



# 200 Years of Cathodic Protection

Paul Lambert

ICorr NW Branch AGM

October 2024



Sir Basil Mott (Bart) &  
Sir Murdoch MacDonald

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# A Little Personal Background



Corrosion



# 1824 – and all that

- January 8 – After much controversy, Michael Faraday is finally elected as a member of the Royal Society, with only one vote against him.
- **January 22 – Sir Humphry Davy has his paper entitled '*On the corrosion of copper sheeting by seawater, and on methods of preventing this effect; and on their application to ships of war and other ships*' accepted for publication in the Proceedings of the Royal Society.**
- April 7 – The Mechanics' Institution is established in Manchester at the Bridgewater Arms Hotel.
- April 19 – Death of Lord Byron.
- May 7 – Beethoven's Symphony No. 9 (the "Choral") premieres at the Theater am Kärntnertor in Vienna.
- June 16 – The Royal Society for the Prevention of Cruelty to Animals is established in Great Britain.
- **October 21 – Joseph Aspdin patents Portland cement.**

VI. *On the corrosion of copper sheeting by sea water, and on methods of preventing this effect; and on their application to ships of war and other ships. By Sir HUMPHRY DAVY, Bart. Pres. R. S.*

Read January 22, 1824.

1. **T**HE rapid decay of the copper sheeting of His Majesty's ships of war, and the uncertainty of the time of its duration, have long attracted the attention of those persons most concerned in the naval interests of the country. Having had my enquiries directed to this important object by the Commissioners of the Navy Board, and a Committee of the Royal Society having been appointed to consider of it, I entered into an experimental investigation of the causes of the action of sea water upon copper. In pursuing this investigation, I have ascertained many facts which I think not unworthy of the notice of the Royal Society, as they promise to illustrate some obscure parts of electro-chemical science; and likewise seem to offer important practical applications.



A.D. 1824 . . . . . N° 5022.

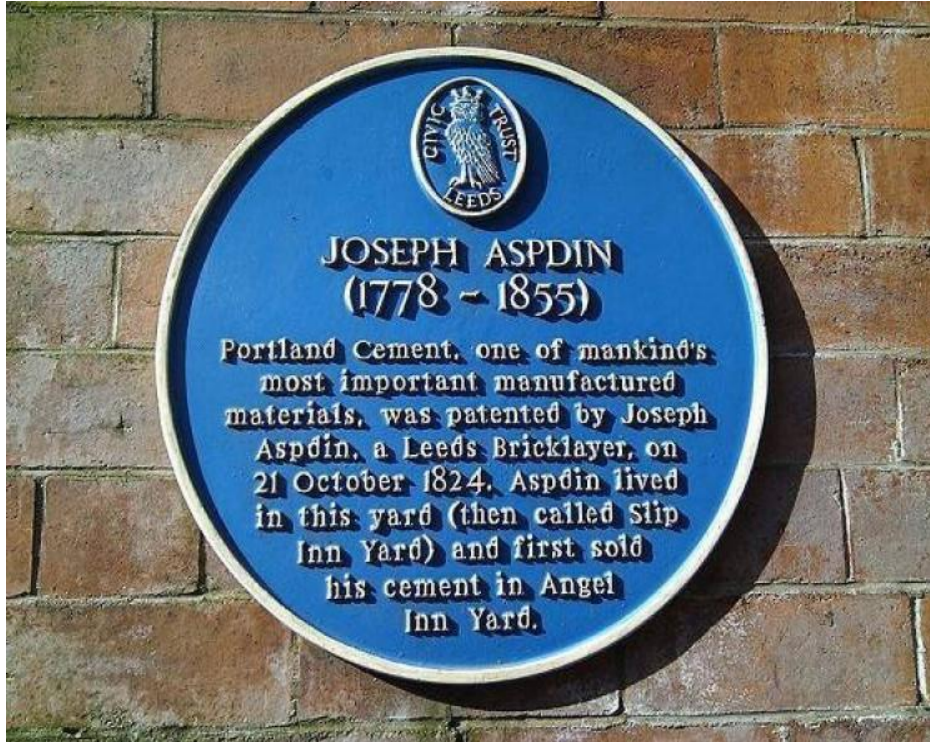
Artificial Stone.

ASPDIN'S SPECIFICATION.

TO ALL TO WHOM THESE PRESENTS SHALL COME, I, JOSEPH ASPDIN, of Leeds, in the County of York, Bricklayer, send greeting.

