CONSTRUCTION STAGE AND
POST OCCUPANCY **CASE STUDY**

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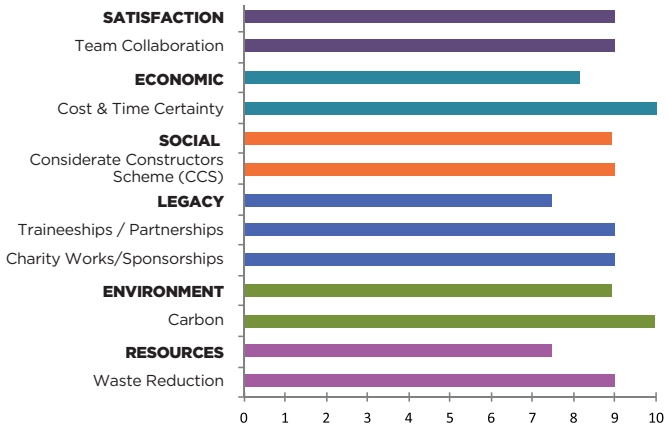
A465 Dualling – Brynmawr to Tredegar

POST OCCUPANCY STAGE - KPI TABLE



PROJECT DETAILS

Client	Welsh Government
Contractor	Carillion Civil Engineering
Designer	Arup
Employers Agent	Arcadis
EA Technical Advisor	Jacobs
Environmental Consultant	TACP
Value	£158m
Project size	7.8 km Dual Carriageway
Contract	NEC Target cost Option C - ECI
Duration	ECI Award / March 2010; Public Local Inquiry / March 2012; Construction Start / January 2013; Completion / September 2015

The A465 Heads of the Valleys trunk road provides a strategically important link between the Midlands and South-West Wales. The local region suffers from long-standing deprivation and became Wales' first Strategic Regeneration Area.

It is characterised by economic inactivity, poor quality jobs, unfavourable image and limited transport and tele-communications. The existing A465 Heads of the Valleys Road was built in the 1960s as a single 3 lane carriageway.

The need for the scheme was identified in the 1990s. The Welsh Government's 'Turning Heads' strategy for the area identified plans to upgrade the A465 as one of the major opportunities to deliver regeneration.

The 7.8km long upgrade between Brynmawr and Tredegar was delivered by Carillion. It sits entirely within Blaenau Gwent County Borough. The project secured £82m of European Regional Development Funding through the collaborative efforts of the team to demonstrate the positive impact it would have on the local community.

A two year programme of engaging with the local community and stakeholders ensured the project proposals were successful at the public inquiry held in March 2012, resulting in the award of a 33 month £116m construction contract in January 2013. Construction was completed in September 2015, on time and under the original budget.

ARCADIS ARUP JACOBS TACP carillion Llywodraeth Cymru Welsh Government

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What is an Exemplar project?

An Exemplar is defined as **'something worthy of being copied'**. The Exemplar programme has been developed to help identify the reasons why certain projects are successful in a standardised, quantifiable way and to share with the industry what enabled these successes.

An Exemplar considers all aspects of sustainability, including economic, social and environmental, demonstrating that the scheme is well rounded and has incorporated best practice and collaboration.

Case studies are prepared at 3 Key Stages Design Stage; Construction Phase; Post Occupation

This ensures that lessons learnt can be demonstrated throughout the development of the project.

What Makes this Project Exemplar

1. This complex project was delivered on time and under the original 2009 budget demonstrating the benefit of fully integrated team working
2. Set new standards for highway community engagement with civic awards from Tredegar Town Council and the Mayor of Blaenau Gwent
3. Also set new standards for highway schools engagement working with over 4600 pupils from 44 local schools and providing 155 weeks of work experience
4. Used a preconstruction whole-life carbon assessment to drive a 10% (5200t) reduction in construction carbon footprint
5. Through comprehensive materials planning achieved 99.3% waste diverted from landfill including reuse of 750,000m^3 of surplus earthworks material
6. Led the way developing BIM visual planning for highways construction, winning the Synchro Visual Planning awards for Roads and Bridges 2014 and enabling full use of GPS machine control in delivery of earthworks, drainage and pavement.

