FEVE based coating systems:
Protecting Steel Bridges for over 30 years!

Humber Bridge

Certified System
Quality
ISO 9001

A&I COATINGS

CONTENT

• **FEVE PAINT TECHNOLOGY**	Ian Robertson
• **LUMIFLON - FEVE RESIN**	Ian Robertson
• **FEVE PERFORMANCE TESTS**	Peter Gillies
• **A&I CASE STUDIES**	Peter Gillies
• **LIFE CYCLE COSTS**	Peter Gillies
• **QUESTIONS**	Peter Gillies

A&I COATINGS

FUNDAMENTAL FUNCTION OF PAINT

PAINT

The finishing touch, formulated to –

1. ***Protect the substrate***
2. ***Maintain aesthetics***

A&I COATINGS

FUNDAMENTAL FUNCTION OF PAINT

1. Protecting the substrate

- *Epoxy Zinc Rich* *(109)*
- *Epoxy Micaceous Iron Oxide* *(112)*
- *Epoxy Surface Tolerant Aluminium* *(115)*
- *Epoxy Surface Tolerant* *(116)*

Proven technology which we endorse

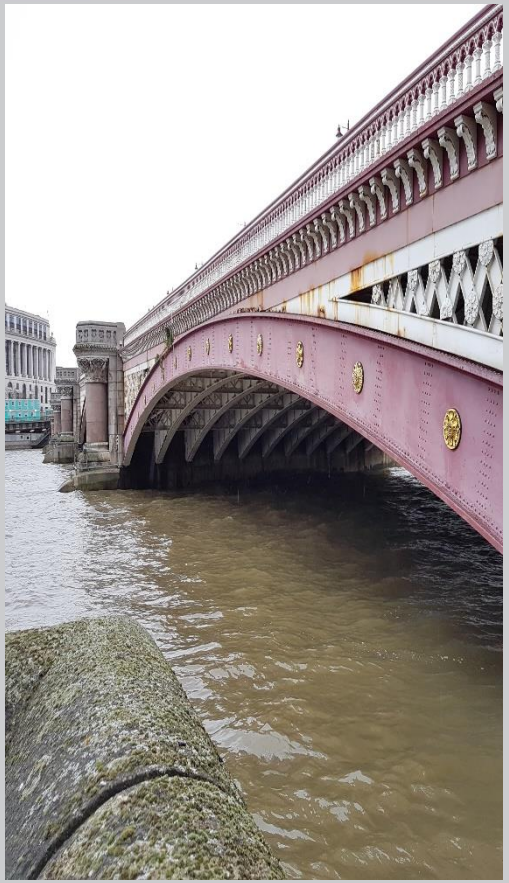
A&I COATINGS

FUNDAMENTAL FUNCTION OF PAINT

2. Maintaining aesthetics

- *Polyurethane* *(168)*
- *Polysiloxane* *(185)*
- *Epoxy Acrylic* *(167)*

Dated technology…rapidly fades



A&I COATINGS

FUNDAMENTAL FUNCTION OF PAINT

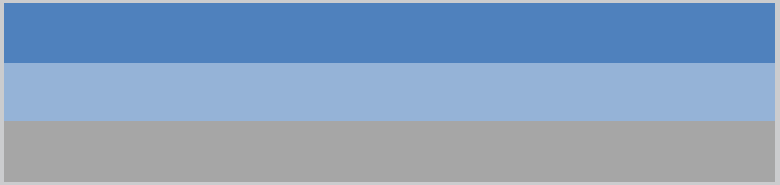
A&I COATINGS

FEVE Topcoat – A New Concept

The role of the topcoat is completely re-written; Instead of being an aesthetic appendix to the paint system, it becomes a major protection asset to the primers and substrate, as well as enhancing the aesthetics all at the same time.

A&I COATINGS

TRADITIONAL PAINT TECHNOLOGY

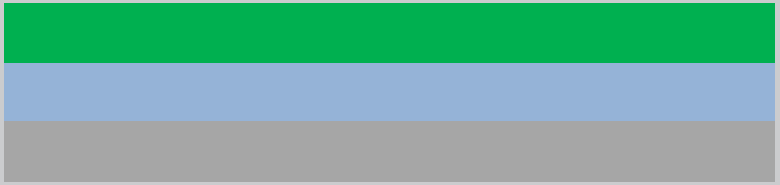


POLYURETHANE TOPCOAT (168)
EPOXY MIDCOAT (112)
EPOXY ZINC RICH (109)

- **Corrosion protection - Good**
- **Gloss and colour retention maintained for 5-10 years**

A&I COATINGS

TRADITIONAL PAINT TECHNOLOGY



FEVE TOPCOAT (195)
EPOXY MIDCOAT (112)
EPOXY ZINC RICH (109)

- **Corrosion protection – ~~Good~~ Very Good**
- **Gloss and colour retention maintained for ~~5-10 years~~ 30+ years**

A&I COATINGS

Introduction of Fluoropolymers

Fluoropolymers have been in use for 40+ years as offering outstanding physical properties including –

- ✓ Weatherability
- ✓ Corrosion resistance
- ✓ Chemical resistance

The use of these Fluoropolymers however has been limited due to application constraints –

- X Very high temperatures (300°C) required to solubilise and fuse the coating
- X Limited gloss levels of 20-40%

e.g. PVDF (Polyvinlyidene Fluoride) as used for coil coated cladding

A&I COATINGS

Introduction of Fluoropolymers

Fluoropolymers have been in use for 40+ years as offering outstanding physical properties including –

- ✓ Weatherability
- ✓ Corrosion resistance
- ✓ Chemical resistance

SOLVENT SOLUBLE FLUOROPOLYMER – **FEVE RESINS**

Maintain all original attributes of Fluoropolymers plus…

- ✓ Room temp curing – can be paintshop or site applied
- ✓ Conventional application equipment and process
- ✓ Wide colour range including vibrant shades & metallics
- ✓ Choice of sheen from Matt to Full Gloss

A&I COATINGS

Asahi Glass Corporation Ltd

Founded in 1907 in Tokyo as the first sheet-glass producer in Japan.

- **Worldwide No.1 glass producer**
- **A company of the MITSUBISHI Group**
- **Worldwide sales €10 billion +**
- **293 subsidiaries in 30 countries**
- **50 000 employees worldwide**
- **Manufacturers of Lumiflon**

LUMIFLON

A&I COATINGS

PRODUCTION PLANT: CHIBA, JAPAN

A&I COATINGS

FEVE Chemistry

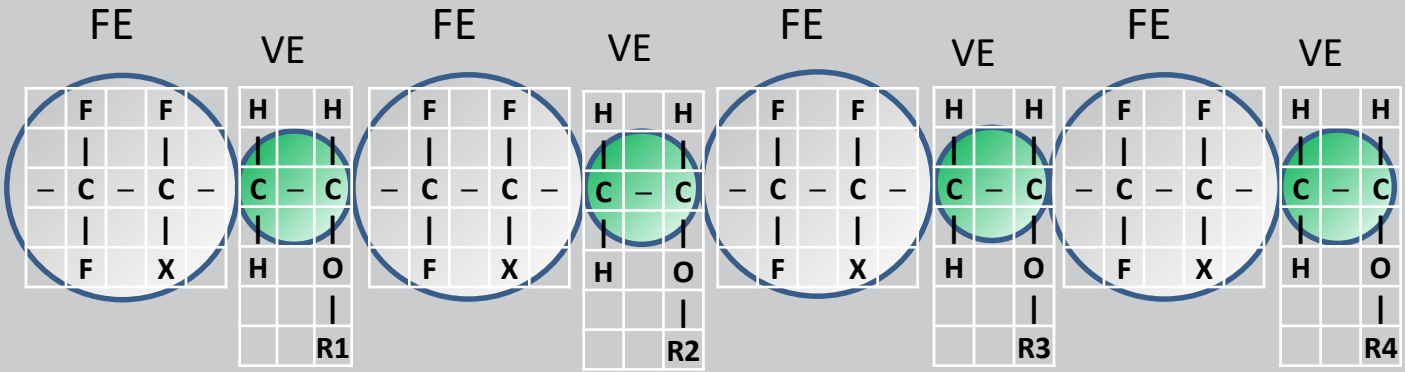
What is FEVE Technology?

