SPS Bridge Decks for New Bridges & Rehabilitating Existing Bridges

Smart

Fast

Economic

Lighter Structures

Shorter Schedules

Intelligent Engineering

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Contents

- **Introduction**
- SPS Bridge Decks
- Engineering & Testing
- Typical Bridge Projects

SPS Team

Intelligent Engineering

- Owner of SPS technology
- Responsible for commercialising SPS via local partners
- Support design and approval of SPS structures
- Incorporated in 1996
- Offices in Europe, North America, Singapore & Middle East
- Global delivery and partner support teams

BASF - Elastogran

- Supply SPS polyurethane
- World's largest chemical company
- Leading developers of polyurethane technologies
- Dedicated team supports development and testing of SPS
- Regional offices to support chemical processes

SPS : Sandwich Plate System

Structural Composite

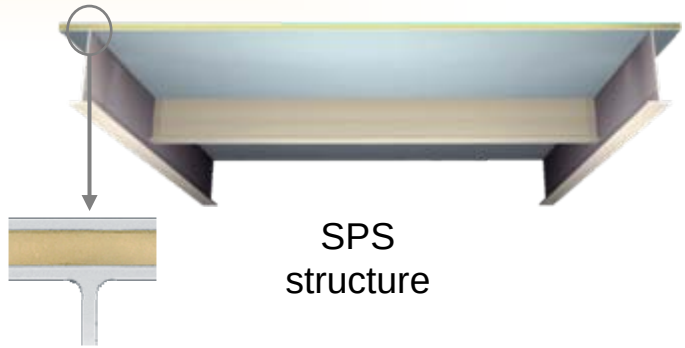
- Alternative to concrete & stiffened steel
  Applications in civil & maritime structures

Key Benefits for Construction

- Lightweight
- Fast erection – Shorter schedules
- Maximizes offsite construction
- Minimizes logistics & risks
- Easy to demount and reuse

History

- Developed in 1993
- Over 200 projects & 200,000m^2 in service
- Used in 30 countries
- Ships, oil-rigs, bridges, stadium & buildings
- Approved by major global regulators



SPS
structure

Conventional stiffened
steel structure

Conventional concrete-
steel composite structure

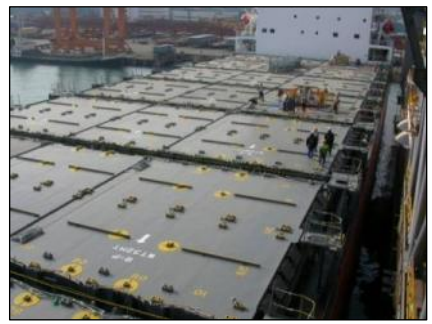
SPS Applications and Benefits

Construction and Civil Engineering

- Bridges, stadia, flooring systems, blast protection
- Controls fatigue and vibration
- 75% lighter than concrete
- Accurate factory fabricated panels
- Reduces wet-work on site and weather delays
- De-risks and accelerates schedule

Shipbuilding

- Any component of ships or offshore structures
- Simplified more robust structures
- 40% less labour, 50% less welding, 20% less coating
- Superior performance & reduced maintenance



Strengthening and Reinstatement

- Ship structures and bridge decks
- Permanent, better than new structure
- Very fast process - minimises disruption

16 Years of Development, Testing & Certification

Over 12,000 tests completed

Material Characterisation

- Mechanical properties, thermal properties, physical characteristics, production

Composite Performance

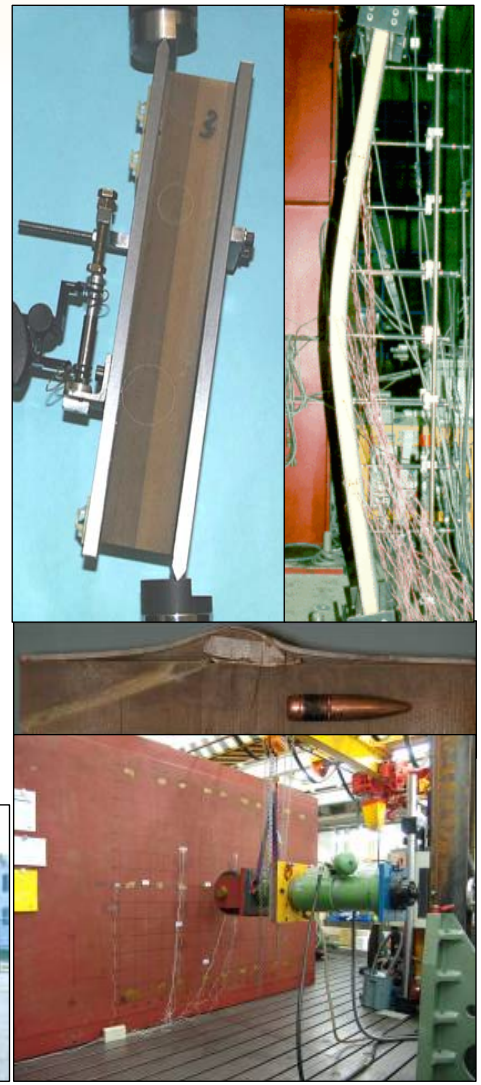
- Bond test programs (performance & longevity)
- Limit state performance at full-scale
- Fire and toxicity tests (SOLAS, BRE, UL)