WHEREAS His present most Excellent Majesty King George the Fourth, by His Letters Patent under the Great Seal of Great Britain, bearing date at  
 5 Westminster, the Twenty-first day of October, in the fifth year of His reign, did, for Himself, His heirs and successors, give and grant unto me, the said Joseph Aspdin, His especial licence, that I, the said Joseph Aspdin, my exors, adfiors, and assigns, or such others as I, the said Joseph Aspdin, my exors, adfiors, and assigns, should at any time agree with, and no others, from time  
 10 to time and at all times during the term of years therein expressed, should and lawfully might make, use, exercise, and vend, within England, Wales, and the Town of Berwick-upon-Tweed, my Invention of "**AN IMPROVEMENT IN THE MODES OF PRODUCING AN ARTIFICIAL STONE;**" in which said Letters Patent there is contained a proviso obliging me, the said Joseph Aspdin, by an instru-  
 15 ment in writing under my hand and seal, particularly to describe and ascertain the nature of my said Invention, and in what manner the same is to be performed, and to cause the same to be inrolled in His Majesty's High Court of Chancery within two calendar months next and immediately after the date of the said in part recited Letters Patent (as in and by the same), reference  
 20 being thereunto had, will more fully and at large appear.

# Joseph Aspdin

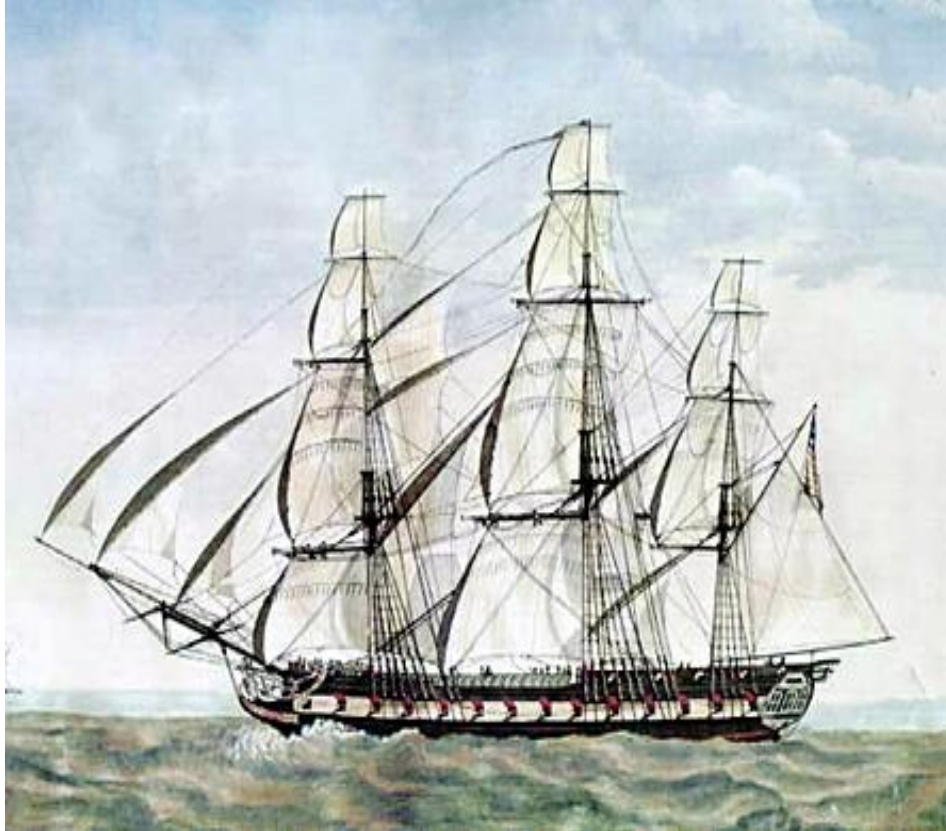


# History of Corrosion and its Prevention

- The majority of the techniques we employ to explain and control corrosion go back a long way
  - 1675: Erosion Corrosion (Boyle)
  - 1763: Bimetallic Corrosion (British Navy)
  - 1824: Cathodic Protection (Davy)
  - 1919: Inhibitive Pigments (Cushman & Gardner)
  - 1920: Intergranular Corrosion of Brass (Moore et al)
  - 1938: Mechanism of Inhibitors (Evans)
- The use of coatings goes back into pre-history



# Bimetallic Corrosion in Seawater



- HMS Alarm, 1763
- Trials with copper sheets nailed to hull
- Effective as antifouling but fails as iron nails and other components corrode preferentially