The polymeric structure of an **FEVE** is a very systematic arrangement of fluoro-ethylene and vinyl-ether molecules.

This image demonstrates the arrangement and also shows that each fluoro ethylene molecule has 3 fluorine atoms as opposed to 2 in PVDF or PVF2 coatings

Fluoro Ethylene:
Durability

Vinyl Ether:
R1 = Transparency, Gloss, Hardness
R2 = Flexibility
R3 = Cross-linkability

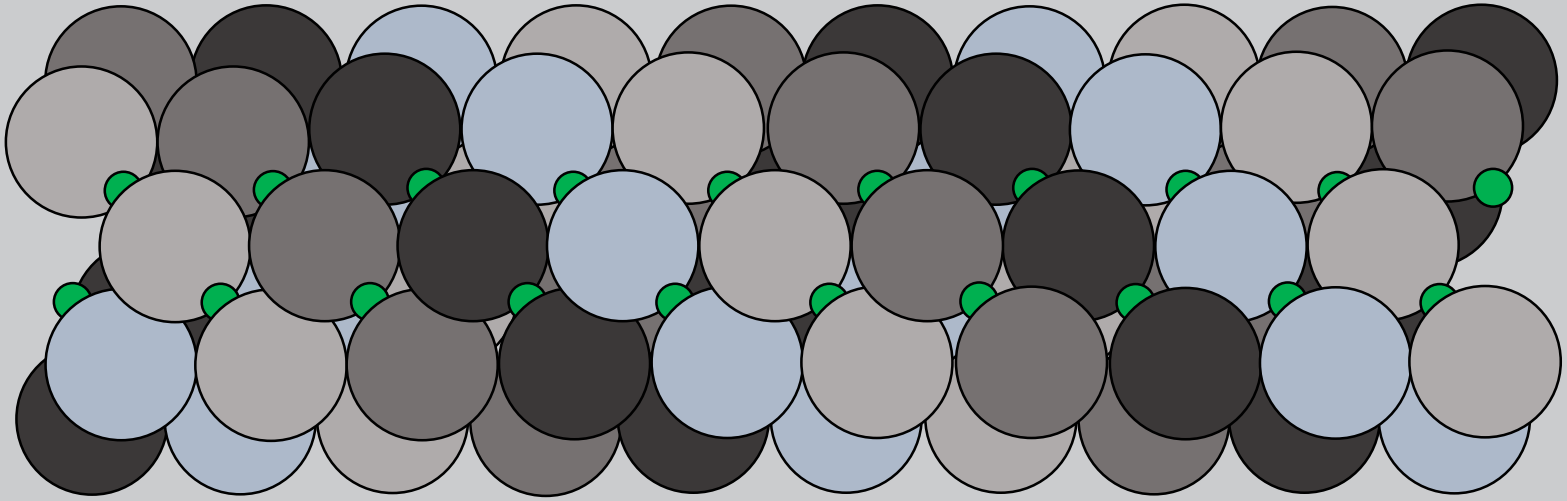


A&I COATINGS

FEVE Chemistry

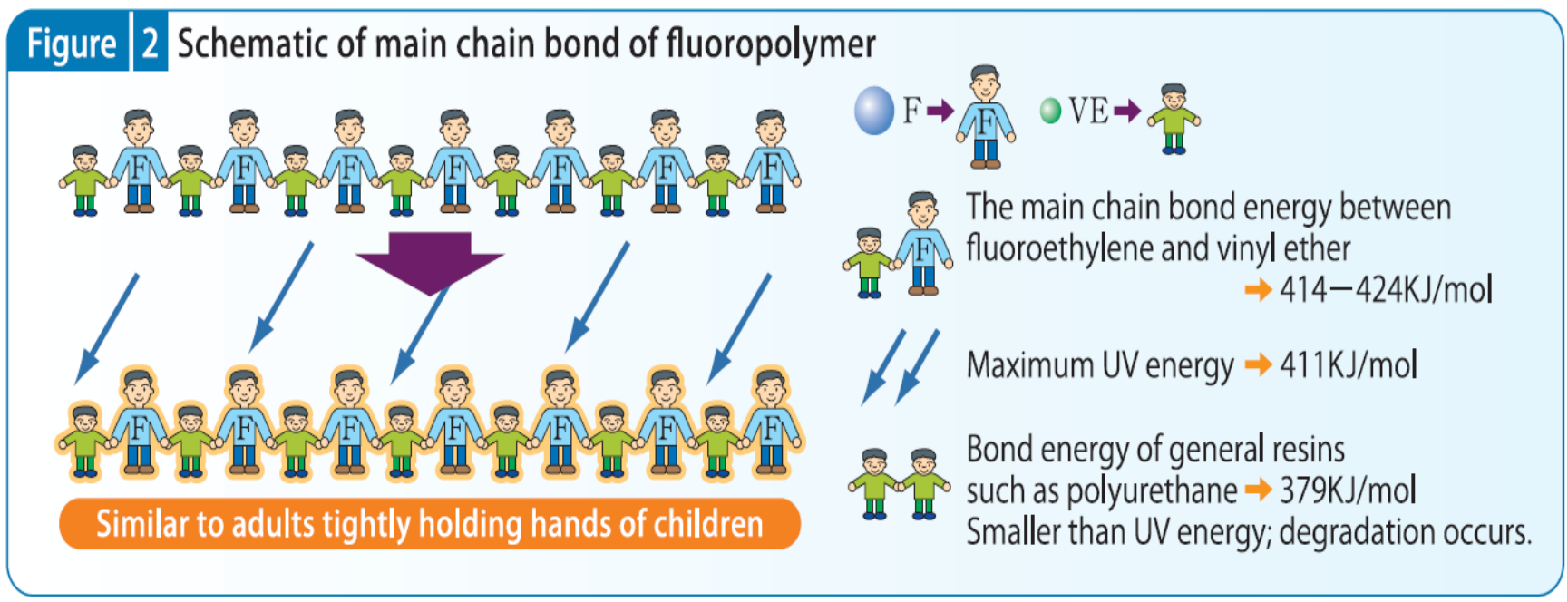
Why is FEVE so durable?

- The fluoroethylene and vinyl ether units are arranged in an alternating sequence – this means that the strong and stable fluoroethylene unit protects it's neighbouring vinyl ether unit.



A&I COATINGS

FEVE Chemistry



A&I COATINGS

UNOVA PRODUCTS

Introduction of Fluoropolymers

Why is FEVE so durable?