Speciality and Application Specific Testing

- Blast, ballistic, high energy impacts, dynamics, acoustics, low temperature

University & Research Institute Tests

- USA, Canada, UK, Germany, Netherlands, China



Approvals

Field	Application	Approval	Body
Civil	Bridge Decks	• New bridge decks • Replacement decks • Deck reinstatement	Berliner Verkehrsbetriebe City of Edmonton, Alberta Ministère du Transports Québec Nordrein Westfalen Port Hope Municipality Texas DoT UK Highways Agency
	Terraces and Floors	Product certification to national building codes	BRE Global New York City OTCR US International Code Council
		Fire resistance rating	BRE Global - Europe Underwriters Laboratory - US
		Project approvals	Arup, Buro Hapold, WSP
Maritime	All	PU materials approval	ABS, BV, CCS, DNV, GL, KR, LR, NKK, RMRS
	Ship structures	Rules for construction	CCS, LR (issued) ABS, BV, DNV, GL in progress
	Various: ship and offshore	Project approvals (185 since 1999)	ABS, BV, CCS, CRS, DNV, GL, IRS, KR, LR, NKK, RINA, RMRS, TC, USCG

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Prefabricated SPS Bridge Decks

New or replacement bridge decks

- Simple flat structural plates
- Bolted to supporting girders & stringers
- All bolted construction - no field welding
- Weathering or standard steel

- Up to 70% lighter than concrete decks
- Work compositely with superstructure
- Uses conventional wearing surfaces

- Simple design
- Single trade for deck & superstructure
- High quality factory production
- Fast installation with immediate capacity
- No delays from concrete curing

- Short, medium & long span bridges as well as movable & pedestrian

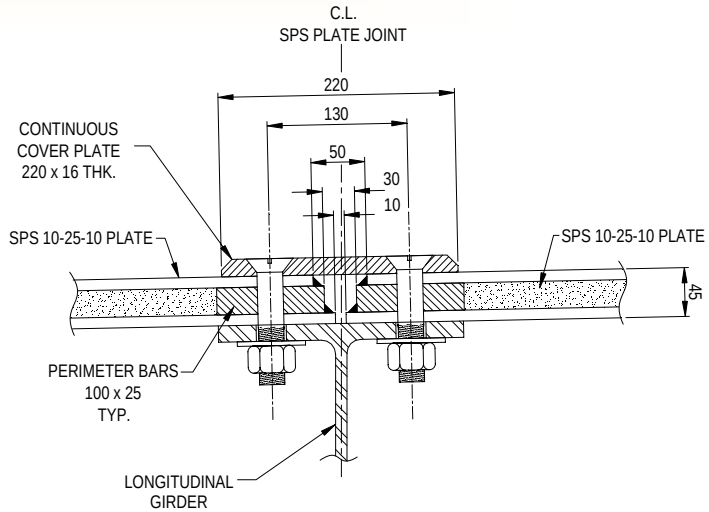
Benefits

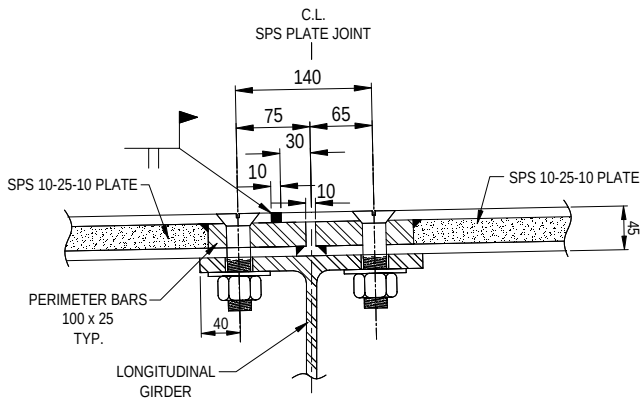
- Fewer and lighter girders
- Longer spans
- Fewer piers, pile sizes and pile caps
- Faster erection and lighter equipment
- Reduced total bridge cost
- Lower through life costs
- Natural long life