Transferable Lessons Learned

Steelwork, concrete and bituminous surfacing account for 80% of construction carbon in a typical major road scheme. To make meaningful savings these areas need to be targeted early in design and early carbon assessments are essential for this exercise.

When considering the whole life carbon cost of this project, over 60 years 78% comes from road users. To make meaningful carbon savings highway design should try to make the road as carbon efficient as possible for the users. 'In use' efficiency should be considered when appraising short term construction carbon gains from, for example, adjusting the vertical alignment to balance the earthworks.

There is no such thing as too much engagement with stakeholders. As engineers we need to make sure we communicate well with our stakeholders, listening and responding to their concerns where we can. Maximising community benefits takes time to plan and deliver. ECI procurement provides time to help maximise this opportunity.

Notable Achievements

The team have dealt with many key issues facing the project and industry as a whole, including:

- The project introduced 'National Skills Academy for Construction' to Wales and became the first on a highways project in the UK
- Early design reduced earthworks disposal from 750,000m^3 to 50,000m^3 saving £20m. Subsequently delivered with zero off-site disposal
- The outline scheme provided a 170m long viaduct running in parallel with existing high voltage overhead cables at Carno Valley. The team proposed an alternative earthworks solution with a 28m embankment and three tiers of reinforced earth on the north face. An 18m wide, 9m tall and 150m long precast concrete arch underpass takes a reservoir spillway and Welsh Water access road under the embankment. This solution brought the benefits of improved earthworks balance, reduced programme risk by opening up a haul route across the valley earlier and improved safety by reducing working at height and next to overhead power lines
- The project team won the BITC Wales 'Workplace Travel Challenge', which set out to reduce journeys to work over a fixed period of time. They mapped all workers home locations to highlight and promote car sharing opportunities, whilst encouraging working from home or using conference calls for remote meetings. With 66 out of the 68 staff taking part in the initiative, the team saved 8900 car commuter miles (equivalent to 1334kg CO^2). These measures were continued after the initiative and prompted the installation of 'Car Share Parking Bays' close to the offices in the site car park
- 5.1km of new segregated cycleway delivered in the scheme. Linking existing networks providing greater access to the local countryside and linking communities
- The project includes a rest area at the highest point with interpretation boards describing the areas rich industrial heritage, flora and fauna. This was added to encourage and enable people to get out of their cars at this natural viewpoint. Working with the local authority the viewpoint enables cycling and walking track connections to the Brecon Beacons to the north and Ebbw Fach trail to the south as well as along the east west alignment of the new road.

INTEGRATED & COLLABORATIVE TEAM WORKING

The Welsh Government chose ECI and the NEC target cost form of contract to provide a framework for collaborative delivery. The project created a team approach through co-location of open plan office facilities throughout delivery. Shared project objectives were agreed at the start. Partnering workshops were held at the start of each key stage to develop and define team behaviours. A 'light touch' approach was established to avoid role duplication.

NEC forms of subcontract were adopted with the supply chain to ensure that the message was consistent across everyone delivering the project. A shared risk management process ensured that risks were managed by the party most able to influence the outcome, regardless of contractual responsibility.

Benefits:

- Early specialist expertise to inform design, reduce risk, improving whole life cost, improving safety
- Back-to-back contract terms with the main contract including financial incentives to promote collaboration and best value proposals
- Shared resources reducing duplication across organisations
- Improved communication, reduced conflict and more open relationships.

Examples:

- **Arup –** Co-location through the development phase and construction improved communication, co-operation and understanding. Strong relationships enabled issues to be resolved quickly and efficiently
- **Walters –** Pre-construction they collaborated with the team to develop the projects earthworks programme, leading to reduction in off-site disposal from 750,000m^3 cubic metres to zero. Back to back pain/gain financial terms to incentivise what is good for the scheme is good for all. Co-located within the main project office to improve communication and issue resolution
- **Tarmac -** Collaborated with the team to develop a flexible composite pavement solution where the lower layer of bitumen bound material is replaced with a cement bound alternative with reduced carbon footprint and cost. Co-located in the project office as part of an integrated highways team
- **Reinforced Earth Company -** Worked in partnership with Arup to develop an integrated design for the Carno arch and retaining walls. Complex analysis required an iterative process with specialist supplier and designer working in close cooperation to resolve issues and ultimately deliver a spectacular solution for Carno north face. The arch is the largest TechSpan arch in the UK and the three tier reinforced earth wall at north Carno is 28m high making it the highest reinforced earth wall in the UK and one of the largest in Europe.