- The fluoroethylene molecule derives high integral strength from it's high frequency of fluorine atoms

Bond Energy
414-424KJ/mol

- The carbon-fluorine bond energy in the fluoroethylene section of the co-polymer is greater than the energy of UV photons.

Max UV Energy:
411KJ/mol

- General resins such as Polyurethane have a bond energy smaller than UV energy which is why degradation occurs

Bond Energy
379KJ/mol

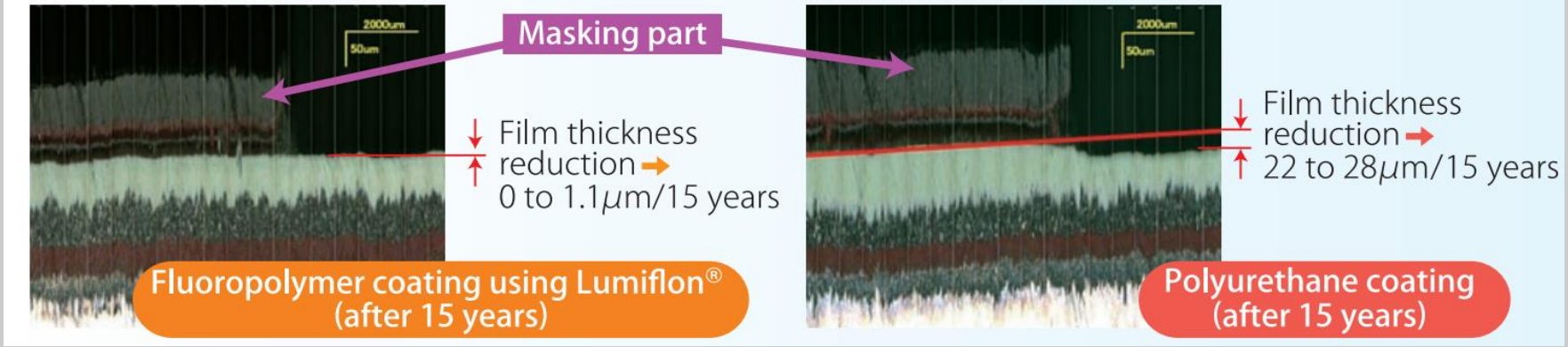
A&I COATINGS

Durability/Life-cycle cost

The advantages of this uv resistant finish are two fold;

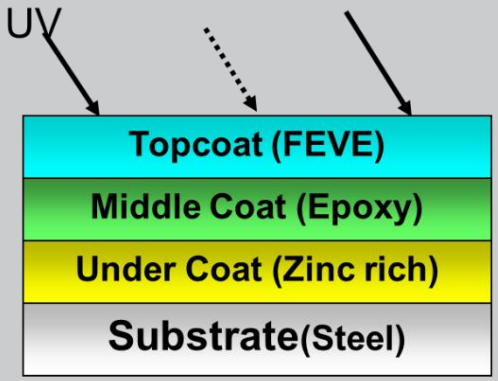
- **Aesthetics** – Colour or gloss level is maintained
- **Corrosion prevention** – There is minimal erosion of topcoat therefore protecting the underlying coats

Figure 7 Degree of coating thickness reduction seen in cross-sections of the coatings (horizontal scale 1/20)

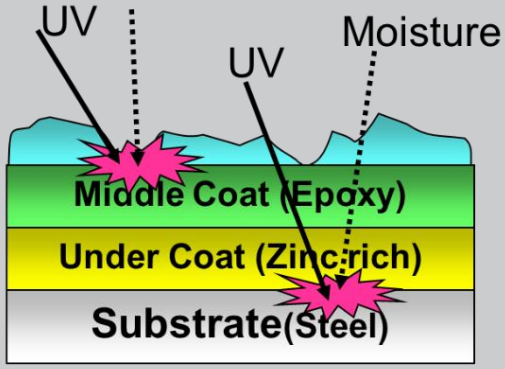


A&I COATINGS

Corrosion Protection



FEVE Topcoat



Others (Conventional)

Chlorinated Rubber

A&I COATINGS

Testing, Validation and QA

Salt Spray Chamber – Corrosion Testing

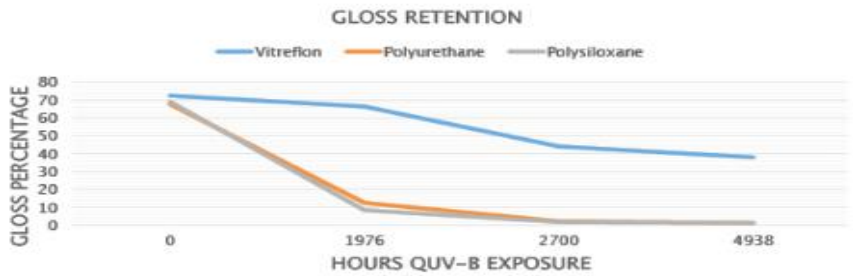
QUV Chamber – Gloss and Colour Retention and UV Stability

A&I COATINGS

Durability/Life-cycle cost

FEVE becomes the logical choice for architects, engineers, specifiers and asset owners.

Unlimited colour and gloss availability with the assurance that it will need little or no major maintenance throughout the life of the coating – estimated up to 60 years



HOURS QUV-B EXPOSURE	GLOSS PERCENTAGE		
	VITREFLON	POLYURETHANE	POLYSILOXANE
0	72.5	67.9	69.1
1976	66.5	12.5	8.5
2700	44.1	2.2	1.9
4938	37.9	1.3	1.2

A&I COATINGS

Colour and Gloss Readings

Gloss and colour variation readings taken at 4938 hours exposure.

	Vitreflon 700	Polyurethane	Polysiloxane
Original Gloss @ 60°	72.5	67.9	69.1
Gloss after 4938 Hours Exposure	37.9	1.2	1.3
Gloss Retention as %	52%	1.8%	1.9%
Colour Variation - dE	8.88	19.83	12.92