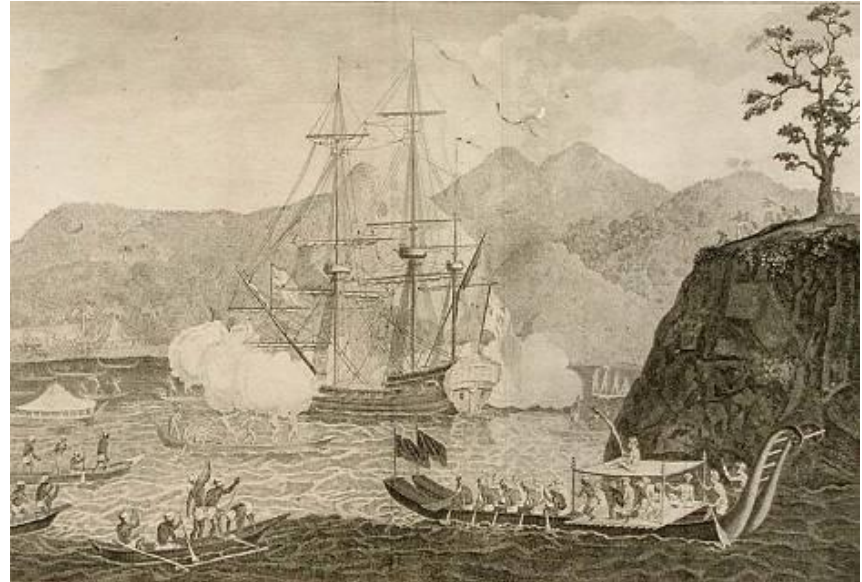
# Bimetallic Corrosion in Seawater

- Bimetallic (Galvanic) Corrosion
- Where the waxed paper that covered the delivered copper sheet was trapped beneath the nail head, little or no corrosion occurred
- The Navy concluded that iron should not be used in direct contact with seawater



# Military Intelligence

- Despite the report on HMS Alarm, in 1763 Commodore 'Foul Weather Jack' Byron began a circumnavigation of the globe in his copper bottomed ship, HMS Dolphin
- As well as the banging of the loose copper sheets, the rudder would periodically drop off as the iron pintles corroded through



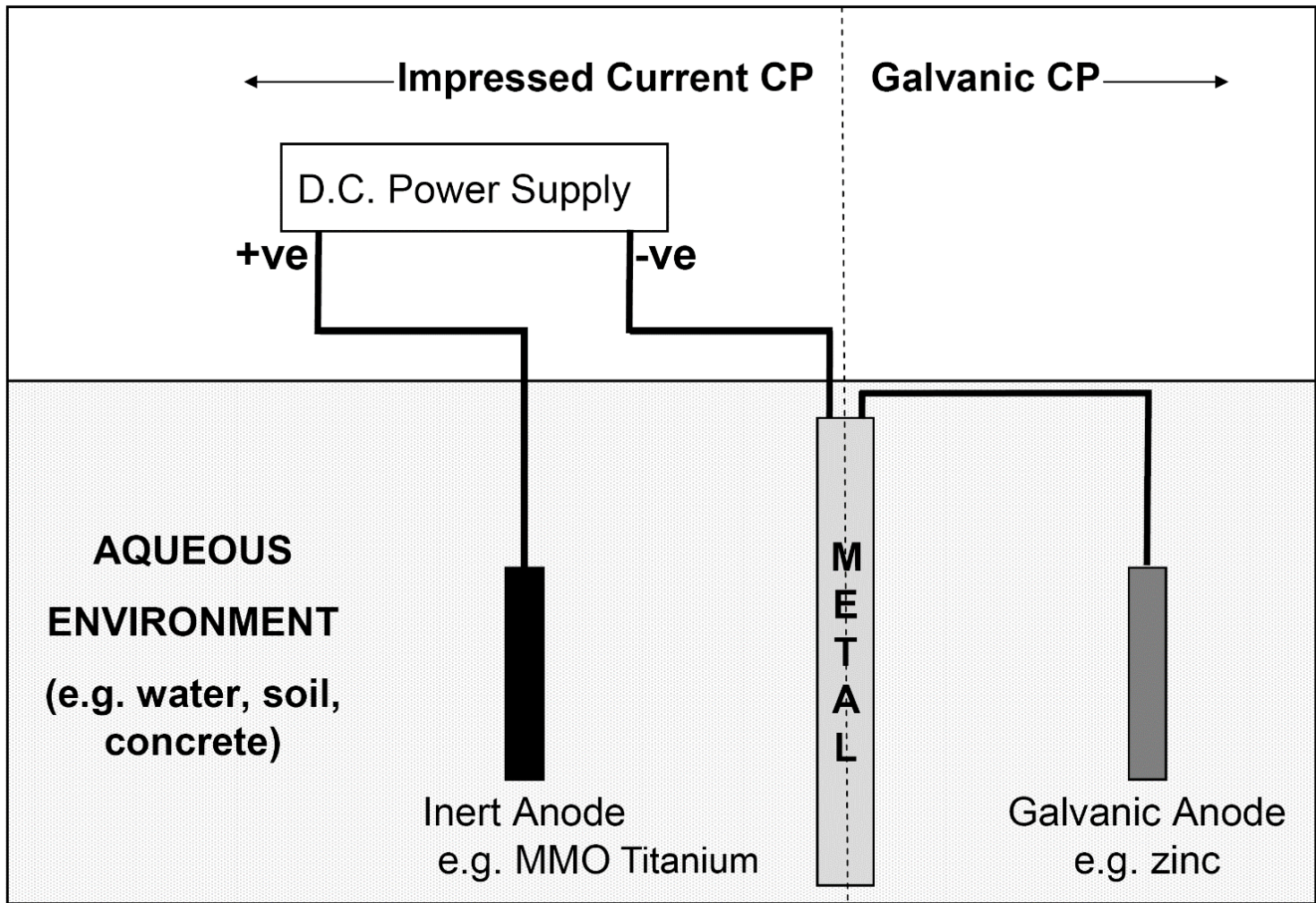
# HMS Sirius (1797 - 1810)



