Problems of the A55 N.Wales Coast Road  By Frank Nicholson, Huyton U3A

Geology and 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
- Well 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 1.9km
- Conwy Crossing £227 million for 5.8km

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

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

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
Kettle holes developing in fresh glacio-fluvial deposits. South Iceland

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.

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 (at £100 plus per metre?)
- 12000 tonnes of cementiferous grout was injected to stabilise the voids
- Total cost £32 million for 11.2 km (completed 1984)

Void migrating upwards in Opencast face – potential serious subsidence.
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Opencast coal was extracted here to 30m – backfill carefully compacted.

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

Glacio fluvial sands and gravels (photo central Ireland).

Extensive mineral workings near Holywell. Lead-zinc veins in Carboniferous Limestone.

Capped mine shaft.

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

Further West (near Travellers Inn) glacial deposits, mainly till, overlying limestone.

Found 50 sinkholes in an area of 35 ha. From 1m to 15m diameter.

Different types of doline (Farrant & Cooper, B.G.S. Geoscientist 2014)

["Dropout doline" also described as "Cover subsidence sinkhole"]
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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.

A range of **geophysical methods** used:
Seismic refraction showed voids and surficial material depth.
Microgravity - 4 sites with either voids or deep depressions.
Ground penetrating radar was not successful.

341 probe **drillholes** on a 10m grid (7643m total).
Rockhead varied 2.8m to 34m.
In limestone bedrock 17 apparent voids were found.
These were drilled larger & CCTV used. No large voids were found.
11 "conventional" boreholes & 8 trial pits were also made. One small void (0.5m diam) found just above bedrock in a trial pit.

Found poor correspondence between geophysical methods and direct observations.
e.g. only 1 gravity low & 3 seismic anomalies corresponded with apparent voids found in drill holes.

The rockhead diameter of sinkholes probably being less than 1m means that investigation is very difficult.

On balance the investigations indicated only minor solution enlarged joints.
However surficial material was excavated from each identified sinkhole, which was then backfilled on strong geotextile webbing.
Even so some remedial work has been needed since the road opened.

راعلت, عاليا من طول صيدر
During construction a large wedge failure occurred – stabilised by cable anchors & rock bolts.

Rock bolts, shotcrete and catch fence.
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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 – compacts and oxidises (especially if drained). The variable soft clays also give problems.

All this material needs excavation and replacement.

Not done thoroughly enough and some remedial work needed!

Just East of Old Colwyn

Just East of Old Colwyn – old complex landslips in glacial till over limestone.

Built toe weight embankment needs marine erosion protection.

Dolos blocks
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Concrete steps eroded by waves bombarding steps with beach pebbles.

Breakwater designed to be submerged and absorb wave energy.

New Brighton Link Wall 1985 & 2009 Demonstrates effectiveness of breakwaters!

Retaining wall in Colwyn Bypass.
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.

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 is the “gangue” mineral.

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

**CONWAY TUNNEL**

**Immersed tube tunnel - 6 x 118m sections**

1. Tunnel units lowered and reconnected.
2. Core. Tunnel units lowered and reconnected.
3. Tunnel units lowered and reconnected.
4. Unit raised by barge to jetty and lowered.
5. Unit raised by barge to jetty and lowered.

Approach sections of tunnel on each bank were made by cut and cover method (excavate, make concrete tunnel section, cover tunnel by burying).

Conway Tunnel West Portal
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 £227 million for 5.8km = tunnel plus difficult approaches both sides.

Penmaenbach Tunnel
- Large volumes of old scree and other unstable materials excavated.
- Ring of rock anchors to form a pretensioned arch before tunneling.
- Cracked tunnel lining was covered over a few years ago but that was only a “cosmetic” cover of the main structural lining.

Penmaenmawr Bypass

Penmaenmawr Promenade

Armour stone imported from Ireland & Sweden. The local quarries were unable to supply enough in the timespan.

East end of Pen-y-Clip Tunnel
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Potentially unstable materials include:
- Quarry & construction waste
- Modern scree
- Fossil Scree
- Irish Sea Glacial deposits
- Welsh Glacial deposits
- The Bedrock is:
  - Microdiorite (igneous)
  - Mudstone (Ordovician)

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- Microdiorite (Igneous)
- Mudstone (Ordovician)

Irish Sea Glacial deposits

Welsh Glacial deposits

East portal of new tunnel.
Now new foot/bicycle bridge.

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

Llanfairfechan Bypass – alluvial silts & clays +/- peats & till, often waterlogged. Excavate & replace with gravel. Or concrete slab with piles where more peat.

- 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. At Malltraeth Marsh (salt marsh) the road is constructed on a high embankment.

Near Pentre Berw the bedrock changes to hornblende schists which are more resistant to erosion, forming a prominent ridge. This ridge required a 17m deep blasted rock cutting.

Site of Stephenson’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.

Thank you for your attention.

Penmaennawr Bypass