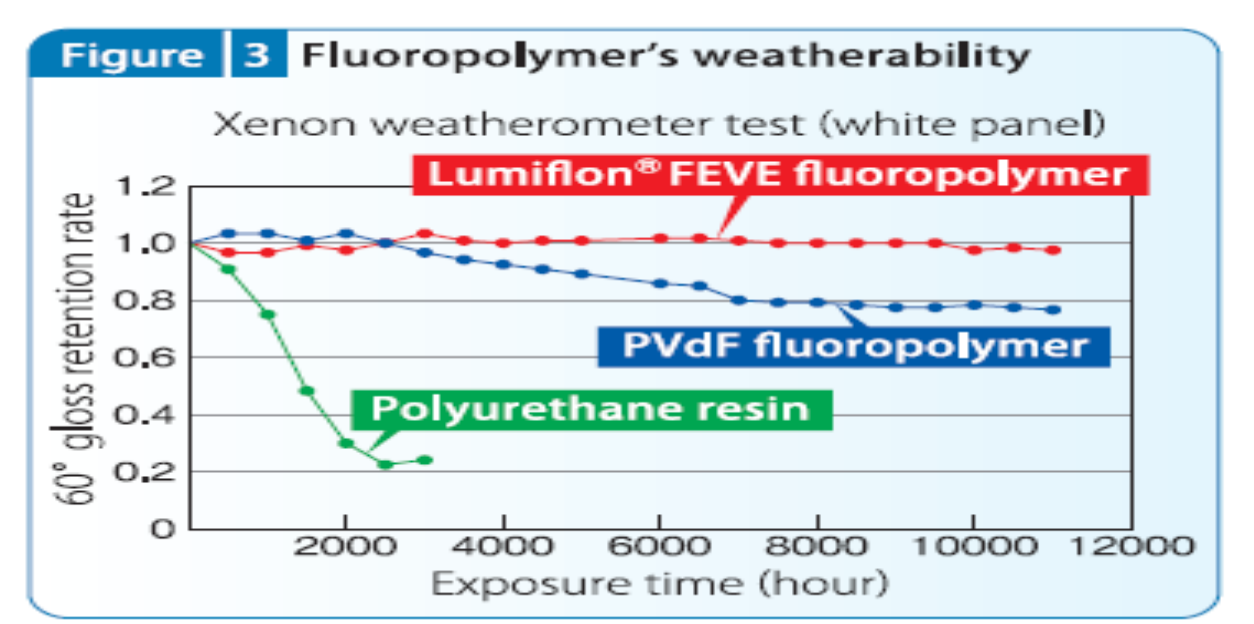
A&I COATINGS

4938 Hours Exposure

A&I COATINGS

Accelerated Weathering

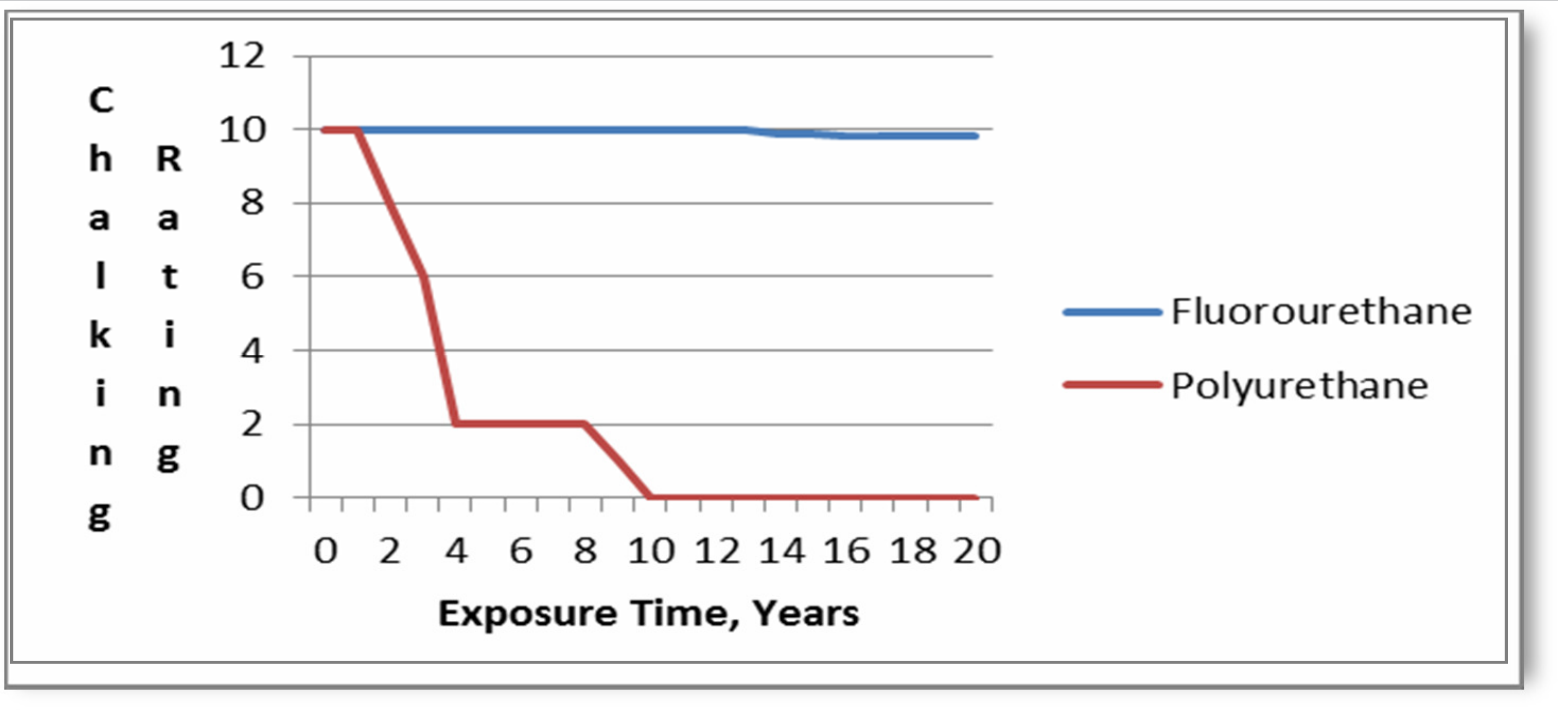
Xenon Weatherometer Test



A&I COATINGS

FEVE PERFORMANCE TEST RESULTS

CHALKING TEST



A&I COATINGS

FEVE PERFORMANCE TEST RESULTS

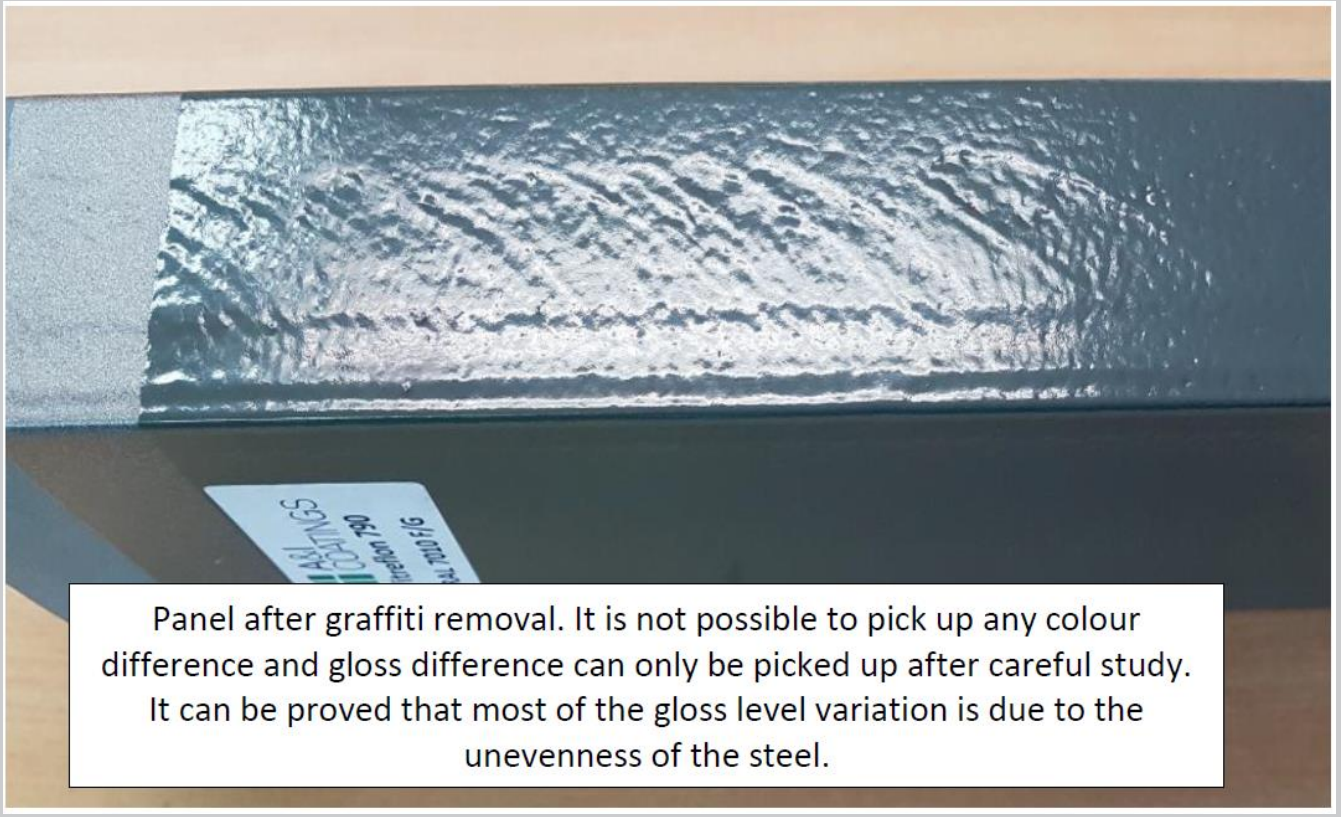
SALT FOG CORROSION TEST – 2000 HOURS

Polyurethane (2) | Fluoropolymer (6)

Polysiloxane (3) | Fluoropolymer (6)

A&I COATINGS

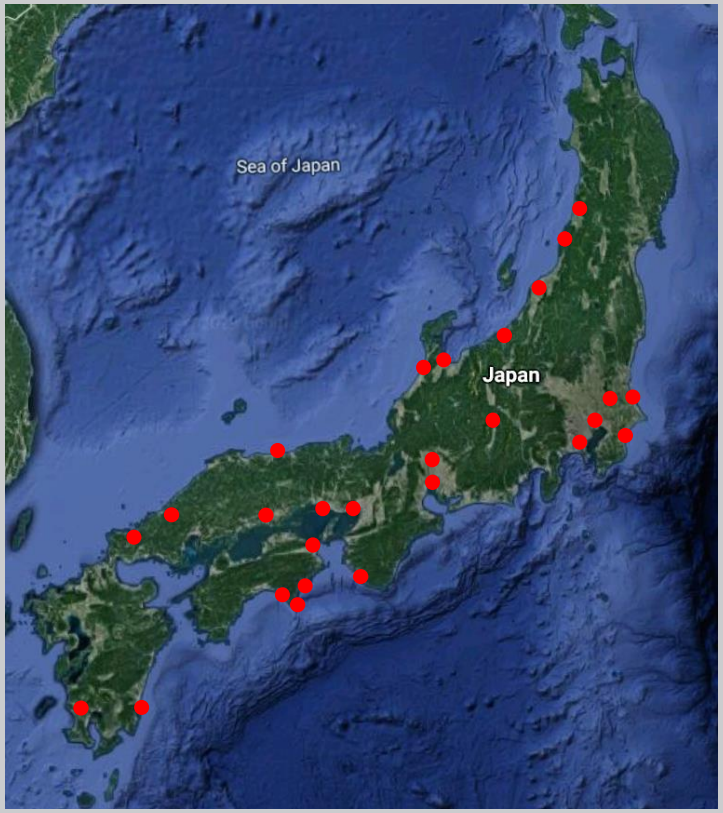
FEVE PERFORMANCE TEST RESULTS



Panel after graffiti removal. It is not possible to pick up any colour difference and gloss difference can only be picked up after careful study. It can be proved that most of the gloss level variation is due to the unevenness of the steel.

A&I COATINGS

Case Studies



LUMIFLON - TRIED & TESTED

Japanese research since 1985

- ***Ministry of Land, Infrastructure & Transport***
- ***Japan Highway Public Corp***

31 Sites (including test structures)

A&I COATINGS

Real Life Situations

A&I COATINGS

Real Life Situations

Daiichi-Mukaiyama Bridge - *Hiroshima, Japan [Constructed 1987]*

Shop spray applied coatings;

Zinc Rich	80µ
Epoxy Mid Coat	60µ
Epoxy MIO	60µ

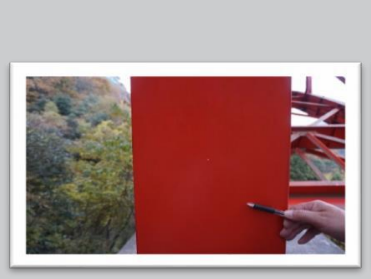
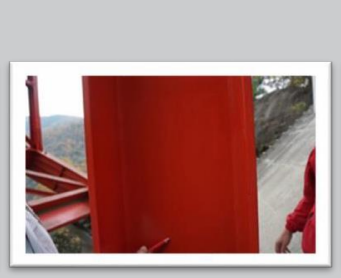
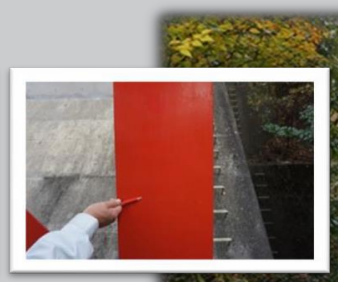
Site brush applied coatings;

FEVE Topcoat	25µ