The team used a range of payment facilities to help SME's compete ranging from back to back with the main contract, fortnightly applications to improve cash flow and early payment facility. This enabled suppliers to receive payments in advance of their contractual terms, providing genuine improvement in liquidity and cash flow management supporting a long term sustainable supply chain.

Outcome – No disputes, average payment time under 28 days (less than main contract) on average final subcontract final accounts settled within 3 weeks of package completion.

Carbon

- A whole life carbon assessment was completed to inform design development
- Value engineering the Carno valley crossing to an embankment saved 10% in the total construction carbon. The embankment solution was 50% less carbon than the viaduct solution and reduced the construction phase carbon by over 5000t
- Grade-separating junctions reduced in-service carbon by 18,300t offsetting 35% of the construction carbon
- 2% increase on design assessment of construction carbon at as built stage
- 2000t of carbon saved through the use of ECO welfare units, hydrogen generators and an ePOD small plant distribution container and LED lighting.

Project External Awards

'Considerate Constructor's Scheme' Bronze 2014, Silver 2015 and Gold 2016 putting the project in the top 2% of UK sites.

Participation & Community Award - Welsh Government Seren Awards (2012)

Business in the Community Responsible Business Awards - 'Wales Education Award' (2014, 2015 & 2016)

Business in the Community Responsible Business Awards – 'Inspiring Young Talent' (2014, 2015 & 2016)

Runner up in Business in the Community Responsible Business Award – 'Building Stronger Communities (2016)

CITB Construction Ambassador Awards – S.E Wales Employer of the Year (2013)

Constructing Excellence in Wales - Project of the Year, Civils (2016); Value Award (2015)

Chartered Institution of Highways and Transportation - Major Project of the Year 2016

Institution of Civil Engineers Wales – George Gibby Award - Major Project of the Year 2016

'The dualling of the A465 across the Heads of the Valleys is one of Welsh Government's priority infrastructure projects, providing, when complete, improved accessibility for long distance journeys for business, tourism and much needed regeneration projects. This scheme between Brynmawr and Tredegar delivers the third of six sections to be dualled from Abergavenny and Hirwaun and was delivered on time and within the target cost. The success of the scheme has been recognised by a number of organisations with awards given for constructing excellence, delivering best value, being considerate contractors, engaging with the community and for their work with training and employing apprentices via the Skills Academy.

Perhaps the most valued accolade came from the local Town Council who awarded Carillion their Civic Award for work in the community of Tredegar. For the work undertaken by Carillion and the team in the delivery of this scheme, the term 'exemplar' is very well-deserved.' **Matt Enoch & Martyn Leech - Department for Economy and Infrastructure, Welsh Government**

Environmental Impact

Running through the Brecon Beacons National Park and several designated sites, the works were delivered without incident. The collaborative team's approach delivered extensive environmental measures to mitigate bats, otters, lapwing and invertebrates with statutory bodies.

Commitments made in the environmental statement and at the public local inquiry included aspects such as habitat creation, relocation, exclusion fencing, planting and underpasses. Temporary environmental controls for noise, dust and water runoff including, settlement lagoons, silt-busters, silt fencing and use of flocculent. Dust control used recycled water from the settlement lagoons. Visual and noise screening in the form of bunding and locally manufactured recycled plastic noise fencing.

Biodiversity

Attenuation ponds were all designed to encourage biodiversity. Bat and bird boxes were constructed by a local construction training centre and were installed nearby the scheme to mitigate for loss of established trees.