Prefabricated SPS Bridge Decks

Connection to girders or stringers

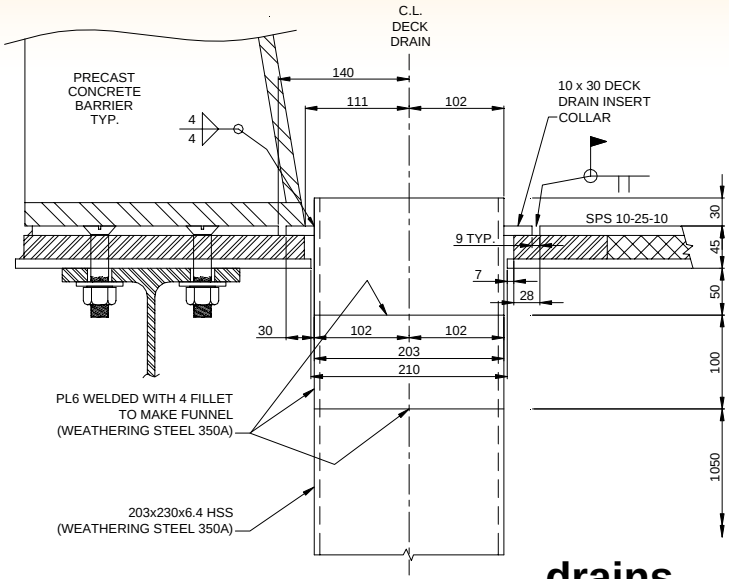
- SPS Bridge Decks bolted direct to top flange of girder or stringer
- Decks work compositely with superstructure (in tension & compression)
- Upper splice plate provides continuous action
- Bolted connections have fatigue category B
- All bolting through sealed perimeter bars
- Factory welds not fatigue critical as supported by flange and transverse load taken by bolts
- Crowns, super-elevations, cross-fall, skew and vertical or horizontal curves are readily accommodated