# HMS Sirius (1797 - 1810)



# Cathodic Protection



# First CP Application

- HMS Samarang
- Effective at preventing the copper sheet from corroding
- The first trial was deemed 'successful' but the hull was covered in shells and weed
- After the 'failure' of CP, Davy was ridiculed by the Fleet Street press (at request of the Royal Navy)
- The 'protectors' were removed – and did not return for 100 years



*Scientific Researches! — New Discoveries in PNEUMATICKS! — or — an Experimental Lecture on the Powers of Air.*





LIVING MADE EASY.

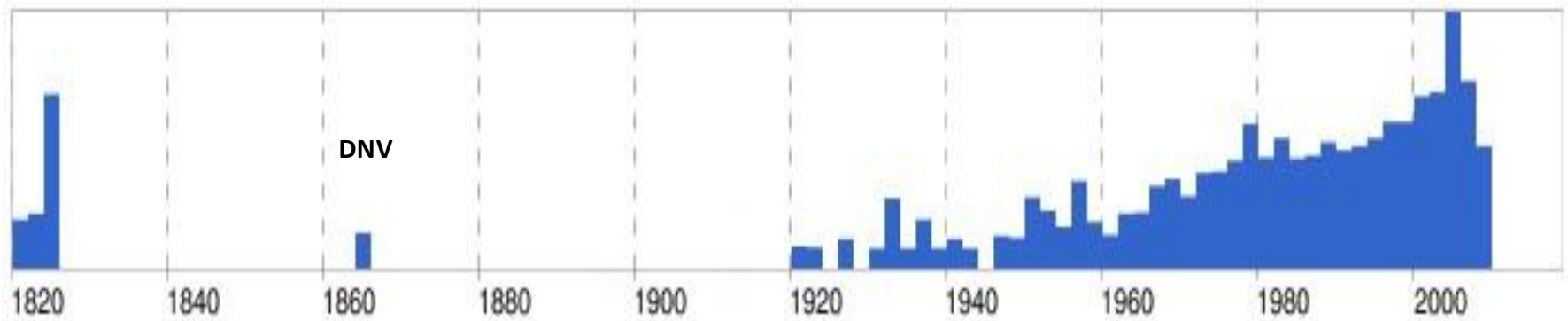
COLECCIÓN VIRIDANS



PRESCRIPTION FOR SCOLDING WIVES.

London, Pub<sup>d</sup> by T. M<sup>c</sup>Lean, 26, Haymarket, Jan 1, 1830.

# CP Timeline



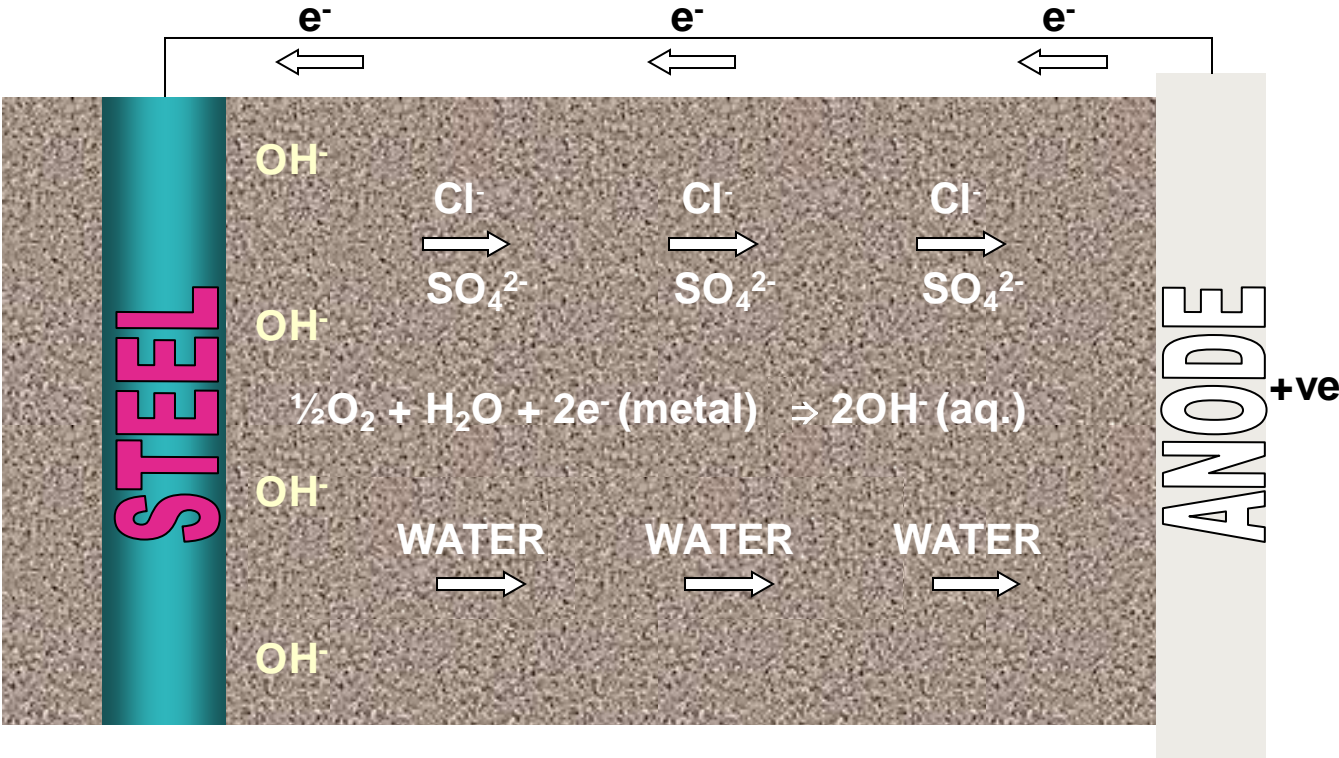
- Davy left England for self-imposed exile in Switzerland where he died from a stroke aged 50
- Coleridge, about Davy - "*chemistry tends to turn its Priests into Sacrifices*"

