Problems of upgrading the A55 North Wales Coast Road

A variety of difficult ground conditions caused many problems during the upgrading of the A55. This talk will explain these problems and how they were overcome.

Frank Nicholson

- £732 million for improvement of 109 km to Menai Bridge
- Over £1 billion at present day prices (to Menai Bridge)
- Basic upgrade to dual carriage about £1.7 million per km
- Pen-y-Clip £110 million for 1.9 km
- Conwy Crossing £227 million for 5.8 km

Breida Glacier, Iceland – probably the ice sheet across Cheshire and the Midlands looked like this.

Part of the Antarctic Ice Sheet and the Trans Antarctic Mountains. North Wales and the Irish Sea looked like this 18,000 years ago.

Ice blocks part buried in sediment after a flood caused by minor volcanic activity under an ice sheet. These would form very small "kettle holes". Southern Iceland
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Kettle holes developing in fresh glacio-fluvial deposits. South Iceland

South of Chester - A55 is built on glacial deposits. Soft clay in kettle holes needed to be excavated and replaced with free draining rockfill. Otherwise settlement would be very likely.

The Vale of Clwyd Fault causes a repetition of the succession Silurian to Triassic along the NE Wales coast.

Clwydian Hills

West of Chester – Coal Measures with a deep cutting and other construction. To investigate and remediate the old coal workings needed:
- 3000 drill holes totalling 60 km of drilling (up to £50 per metre)
- 12000 tonnes of cementiferous grout was injected to stabilise the voids
- Total cost £32 million for 11.2 km (completed 1984)
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Void migrating upwards in Opencast face – potential serious subsidence.

Opencast coal was extracted here to 30m – backfill carefully compacted.

Extensive mineral workings near Holywell.

Glacio fluvial sands and gravels – central Ireland.

Where there are substantial glacio fluvial sands and gravels under the A55 – no special problems. Unusual for the A55!

Capped mine shaft.

- 36% of Holywell Bypass in Carboniferous Limestone was affected by old workings in mineral veins (lead, zinc, silver).
- 34 mineshafts capped as part of the road works.
- Also 10 reinforced concrete rafts needed to stabilise the upgraded carriageway where the road crosses mineral veins.

Types of sinkhole often found in limestone.
Sinkholes in cohesive soil over limestone are most dangerous. More likely if the road works increase seepage into the ground!

Detailed (and costly) investigation was needed east of the Vale of Clwyd, using a range of methods. But fortunately only minor solution enlarged joints were found. However these still needed excavation and backfill on geotextiles. STILL a little remedial work needed since the road opened.

Ruallt, East slope of Vale of Clywd
Pre split blasting

Rock bolts, shotcrete and catch fence.

Safety bench and catch fence.
Dee valley/St Asaph bypass – limited problems.
Bodelwyddan Bypass – No problems on till plain over limestone.

Abergele bypass ground conditions
Peat is unstable material for engineers – compacts and oxidises (especially if drained). The variable soft clays also give problems. All this material needed excavation and replacement. Not done thoroughly enough and some remedial work needed!
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Just East of Old Colwyn – old complex landslips.

Just East of Old Colwyn

Toe Weight

Old rotary slip plane: could move again in very wet spell.

Constructed toe weight embankment needs marine erosion protection

Dolos blocks

Concrete steps eroded by waves bombarding steps with beach pebbles.

Now covered in armour stone ("rip rap").

Retaining wall in Colwyn Bypass.
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How a DIAPHRAGM WALL is used to make a cutting with retaining walls to support the soil.

Frame for making a diaphragm wall.
The trench walls need support as they are dug.
The trench is filled with bentonite (a clay with special properties - thixotropic).
The side support is withdrawn.
Concrete is pumped in, displacing the bentonite.
Iron reinforcement is added.

Frame for making a diaphragm wall.

Retaining wall in Colwyn Bypass, with decorative concrete finish.

Great Orme – Llandudno
ANCIENT copper Mines – Bronze Age (best example anywhere)
Reused in Roman times
And again 1692 to end of 19th Century.

Carboniferous Limestone
With mineral veins – copper (probably plus a little of other minerals e.g. silver, even a trace of gold)
Calcite as the “gangue” mineral.

Lead-Zinc is much commoner in Carboniferous Limestone as at Holywell Bypass, but also copper etc sometimes present.
Geology of the Llandudno & Colwyn areas.

**CONWAY TUNNEL**

Immersed tube tunnel - 6 x 118m sections

- Lighting Units
- Protective Concrete
- Bituminous Waterproofing Membrane
- Access Passage
- Protective Concrete
- Bituminous Waterproofing Membrane
- 6mm Thick Steel Plate Waterproofing To Walls and Underside
- Reinforced Concrete

1. Core
2. Tunnel units lowered and penstock
3. Service jetty
4. Unit raised brought to jetty and lowered
5. Temporary location for unit and pump
equipment

Conway Tunnel West Portal

Lightweight pulverised fuel ash (from coal burning power stations) used to make the embankment on the soft alluvium of the old River Conwy.

- PFA Embankment
- Concrete raft
- Soft estuarine alluvium
- PILES
- Glacial Till
Problems with soft alluvium near the banks of the River Conwy

Excavate and replace with free draining rockfill, but not reasonable for deeper deposits.

For deeper deposits:
- Improve rate of water escape by using “BAND DRAINS” = vertical plastic drains cased in fine mesh geotextile.
  
  45,000 band drains were installed. (≈ 500km of drains)
- With 10 to 15m of alluvium the ground usually settled about 2m after the embankment was constructed.

Conwy Crossing £227million for 5.8km = tunnel plus difficult approaches both sides.
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Armour stone imported from Ireland & Sweden. The local quarries were unable to supply enough in the timespan.

Potentially unstable materials include:
- Quarry & construction waste
- Modern scree
- Fossil Scree
- Irish Sea Glacial deposits
- Welsh Glacial deposits
- The Bedrock
- Microdiorite (igneous)
- Mudstone (Ordovician)

East end of Pen-y-Clip Tunnel

East portal of new tunnel. Now new foot/bicycle bridge.
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"Brazilian" Wall

West end - 35 m high

Ground anchors: 3 to 12.5m grouted and up to 25m long (inner half grouted in, outer half free in drilled hole).

2000 ground anchors were needed at Pen y Clip.

Anchors with big caps had continuous monitoring strain sensors. BUT they have now failed after 25 plus years operation. Now use resurvey annually to check for movement.

Cycleway.
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Railway on masonry arches outside old Pen-y-Clip Tunnel route.

- Bangor Bypass. Shallow till over Ordovician siltstone & mudstone. Extensive cuttings needed. Local slate waste used for road base & slate for bridge abutment cladding.

- Similar problems continue beyond Pont Britannia to Holyhead, where Mona Complex schists are prominent. The schists are susceptible to deep weathering.

- In places salt marsh etc causes problems. Engineering measures were applied as necessary. e.g. At Malltraeth Marsh (salt marsh) the road is constructed on a high embankment.

Near Penfynyng Tunnel

- Railway on masonry arches outside old Pen-y-Clip Tunnel route.

- West end of Pen-y-Clip Tunnel

- Site of Stepheon's classic box beam Pont Britannia across Menai Straight to Anglesea.

- 1970 Weakened by fire all along box beam railway bridge. THEN replaced the box beam with spans supported by steel arches AND added the new A55 roadway on top.

- Penmaenmawr Bypass

- Thank you for your patient attention

- If anyone would like a pdf handout with all the slides just give me your email address. (Visit?)