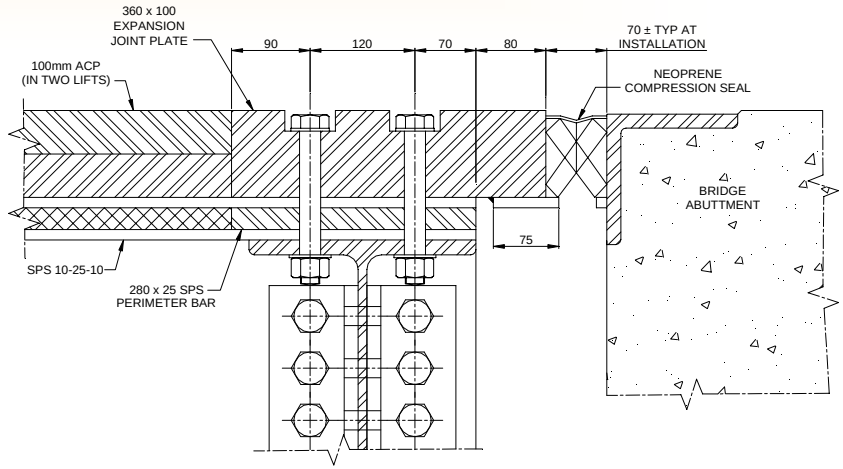


Prefabricated SPS Bridge Decks

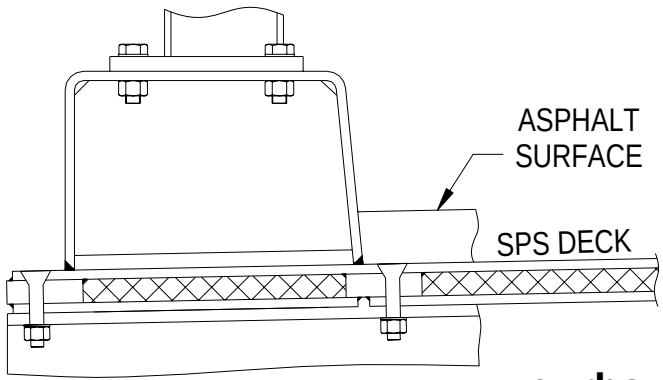
Pre-engineered details



drains



expansion joints

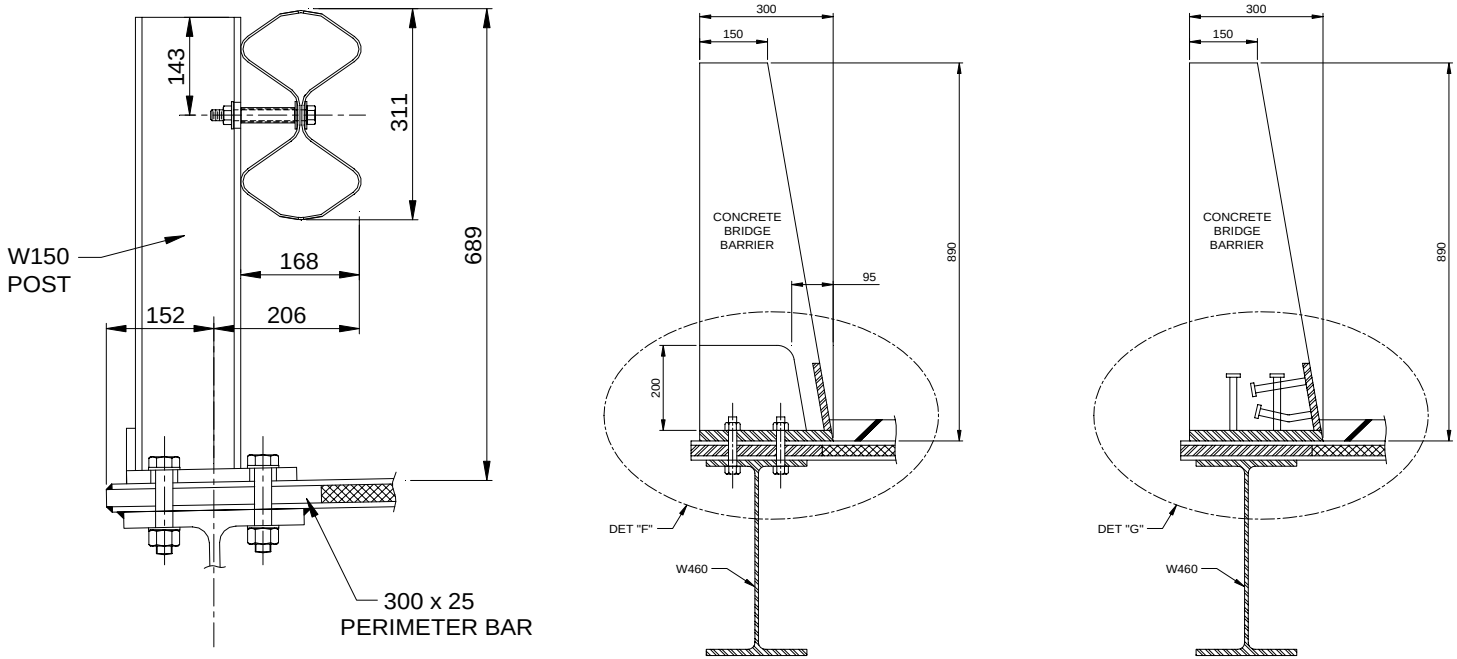


curbs

Connections for details incorporated in prefabrication

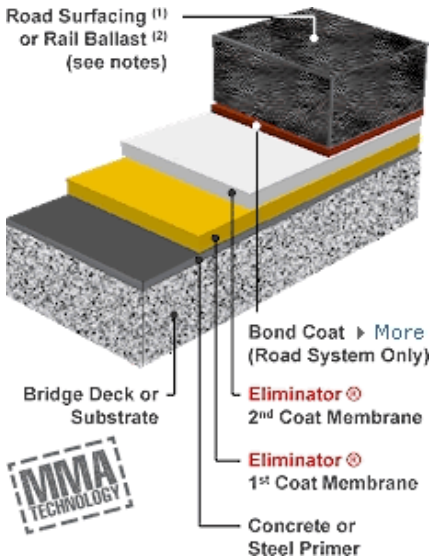
Prefabricated SPS Bridge Decks
Barrier options

- Crash barrier connections: Meet CHBDC: performance level 2 and NCHRP 350 test level 4 (Posts bolted to the edge or centre of the SPS deck)
- Attached through girder or edge section supported by discrete cantilever
- All typical bridge attachments possible, such as crash barriers, signs and lamps
- Attached using industry standard steel connection techniques



Prefabricated SPS Bridge Decks

Coatings & wearing surfaces



Thick or thin wearing surface options:

- Asphalt + Stirling Lloyd membrane
- Thin wearing surface – polyurethane + bauxite grit (RSClare Bimagrip 6mm thick, 2kg/m^2, 2hr cure)