# Growth of Oil & Gas Exploration

- The US oil and gas boom resulted in thousands of miles of iron and steel pipes
- By the 1920's corrosion problems started to be identified
- From the early 1930's corrosion control measures including coatings and CP were adopted
- In 1936 the Mid-Continent Cathodic Protection Association was formed (later became NACE and now AMPP)



# Cathodic Protection in Reinforced Concrete



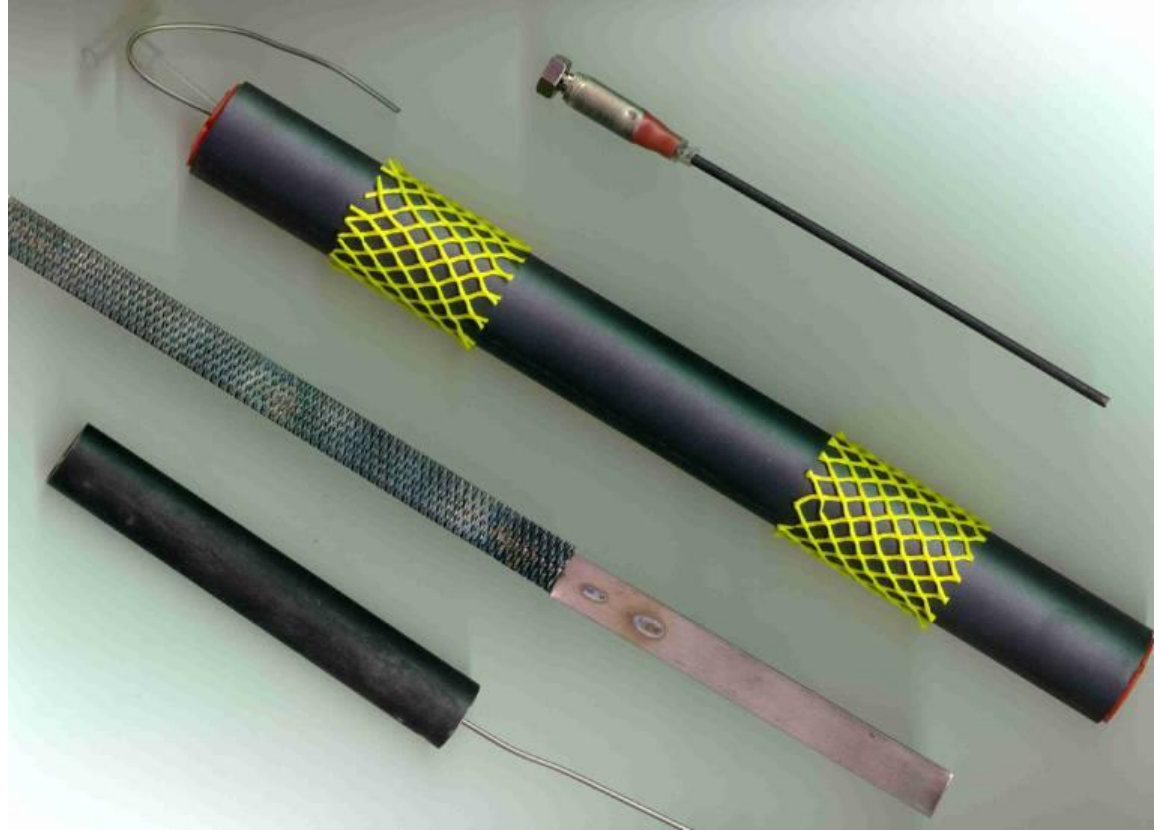
# Anode Types

- Surface protection
- Mesh and overlay
- Conductive overlays
- Conductive coatings