- 9ha Lapwing breeding area established, incorporating scrapes to replicate their breeding habitat. Other grasslands will be maintained to maximise breeding potential for Lapwings
- 32ha replacement habitat in lieu of 16ha lost. Improved wildflower habitat suitable for bat foraging. Maintaining routes under the new road for lesser horseshoe bats
- The incorporation of petrol interceptors and attenuation ponds ensures that the scheme has minimal impact on the existing river network
- Otter proof fencing has been installed to prevent access of otters onto the new road helping guide them further into the catchment area to the north.

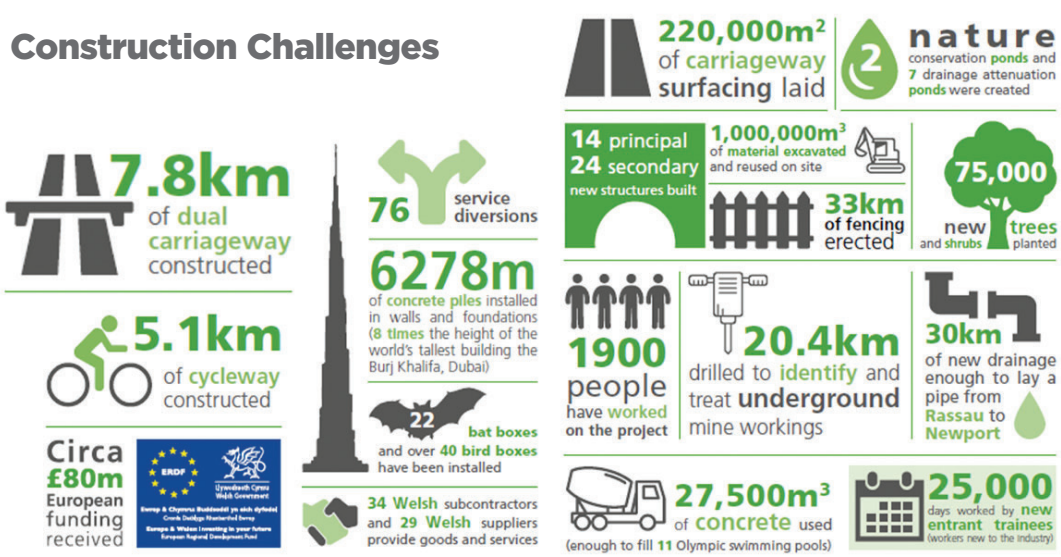
Resource Management

The road design is sensitive to the Beacons' landscape while enabling views down the Welsh valleys to the south. Many of the cuttings have been left with natural rock finishes. Where appropriate, structures have been clad in pennant stone to provide continuity of finish with other sections of the A465.

Examples:

- Re-used 100% of the material excavated on site within the work
- Diversion of 99.3% of site waste from landfill by site-wide waste segregation
- 500,000 tonnes of rock was processed for re-use as structural fill within the project
- The team sought to minimise whole life cost through material choice. Cor-ten pre weathered steels to bridges; recycled plastic noise barriers; aluminium lighting columns
- Circular economy reviewed by using recycled noise barriers, aluminium parapets and lighting columns. In dismantling, all materials can be segregated into their constituent parts for recycling or re-use
- With addition to the 300,000m^3 used in the embankment, further re-use of excavated material was achieved through installation of landscaping noise bunds and visual screens
- Materials were also donated to local community projects including bark chipping to local nature reserves and schools, donation of pipes and timber for a nursery school playground and paving slabs and kerbs to create a safe outdoor area at a local hospice
- Carillion operate a 'Responsible Timber Sourcing Policy' across all sites, including their supply chain. This requires the purchase of all timber to be from a Forestry Stewardship Council (FSC) sustainable source. Reported monthly to demonstrate compliance.

Construction Challenges



Over 300 million litres of rainwater fell on the site during construction, requiring treatment to remove sediment before being discharged back into rivers flowing through the scheme. Innovative silt manifolds, filtration bags and flocculants were used for dual purpose of ecological improvements.

Waste water management also enabled reuse of 8 million litres of rain water to be used for dust-suppression.

'Fantastic scheme – sets the bar for legacy.'
Clive Rogers – Head of Engineering, Blaenau Gwent County Borough Council.