FEVE Topcoat	25µ

A&I COATINGS

Real Life Situations

Daiichi-Mukaiyama Bridge - *Hiroshima, Japan [Constructed 1987]*


		Initial	22 years	30 years
Non-Wiped	Measured Value	52.4	46.5	28.3
	Retention %	-	88.7%	54.0%
Wiped	Measured Value	52.4	49.9	38.7
	Retention %	-	92.5%	73.8%

A&I COATINGS

Daiichi-Mukaiyama Bridge: Comparison with Alkyd resin

Comparative verification

The arch part of the bridge was coated in a FEVE system. The approach part was painted by an Alkyd (phtalic acid) resin system.

Painting specification for Alkyd system

Classification	Process	Type of paint	DFT µm
In the shop	Surface preparation	Blasting 1st Grade (ISO Sa2 1/2 level)	
	Primary primer	Etching primer	20
	Secondary Surface preparation	Treatment by Power Tool	
	Undercoat 1st layer	Lead type paint	35
	Undercoat 2nd layer	Lead type paint	35
On site	Intermediate coat	Alkyd resin paint	30
	Top coat	Alkyd resin paint	25

The alkyd resin topcoat showed remarkable deterioration of paint film in 16 years (2003). In the 18th year this approach part was repainted with polyurethane resin paint.

A&I COATINGS

Daiichi-Mukaiyama Bridge: Comparison with PU resin

12 years after repainting with the PU resin paint no film defect on the web plate or bolt joint was observed. However chalking was observed at a higher degree than had occurred with the original 30y old FEVE coating.