- Increased life due to reduced curvatures
- Easy repair and replacement as required

Prefabricated SPS Bridge Decks
Fabrication

- Parametric CAD modules
- Dedicated production line
- Fast efficient CNC manufacturing
- Excellent dimensional control
- Maximum use of factory integrated details

Prefabricated SPS Bridge Decks

Erection / installation

Bridge Erection

1. Erect bridge girders
2. Locate SPS Bridge Decks
3. Bolt deck plates to girders
4. Erect barriers and signage
5. Complete coatings

- Fast erection schedules
- Light equipment required
- Single trade erection
- Simple attachment details
- Bridge open 2 hours after last coating applied

SPS Overlay for Bridge Decks

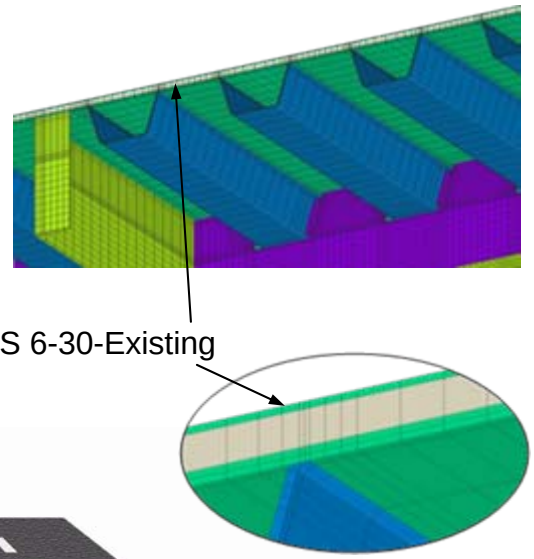
Strengthening & reinstatement of orthotropic bridge decks

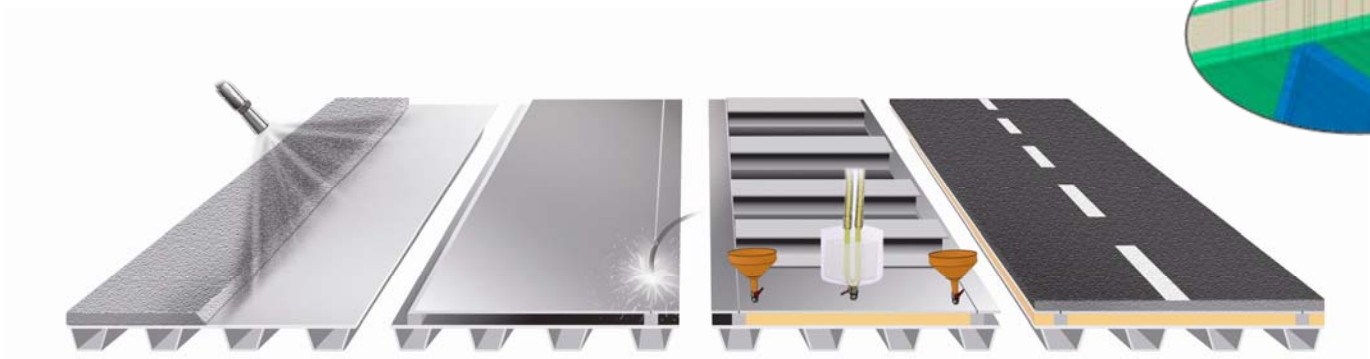
- Orthotropic deck strengthening without removal and with limited traffic disruption
- Weight and thickness neutral

- New steel plates applied above existing deck using SPS Overlay composite
- Fast process with only partial bridge closure required
- Asphalt thickness reduced

- Reduces fatigue stresses in orthotropic bridge decks
- Increases distribution of wheel loads across stiffeners

- Increases service life of bridge deck
- Increases service life of wearing surface