# Anode Types

- Discrete Anodes
- Protection at depth



# Anode Types



# Anode Types





# Galvanic Anodes

- Usually Zinc
- Sprayed on, stuck on, bolted on, tied on
- Less to do
  - Cannot adjust output
  - Monitoring to check anode still functioning



# Prestressed Beams



# Reinforced Concrete CP Design Example

- M4 Elevated
- Carries 90,000 vehicles per day into West London
- Runs over A4, that carries 50,000 vehicles per day
- Adjacent to residential area

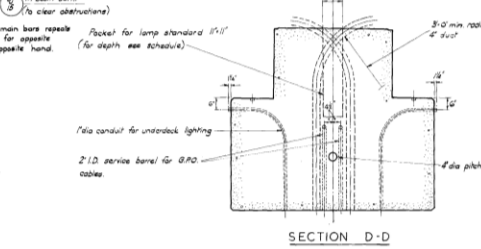
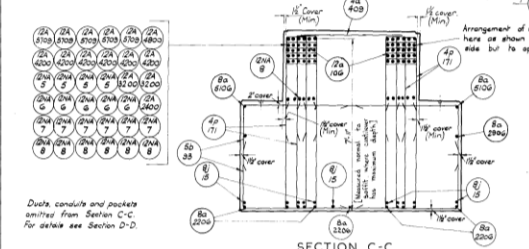
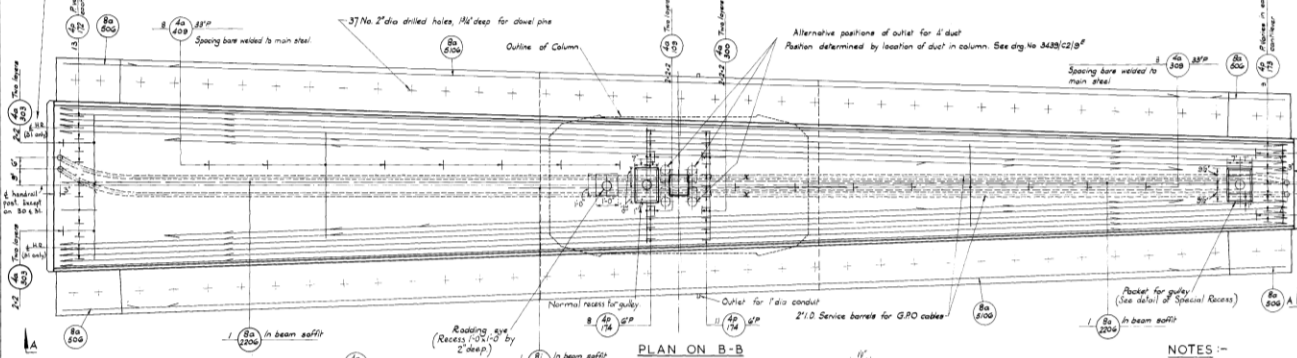
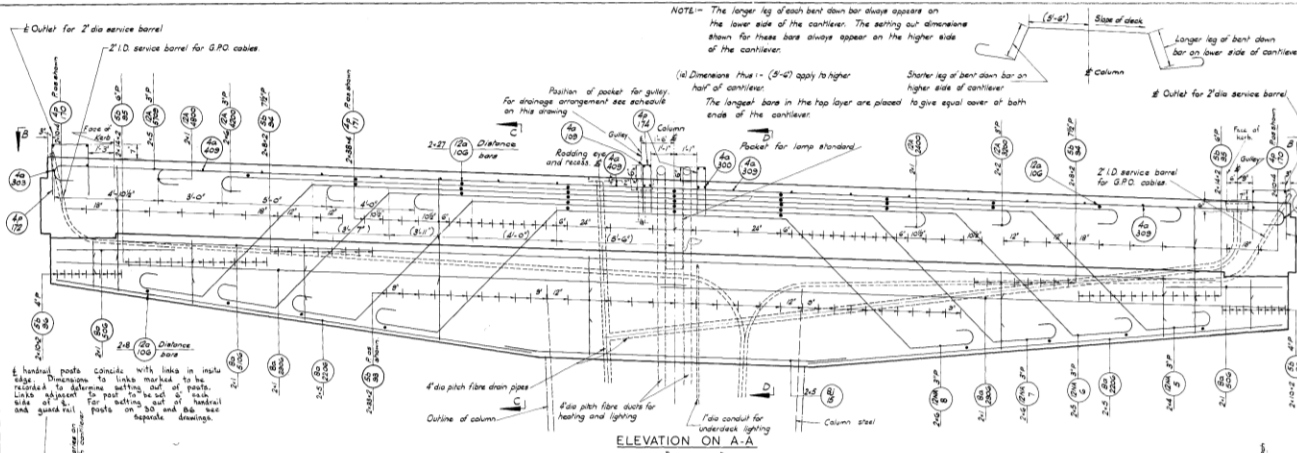