Gloss and colour no initial data available

A&I COATINGS

Daiichi-Mukaiyama Bridge:

Arch Part	FEVE	30 Yrs
Approach Part	ALKYD / POLYURETHANE	

A&I COATINGS

Real Life Situations

Tokiwa Bridge – *Hiroshima, Japan*: **30 years survey**

1977 –
Originally painted with Chlorinated Rubber

1986 –
Prep'd ST3

Epoxy Primer	40µ
Epoxy Midcoat	40µ
FEVE Topcoat	25µ
FEVE Topcoat	25µ

		Initial	22 years	30 years
Non wipes	measured value	75.2	66.2	52.7
	retention %	-	88	70.1
Wipes	measured value	75.2	77.6	73.2
	retention %	-	103.2	97.3

A&I COATINGS

Real Life Situations

A&I COATINGS

Real Life Situations

FERRARI THEME PARK – Abu Dhabi

SPANDA – Perth W.Aus

A&I COATINGS

REAL LIFE SITUATIONS

SKYDANCE BRIDGE, OKLAHOMA – USA

A&I COATINGS

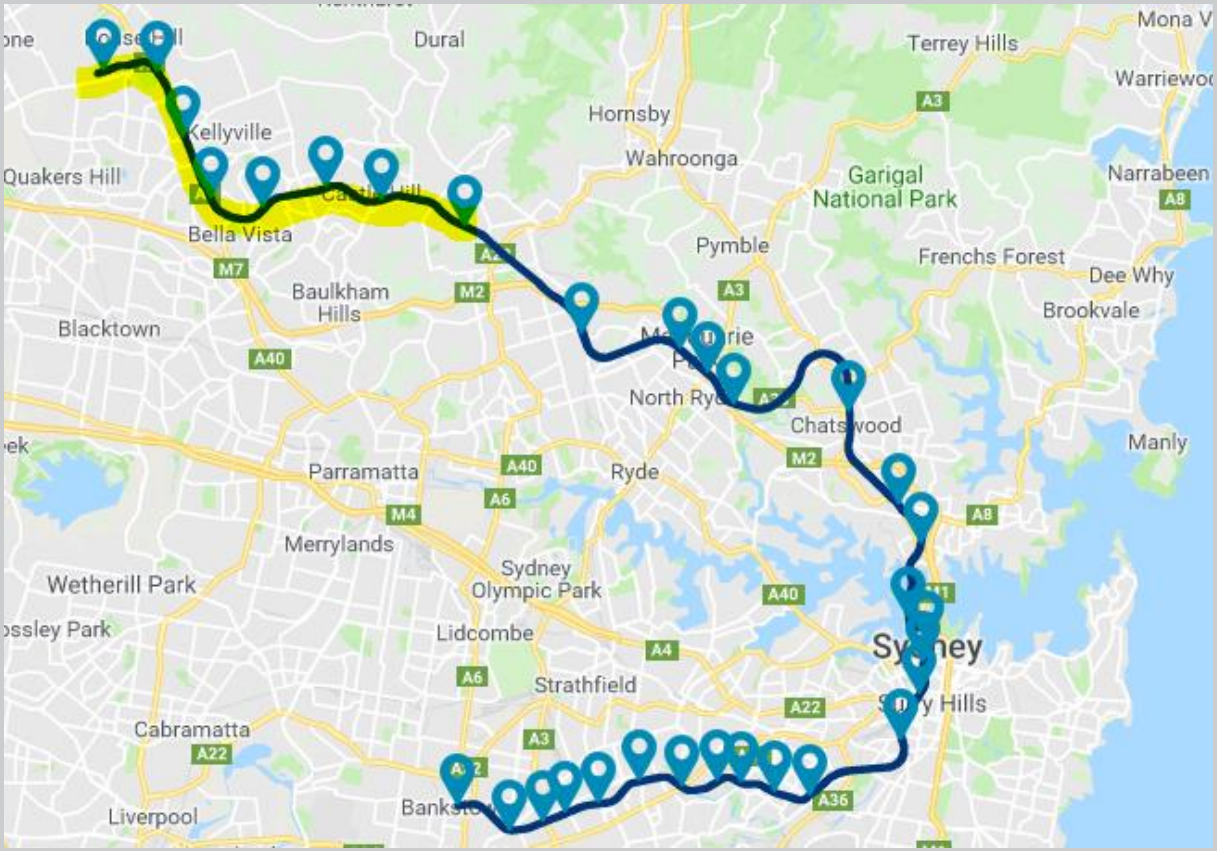
REAL LIFE SITUATIONS

WATER STORAGE TANK – WEST COAST USA

MERCEDES-BENZ - STUTTGART

A&I COATINGS

Live Project – Sydney Metro



Northwest Rapid Transit - Consortium

CPB CONTRACTORS

JOHN HOLLAND

MTR caring for life's journeys

UGL

Plenary

A&I COATINGS

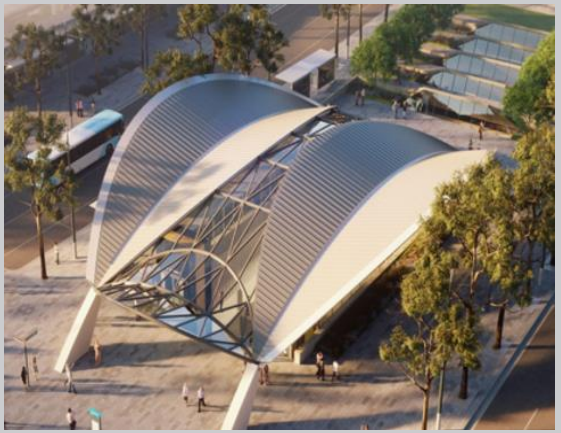
Live Project – Sydney Metro

- Building **eight** new railway stations and 4,000 commuter car parking spaces
- Delivering Sydney's new generation of metro trains
- Building and operating the Sydney Metro Trains Facility, including train stabling and maintenance
- Installing 23 kilometres of new track and rail systems
- Converting the existing 13 kilometres of railway between Epping and Chatswood to metro status
- Operating and maintaining Sydney Metro Northwest for 15 years.

A&I COATINGS

Live Project – Sydney Metro

Each station canopy is a unique structure designed to reflect the shape of a gum leaf.



For such iconic structures it was a key requirement for the asset owners that the coating system specified provided the best colour stability and the longest time to first maintenance.

A&I COATINGS

Live Project – Sydney Metro

KEY FIGURES

- 2 product paint system Vitrezinc 586 and Vitreflon 790
- Over 100,000 square metres of steel substrate protected
- Steel fabrication and painting was carried out in New South Wales, Victoria, South Australia and Western Australia.

A&I COATINGS

Live Project – Sydney Metro

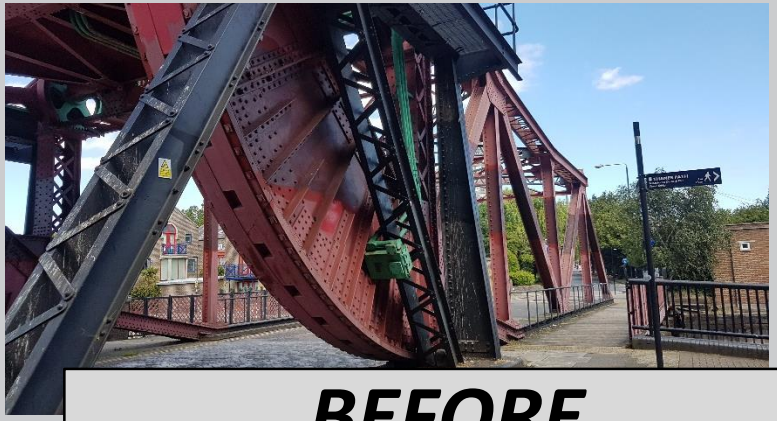
CLIENT FEEDBACK

Stakeholders involved in the paint specification and application consistently provided the following feedback:

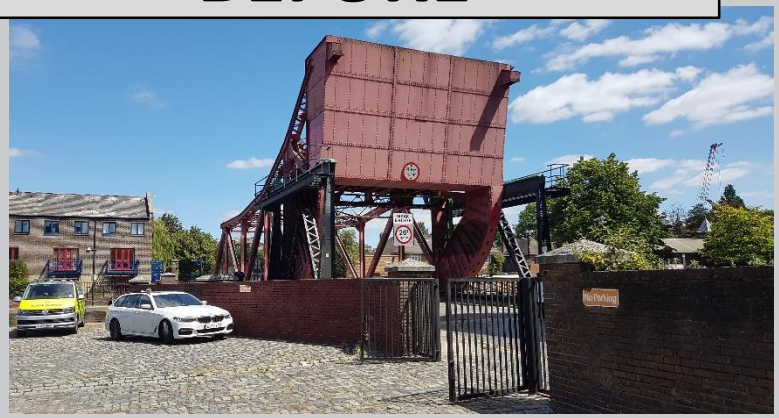
- The coating system was user friendly
- Cure speeds and application properties were suitable across all seasons (+40°c in summer and down to 0°c in winter)
- Finish achieved was a smooth satin finish as desired by the architect (Hassell).
- Site touch up was straightforward, both products brush and roll easily.

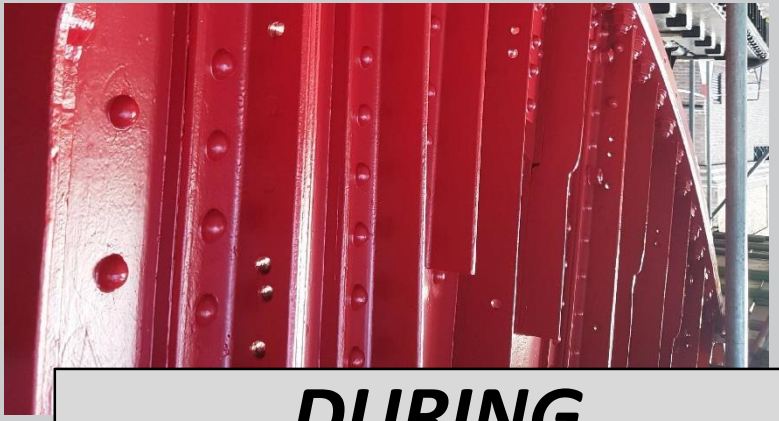
A&I COATINGS

Live Project – Tower Hamlets

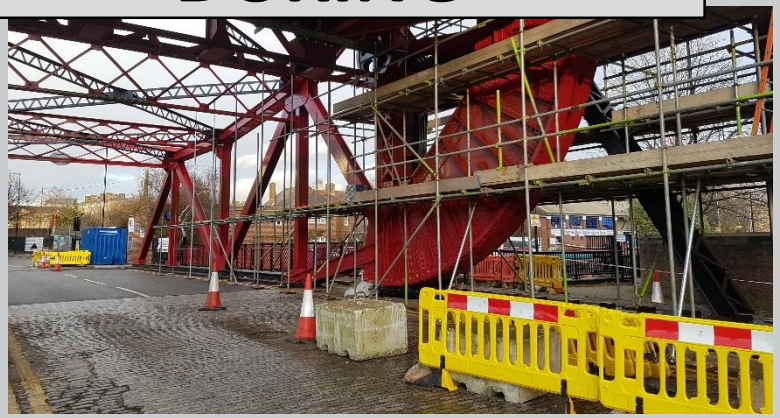


BEFORE





DURING



A&I COATINGS

Live Project – Chenab Bridge

Used on many bridges round the world. Currently specified for Chenab Bridge, India - the world's tallest railway arch bridge..

A&I COATINGS

Live Projects

Vitreflon 790 is being used on a number of key government projects following Sydney Metro North West inc.

- Capital Metro Canberra (Rail infrastructure)
- Sydney Light Rail
- Melbourne Convention Centre
- 12 Live UK bridge projects

A&I COATINGS

Durability/Life-cycle cost

THE COST OF MAINTENANCE

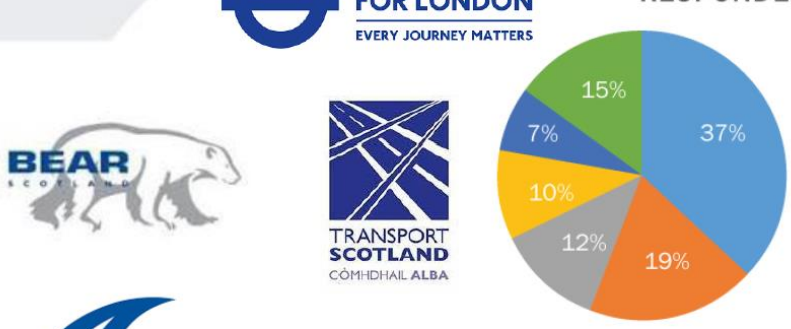
PAINT IS THE SMALLEST ELEMENT

A&I COATINGS

Durability/Life-cycle cost

Industry Consultation Courtesy of the SCI Steel Bridges Group

Survey Respondents



CASS HAYWARD CONSULTING ENGINEERS

highways england

NetworkRail

M6toll A better way around

wsp

TRANSPORT FOR LONDON EVERY JOURNEY MATTERS

Glasgow CITY COUNCIL

PERTH & KINROSS COUNCIL

BEAR SCOTLAND

TRANSPORT SCOTLAND CÒMHDHAIL ALBA

BOF Bridge Owners' Forum

SOUTHAMPTON CITY COUNCIL

one+ Integrated Highway Services

Connect Plus Services

Connect roads

Cyngor sir ddinbych denbighshire County Council

Fife COUNCIL

STEEL BRIDGE GROUP

Devon County Council

ScotlandTranServ A Balfour Beatty Mouchel Joint Venture

hewson consulting engineers

A&I COATINGS

Durability/Life-cycle cost

Industry Consultation Courtesy of the SCI Steel Bridges Group

Key issues experienced in the past 5 years

90% choose ‘Deterioration of corrosion protection systems’

Highest annual cost element for bridge maintenance

Maintenance Painting

A&I COATINGS

Durability/Life-cycle cost

Summary of Bridge Painting Costs:

- Feasibility and Project Evaluation
- Consultation
- Site and Structure Surveys
- Financials
- Legals and Risks
- Environmental, Ecological
- Tendering procedures
- Contractors Preliminaries
- Enabling Works
- Contract Administration
- Traffic Management – Highways and Rail
- Difficult Access
- Surface Preparation
- Waste Disposal
- Paint application

Paint

- Zinc Rich Primer 75µ d.f.t.
- Epoxy MIO Build Coat 200µ d.f.t.
- **FEVE Topcoat 75µ d.f.t.**

(FEVE IS THE ONLY VARIABLE)