SPS Overlay for Bridge Decks

Strengthening & reinstatement of orthotropic bridge decks

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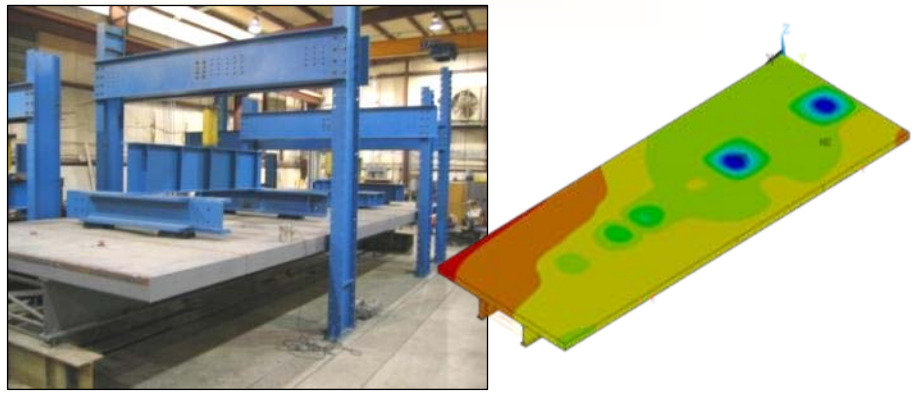
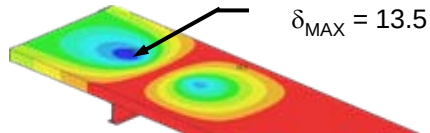
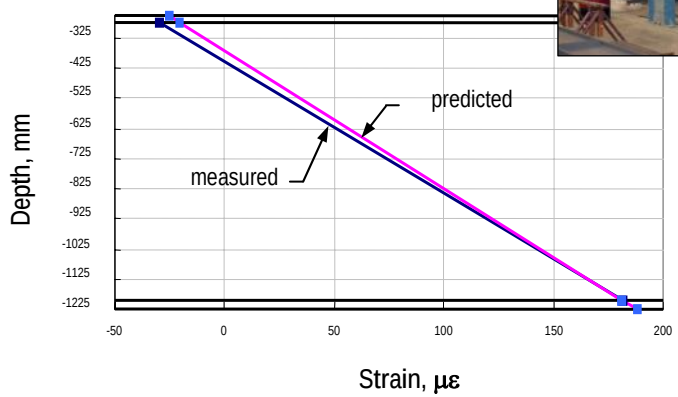
Prefabricated SPS Bridge Decks

Static performance

- Overall deflections are small (60% less than 1mm)
- Local deflections at CHBDC serviceability load are L/331
- Tests show composite action is achieved (deflections 2.9x lower)
- Field tests show close correlation to predicted results
- No plastification of SPS at test with 118 tonne load from lab actuator



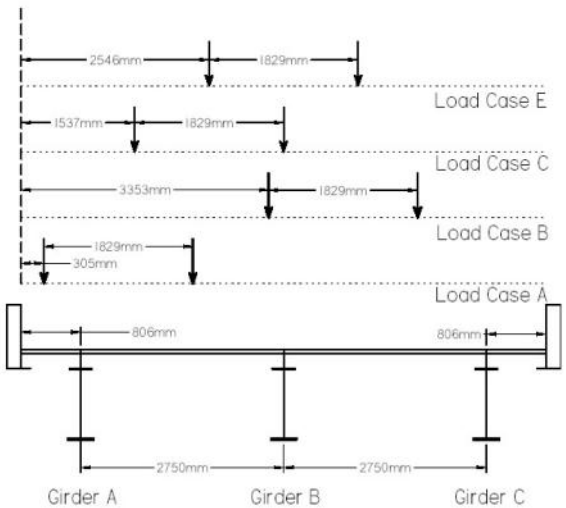




Prefabricated SPS Bridge Decks

Load distribution & dynamic load allowance

- SPS Bridge Decks are stiff and distribute loads across structure well
- Standard specified lateral load distribution factors for a concrete deck on steel girders are conservative for SPS Bridge Decks for exterior and interior girders
- AASHTO dynamic load allowance of 33% and CHBDC value of 30% are conservative for SPS Bridge Decks
- When the tires are not above a girder, 40% DLA is recommended



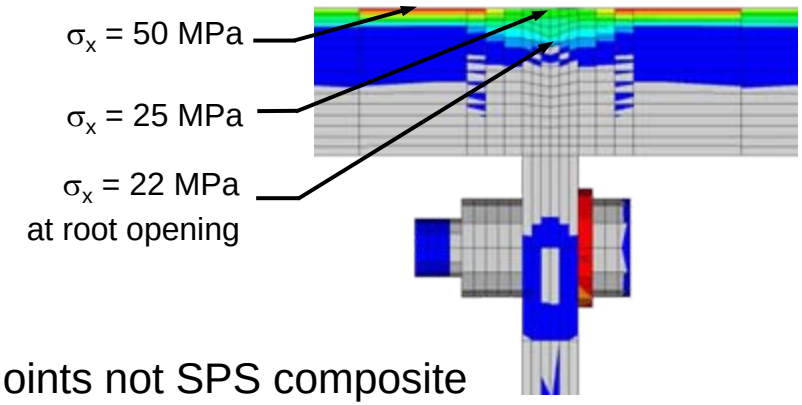
Tests confirm distribution

Girder	Load Case	Test Results		Specified for concrete slab on steel girders				Very stiff deck
		DF_{Δ}	DF_{ε}	Standard	LRFD	Lever Rule	CHBDC	
Exterior	A	0.654	0.676	0.814	0.849	0.849	0.772	0.758
Interior	E	0.380	0.427	0.644	0.668	0.668	0.638	0.333
Exterior	A+B	0.850	0.894	0.885	0.885	0.885	0.810	0.925
Interior	A+B	0.688	0.676	0.820	0.819	0.819	0.823	0.666

