inspection and maintenance of bearings and deck joints;
- 3. Describe the requirements and outline procedure for the replacement of bearings by jacking up the bridge deck and;
- 4. Describe the procedure for adjustment and/or modification of safety screens, steel traffic barriers and barrier/footway cover plates that will be required if the magnitude of the ground movement (specifically opening and closing between abutments) for which they have been designed is going to be exceeded (based on regular monitoring of movements by others). It is noted that the likelihood of these adjustments being required is between 1% and 0.05%.

Program Milestones

Commence Detailed Design
Detailed Design Complete
Tender Works for Construction (6 week Tender Period)
Award Contract
Commence Construction
Rail Possession (Demolition of Existing Bridge)
New bridge opened to single lane traffic
New bridge opened to full traffic operation
Anticipated first impact of Longwall 29
Longwall 29 expected to be directly under the bridge
Longwall 29 expected to be complete



Figure 14 – Erection of Super T Girders



Figure 15 – Demolition of Existing Bridge



Figure 16 – Picton Railway Overbridge 16th November 2015

Conclusions

The design for this single span bridge of modest dimensions was relatively complex due to the requirement that the bridge should accommodate potential significant mining induced ground movements without intervention or adjustment. Through consultation with a wide range of parties an efficient and robust design solution was achieved.

The existing bridge was demolished and the new bridge constructed with minimum disruption to road and rail users and with no delay to the longwall mining operations.

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Author Biographies

Geraint Jones – Geraint has 18 years' engineering experience and currently works as a project manager and senior bridge engineer for Cardno. His main experience is in bridges and civil structures, undertaking feasibility studies, concept and detailed designs, and contract management. He was the Chairman of the Institution of Civil Engineers in the Republic of Ireland from 2009 to 2011. Geraint was the Project Manager responsible for the design of the Picton Railway Overbridge.

Long Bai - Long has over 14 years of experience as a Structural Design Engineer. Long is currently a chartered Senior Bridge Engineer with Cardno. He has been principally involved in the design of bridges. He is also specialized in concept development, proof checking, and assessment of a wide range of bridge structures in steel and concrete. Long was the designer of the Picton Replacement Railway Overbridge project.