Community Engagement

The project was set out to gain a clear understanding of issues by listening to local people. Successfully addressing community concerns ensured that only 3 objections were heard at Public Inquiry with the Inspectors report received in only 4 weeks.

The development phase engagement included:

- **24 hour access to Carillion's public liaison officer –** ensuring queries could be addressed before they turned into concerns
- **Five information days in community centres –** enabled local people to find out first-hand how the proposals may affect them
- **Nine presentations to local interest groups –** engaging wider interest groups ensured that proposals were understood by all stakeholders
- **Four supermarket road shows –** reaching the wider population to raise awareness and highlight concerns early
- **'Meet the buyer days' for local SME's –** maximised opportunities for local company to develop their offering in readiness for supply packages being made available
- **Project website –** kept everyone informed of basic information as well as offering an update on scheme progress and likely timescale for development
- **Interactive 3D video flythrough –** provided clear visual representation of the scheme proposals which could be understood by all

During the construction phase, engagement included:

- **Continued 24 hour access to Carillion's public liaison officer –** ensured that concerns were addressed promptly to avoid escalation
- **Project website (received up to 200 visitors per day) –** provided regular updates on sectional progress and future work so that people could plan to minimise impact
- **Twitter feed to communicate live updates (1900 followers) –** This helped us reach the travelling community quickly to advise of road works, diversions and progress helping minimise disruption
- **Site open days –** giving hundreds of local residents access to the construction works and providing an opportunity to speak to the team about the project
- **Project newsletters –** distributed to over 1000 local residents twice a year to keep them informed and profile the positive work that had been done in the community
- **Quarterly local authority liaison group meetings –** kept local officers informed and helped them keep up to date with progress, so that they could respond confidently to their community when questioned, helping avoid concern before becoming an issue.

Community Enhancement

- 66 members of staff (58%) were actively involved in community engagement activities contributing over 2788 hours of support
- 38 local community groups, charities and initiatives were supported
- Over £15,425 has been given in cash contributions, gifts in kind and employee fundraising.

Community Benefits Delivered

The team have supported the client in delivering significant added value to the local community and supporting their aspirations to regenerate the Heads of the Valleys. This has been achieved by setting new standards for the industry, such as:

The project set up the first CITB National Skills Academy for Construction in Wales and the first on a UK Highways scheme to provide training, skills and qualifications to local people to increase future employment opportunities. It has become the catalyst and benchmark for other projects in Wales, with three further 'academies' now operational.

Carillion worked with 'Business in the community' to bring their school & business engagement model to Wales – BITC's business class. It establishes long term partnership between a school and a business, grouping a number of partnerships together to form clusters where ideas and resources can be shared. Chairing the Heads of the Valleys cluster, Carillion led the way in changing business to schools engagement. The team's commitment since 2012 to bring business class to Wales is shaping the future of young people, demonstrated by Welsh Government funding to roll it out across the whole of Wales.

Supporting education by engaging with 4600 pupils in 44 local schools (primary and secondary) being involved in 100 separate activities including; site visits, work experience, careers advice, girls into construction days, health & safety talks and curriculum support activities. Carillion also provided over 155 weeks of work experience helping inform career choices.

Local economy

- Maximising jobs for local people, Carillion achieved an 85% Welsh workforce (874 people) with 99% Welsh employment through our on-site 'Job-Shop'
- 84% of the projects supplier and subcontractor spend was directly with Welsh companies
- The project supported a social enterprise which employed over 40 disabled workers for the manufacture, supply and installation of road signs.

New skills and qualifications

- Skills academy funding supported delivery of over 900 training outcomes to the workforce
- Targeted efforts provided employment to 91 new entrant trainee's within Wales, 55 of which were from the Heads of the Valleys region
- Over 5000 weeks of new entrant trainee employment, exceeding the project target by 21%
- 21 apprenticeships have been completed during the scheme at level 2 and level 3 (professional).

The scheme formed the nucleus for formation of the 'Professional Apprenticeship Academy' which has now delivered over 80 Level 3 apprenticeships in civil engineering and quantity surveying.