NO STOPPING  
ANYTIME



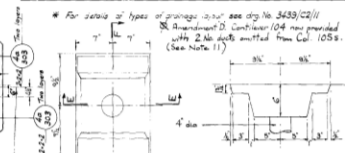






**SCHEDULE OF DUCTS CONDUITS & POCKETS REQUIRED IN CANTILEVERS WITH TRANSVERSE SLOPE OF 1 IN 24 TO 1 IN 60 (EXCEPT CANTILEVER No 10)**

| Cantilever Number | Position of Gully | # ducts of 2" dia | Follow conduit 2" ID ducts 1/2" clear of inner of bar | Follow conduit 2" ID ducts 1/2" clear of inner of bar | Depth of floor to top of bar | Slope of floor to top of bar |
|-------------------|-------------------|-------------------|---|---|------------------------------|------------------------------|
| 1                 | TYPE B            | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 2                 | -                 | 1                 | Yes   | Yes   | 4'-0"                        | -                            |
| 3                 | -                 | 2                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 4                 | -                 | 2                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 5                 | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 6                 | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 7                 | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 8                 | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 9                 | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 10                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 11                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 12                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 13                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 14                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 15                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 16                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 17                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 18                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 19                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 20                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 21                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 22                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 23                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 24                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 25                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 26                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 27                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 28                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 29                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 30                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 31                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 32                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 33                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 34                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 35                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 36                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 37                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 38                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 39                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 40                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 41                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 42                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 43                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 44                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 45                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 46                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 47                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 48                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 49                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 50                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 51                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 52                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 53                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 54                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 55                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 56                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 57                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 58                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 59                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 60                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 61                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 62                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 63                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 64                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 65                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 66                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 67                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 68                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 69                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 70                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 71                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 72                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 73                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 74                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 75                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 76                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 77                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 78                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 79                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 80                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 81                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 82                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 83                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 84                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 85                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 86                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 87                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 88                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 89                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 90                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 91                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 92                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 93                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 94                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 95                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 96                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 97                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 98                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 99                | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 100               | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 101               | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 102               | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 103               | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |
| 104               | -                 | 1                 | Yes   | Yes   | 4'-0"                        | 1 in 24                      |



**NOTES -**

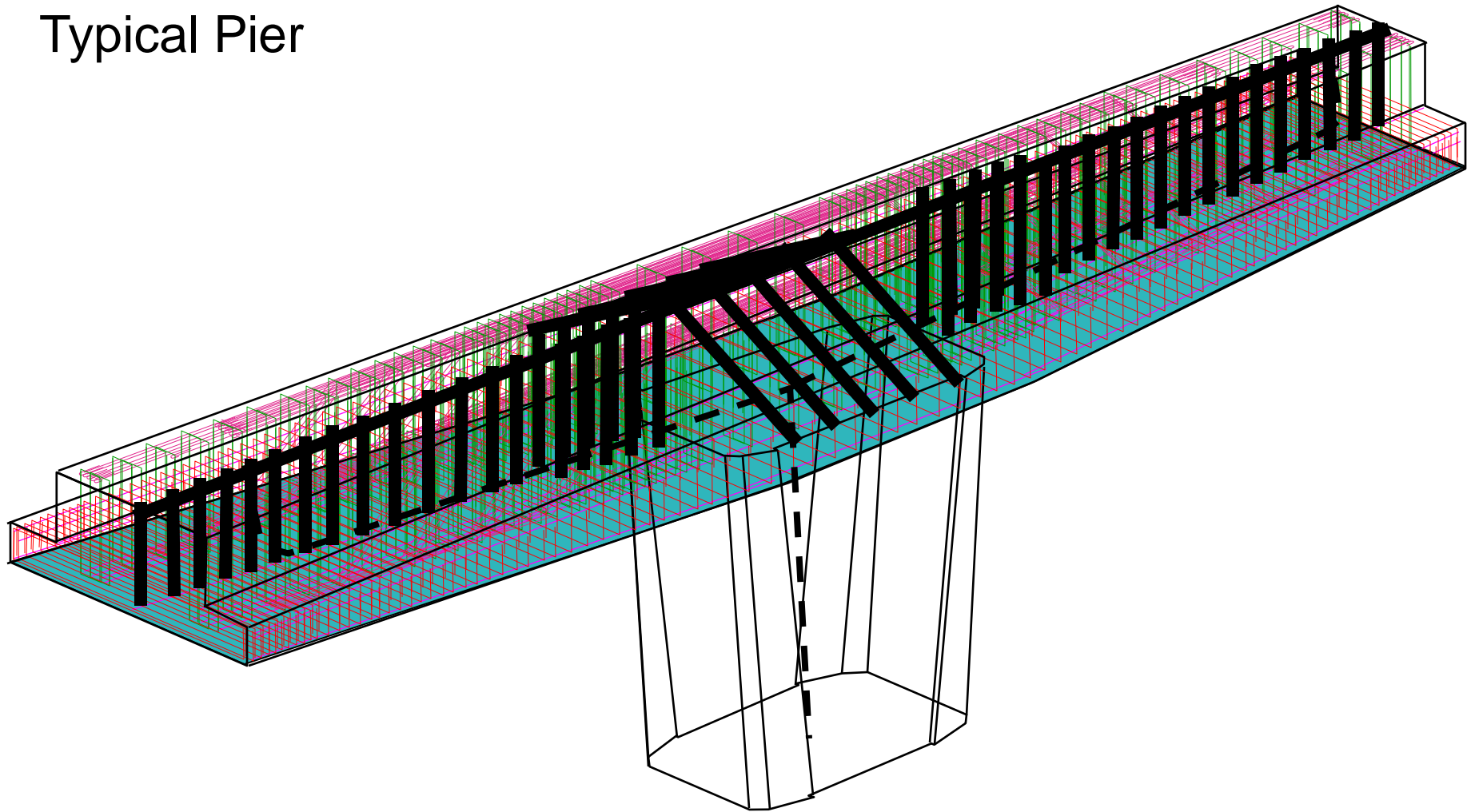
- This drawing shows reinforcement details for cantilevers with transverse slope of 1 in 24 to 1 in 60. It applies to cantilevers listed in the schedule.
- For setting out details of cantilevers see separate drawings.
- No cantilever has built in ducts for all services. For details of ducts required in a particular cantilever see schedule on this drawing.
- Cover to reinforcement as indicated on drawing, or 1 1/2" minimum.
- Symbol such as 2/5 (2) 2/5 indicates 10 groups each containing 4 No 5/8" dia bars of type 'D' or centres as shown in two cages.
- Symbols such as 2/5 (2) 2/5 indicate 5 No 5/8" dia bars of type 'X' 5/8" long at 2' centres in two cages.
- For schedule of reinforcement see Ref List No 3439/C2/10.
- For details of columns see Ref List No 3439/C2/10.
- Cantilever No 10 falls within the range of transverse slopes for which this drawing is applicable, but details are special and are shown on separate drawing.
- The lower gully on the following cantilevers must be provided with a special recess as detailed on this drawing:
  - (a) Cantilevers Nos 12, 3, 4, 7, 31, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103 & 104.
  - (b) Cantilever in normal recess is required.
- Cantilever No 104 provided with 2 No built in ducts of type 'D' 1055. For details see Ref List No 3439/C2/10/11.