Response	Load Case B (Grd. C)		Load Case C (Grd. A)		Load Case E (Grd. B)	
	Average %	Coef. of variation	Average %	Coef. of variation	Average %	Coef. of variation
Δ	**12**	0.3	**26**	0.2	**42**	0.5
ε	**6**	0.6	**24**	0.4	**32**	0.6

Prefabricated SPS Bridge Decks

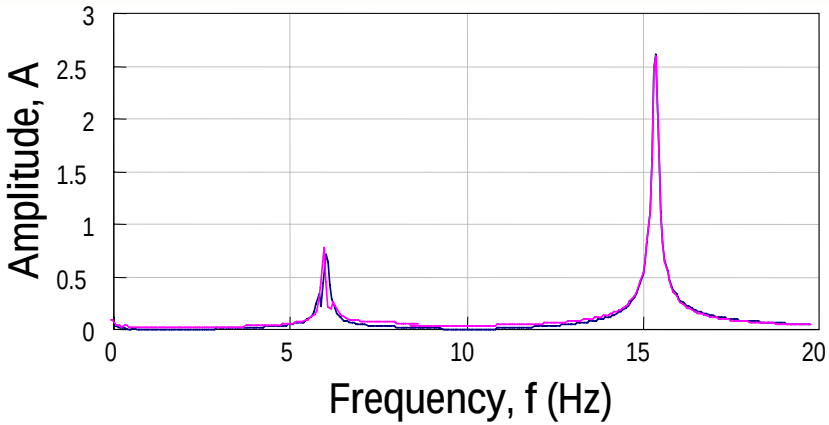
Fatigue performance

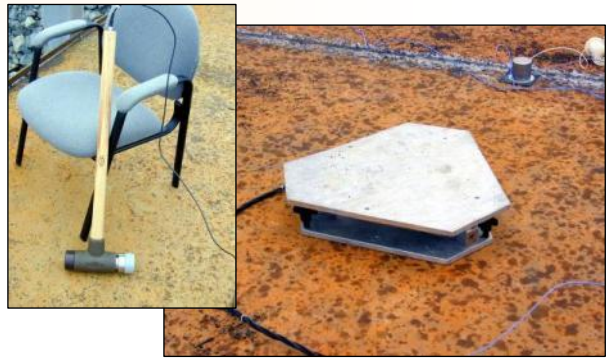


- Fatigue performance of SPS governed by joints not SPS composite
- Fatigue class of the SPS bridge deck joints established by fatigue tests
- Stress ranges conducted for FLS design cases and higher stress ranges
- Joints tested to a minimum of 10 million cycles

Prefabricated SPS Bridge Decks

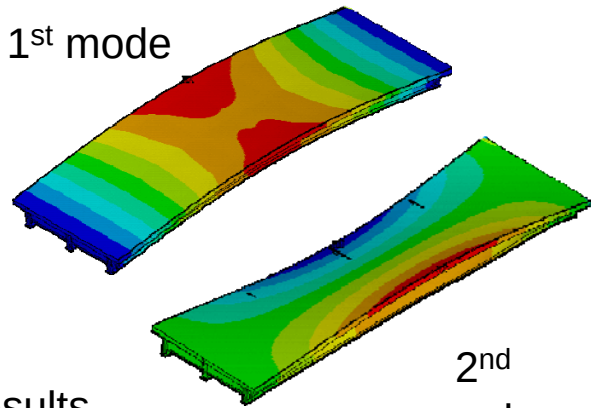
Vibration characteristics





modal hammer and force plate

Vibration Mode	Natural Frequency, Hz		Test/Predicted Ratio
	Measured	Predicted	
1	5.8	5.7	0.98
2	6.0	5.9	0.98
3	15.3	11.6	0.76