A&I COATINGS

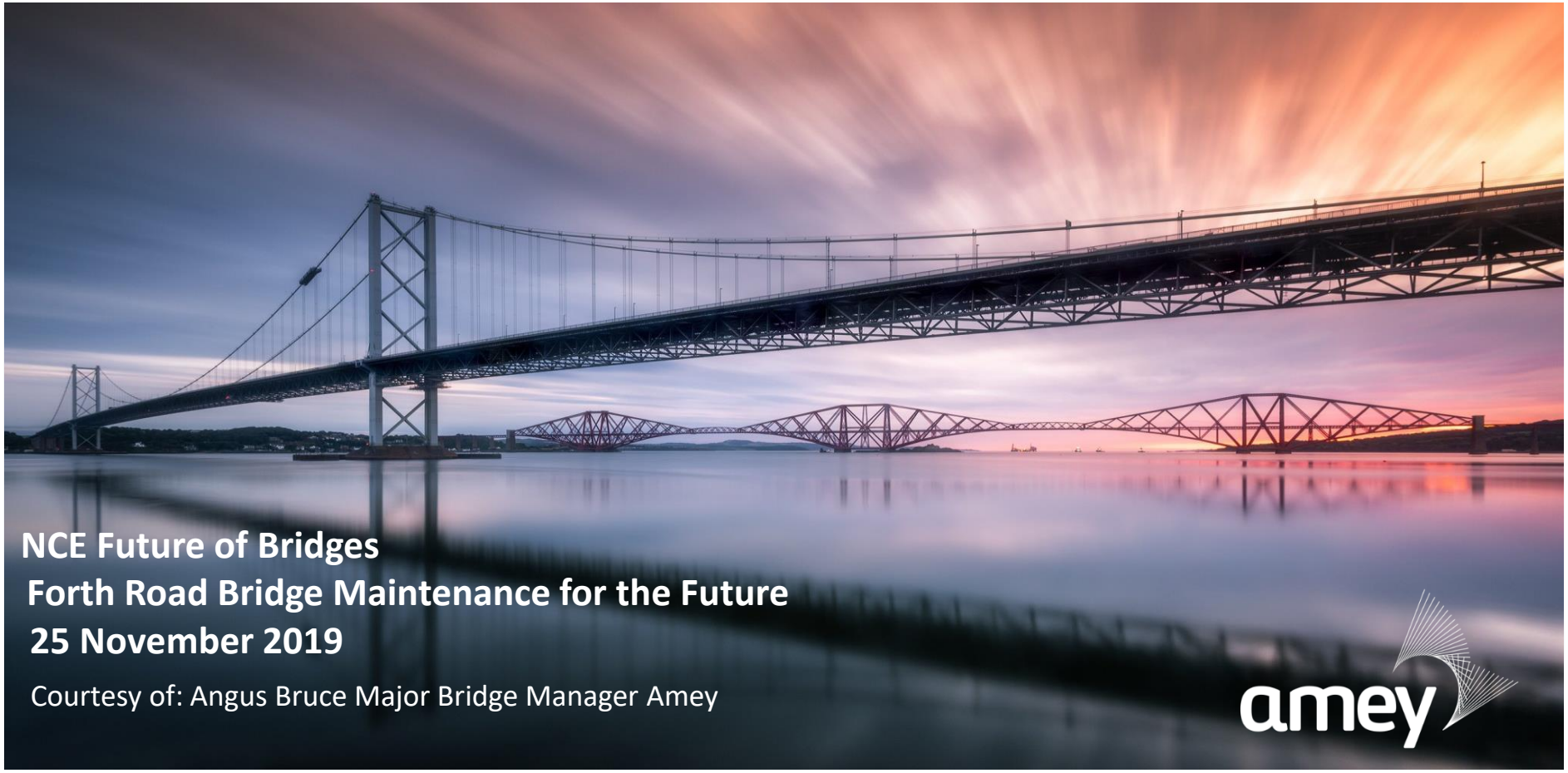
Durability/Life-cycle cost

Forth Road Bridge Repaint 350,000m² of steel. Provisional cost of up to £100M. 7-8 Yrs Duration.	**Polyurethane System 50µ topcoat (168)**	**FEVE Fluoropolymer System 75µ topcoat (195)**
Total Contract Repainting Cost £/m²	£285.71 (£1.00/m² for 50µ Paint)	£288.31 (3.60/m² for 75µ Paint)
Estimated Coating Life	25 years	60 years
Total Paint Maintenance Life-Cycle cost of the structure £/m²/Year	£11.43	£4.80
Cost Index	100	42 (58% Saving)

- *Increase total project cost by less than 1%*
- *Enjoy Life cycle cost saving by 58%*
- *Reduce Carbon Footprint*

A&I COATINGS

Live Project – Forth Rd Bridge



A&I COATINGS

Live Project – Forth Rd Bridge

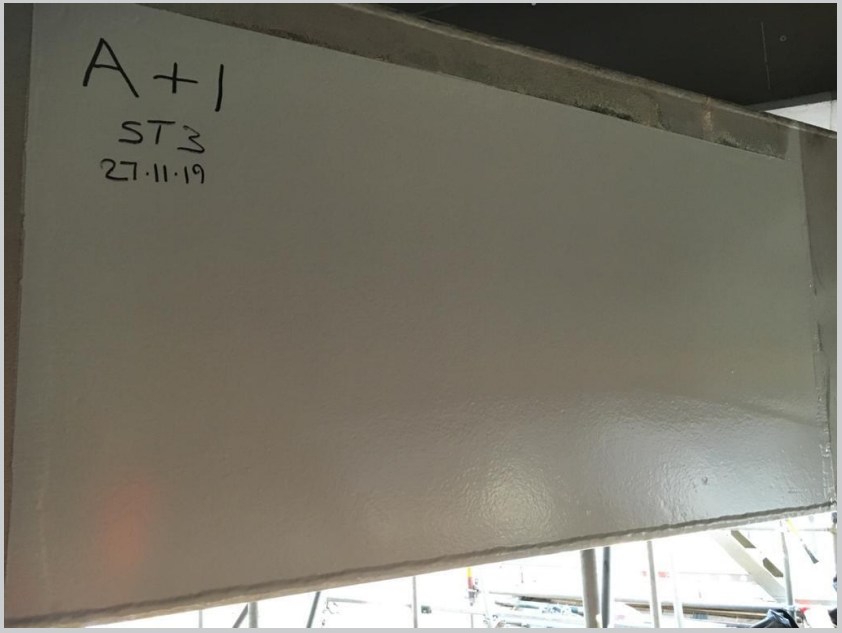
Courtesy of: Angus Bruce Major Bridge Manager Amey

- Largest Major Contract being planned for the bridge.
- Include painting of all underdeck steelwork 350K m^2 of paintwork.
- Will include strengthening to support steelwork, being calculated as part of the CEP.
- Trial of access systems to be considered. Looking at purchasing access platforms currently being used on the Queensferry Crossing.
- Estimated cost for works £75M - £100M, 7-8 year duration.
- Trialling new paint systems, Fluro-polymer paints, developed in Japan with a possible design life of 60 years.

A&I COATINGS

Live Project – Forth Rd Bridge

SA2½ Surface Preparation



ST3 Surface Preparation

A&I COATINGS

Conclusion

FEVE

- Extreme outdoor durability
- Very effective corrosion protection
- Over 30 years of application history
- Mandatory use of FEVE for bridges in Japan
- Mentioned in latest ISO 12944 standard
- 60 years or more expected life time for bridge coatings

THANK YOU

A&I COATINGS

- A & I Coatings (UK) are currently engaged with SOCOTEC and the British Board of Agrément to secure HAPAS approvals by July 2020.
- System 5000 Maintenance Work: HE115; HE116; HE195
- System 1900 New Work: HE109; HE112; HE195
- Additional testing to secure Network Rail approvals is underway, although Network Rail approvals are under revision

Environmental Responsibility

Why paint every 20 Years…

When you could paint every 60 years

A&I COATINGS