**AMENDMENTS**

| No. | Description  | Date   |
|-----|--|--------|
| 1   | Revised details of reinforcement for cantilevers with transverse slope of 1 in 24 to 1 in 60. See Ref List No 3439/C2/10/11. | 1/1/77 |
| 2   | Revised details of reinforcement for cantilevers with transverse slope of 1 in 24 to 1 in 60. See Ref List No 3439/C2/10/11. | 1/1/77 |
| 3   | Revised details of reinforcement for cantilevers with transverse slope of 1 in 24 to 1 in 60. See Ref List No 3439/C2/10/11. | 1/1/77 |
| 4   | Revised details of reinforcement for cantilevers with transverse slope of 1 in 24 to 1 in 60. See Ref List No 3439/C2/10/11. | 1/1/77 |
| 5   | Revised details of reinforcement for cantilevers with transverse slope of 1 in 24 to 1 in 60. See Ref List No 3439/C2/10/11. | 1/1/77 |
| 6   | Revised details of reinforcement for cantilevers with transverse slope of 1 in 24 to 1 in 60. See Ref List No 3439/C2/10/11. | 1/1/77 |
| 7   | Revised details of reinforcement for cantilevers with transverse slope of 1 in 24 to 1 in 60. See Ref List No 3439/C2/10/11. | 1/1/77 |
| 8   | Revised details of reinforcement for cantilevers with transverse slope of 1 in 24 to 1 in 60. See Ref List No 3439/C2/10/11. | 1/1/77 |
| 9   | Revised details of reinforcement for cantilevers with transverse slope of 1 in 24 to 1 in 60. See Ref List No 3439/C2/10/11. | 1/1/77 |
| 10  | Revised details of reinforcement for cantilevers with transverse slope of 1 in 24 to 1 in 60. See Ref List No 3439/C2/10/11. | 1/1/77 |

Ducts, conduits and pockets omitted from Section C-C. For details see Section D-D.

# Typical Pier









## Contractor / Client

- Fewer holes required
  - Less drilling = reduced white finger risk
  - Fewer staff = less overall risk
- Less abortive work
  - Easier to programme
  - Lower financial risk
- Shorter Duration
  - Less traffic management

## Community

- Less drilling
  - Less noise
- Shorter programme
  - Shorter roadworks, fewer accidents
  - Less traffic disruption
- Enhanced appearance
  - No more rust



# Thank you

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