SME opportunities in the supply chain:

In the development phase, Carillion undertook a number of 'Meet the Buyer' events. This was a chance for them to find out about opportunities on the project and expectations for quality, safety and sustainability. In turn, Carillion were able to consider their experience and systems to identify with them gaps that would need to be addressed to allow them to compete equally for supply packages.

Examples:

- The supplier of recycled plastic noise fence based locally to the scheme. During the development stage, Carillion made sure that the project specification did not unnecessarily preclude this type of product. A cost analysis demonstrated that although the initial cost was marginally higher the whole life cost to the client was significantly improved relative to a traditional timber barrier
- A locally-based company were commissioned to produce the project website www.a465brynmawr2tredegar.co.uk

84% of the supply chain came from the local area and Wales.

On time budget & specification:

The team's approach from development through Public Inquiry to construction has been one of open collaboration. Together achieving zero defects at handover. Full 'as-built', health and safety and O&Ms were submitted within 3 months of road opening to traffic. Through collaborative working the project was delivered on time and 9% under target. 14% under the employers original budget set in 2009. Value engineering solutions have saved our client over £20m, avoiding 26 weeks of additional time on site.

These include;

- Removing the need for 600m of temporary access road at Cemetery Road
- Introducing a steepened slope at Rassau West avoiding an expensive service diversion and reducing impact on a business
- Moving Ebbw Vale junction further west to reduce impact on businesses and minimise retaining structures
- Introducing an alternative retaining wall at Tredegar to simplify a complex service diversion
- Curving the bottom tier of 'reinforced-earth' at Carno embankment reduced rock excavation.

Whole life value:

Early contractor involvement form of procurement enabled the team to consider whole life value from the outset. Whole life value was considered and delivered on a number of fronts during the detailed design phase including:

- Future maintenance costs were reduced by designing integral bridges (without bearings) and using Cor-Ten steel (weathering steel) or precast concrete beam
- Constructing an embankment at Carno rather than a viaduct eliminated a number of replaceable structural elements such as bridge bearings and movement joints and reduced the risks of working at height for future inspection work
- Use of plastic noise barrier reduced long term maintenance requirements.

Health and Safety

Collaboration ensured that the scheme was developed to minimise health and safety risk through construction, operation and maintenance.

- Working at height during construction reduced and avoided on Tredegar junction by constructing top-down with the added benefit of enabling a more economic composite design. Precast parapets were used on all bridges avoiding working at height
- Tredegar Junction temporary roundabout solution reduced construction/public interfaces and traffic management switches, making it safer and easier for the travelling public to navigate the works
- Earthworks, drainage, channel and pavement operations controlled directly by GPS machine control using the BIM model. Providing a clear safety benefit with less people working around machines
- The alternative solution from a 30m high viaduct to a 30m high embankment will greatly reduced maintenance work at height and avoid crane operations directly adjacent to overhead HV powerlines
- Designing bridges as integral bridges, where possible, avoids the need for future bearing replacement, thus reducing future work at height
- The use of Cor-ten 'rusty' steel bridge beams eliminates the need for future painting over live traffic lanes
- Using aluminium, LED lighting columns that won't require painting in the future and have a longer life thus reducing maintenance works adjacent to live traffic.

BIM

The team's use of BIM visual planning is leading the way in delivering efficient infrastructure projects. Integrating time, cost, temporary works and earthwork solutions into planning software has supported 'right-first-time' delivery. Beyond the 'standard' BIM benefits achieved were:

- Improved communication in the use of virtual design reviews and creation of 4D models – one example of the benefit this had on the project was the curving of the bottom tier of the reinforced soil wall at Carno. It was picked up in a virtual design review that the proposed straight wall would require a large temporary excavation into the slide of the valley in order to accommodate the long reinforced soil straps. The design and construction teams worked together and came up with a solution which curved the wall in order to bring the straps away from the side of the valley – eliminating a large rock extraction and temporary works issue
- GPS machine control was used for all earthworks, drainage and pavement using data directly from the designer's model. This improved safety conditions on site with less need for people to work on the ground next to machines
- Electronic handover of all information within 3 months, formatted to suit end user systems.