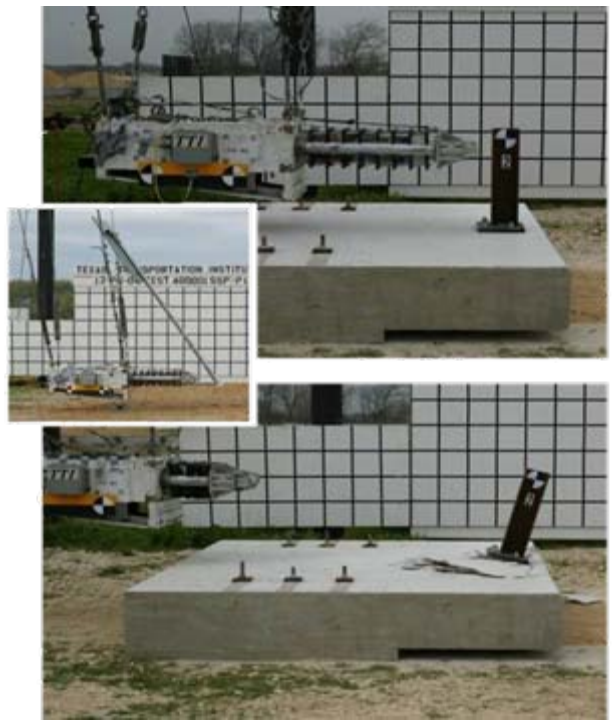


- Close correlation between measured and predicted results
- Natural frequency of bridge deck panels meet design codes
- Elastomer dampens vibrations and reduces structural borne noise

Prefabricated SPS Bridge Decks
Crash barrier performance

- Posts bolted to steel brackets on SPS Bridge Decks
- Stiffeners below SPS for local strengthening (if not connected to beam flanges)
- Pendulum tests by Texas Transportation Institute (TTI)
- Crash barriers on SPS achieve TL4 performance level
- SPS deck undamaged

Crash barrier bolted to SPS Bridge Deck

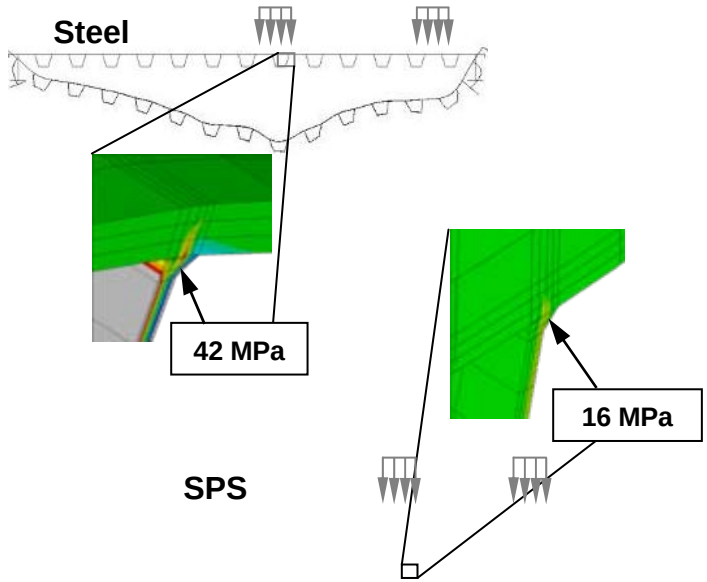


SPS Overlay for Bridge Decks

Testing, verification and approvals

RWTH AACHEN UNIVERSITY

- Full scale pilots, lab testing, FEA analysis
- Static, dynamic, fatigue and ultimate load tests
- Field installations verifie quality control, durability, robustness



- reduced critical stresses
- increased fatigue life

SPS Bridge Decks
Design rules

- Guidelines for the design of SPS Bridge Decks (specs v. girder spacing)
- Designed to satisfy fatigue, serviceability and ultimate limit states
- Direct calculation of deflection of SPS plate under a single wheel load including transverse shear deformation through the core
- Design tables for welded and bolted splice connections between plates
- Connection details for crash barriers, drains, expansion joints
- Available for US, Canadian & UK codes

SPS Plate/ Girder Combination	Spacing Range mm	Longitudinal Girder				SPS	
		Spacing mm	Min Flange Thickness, mm	b/t ratio	Class[2]	Thickness, mm	Weight[1], kg/m[2]
1	$s \leq 2200$	1800	16	9.4	3	8-30-8	190
2		2000					188
3		2200					186
4	$2200 \leq s \leq 2400$	2200	16	9.4	3	10-25-10	207
5		2400					206
6	$2400 < s \leq 2800$	2600	16	9.4	3	10-30-10	214
7		2800					213
8	$2800 < s \leq 3000$	2600	25	7.5	1	12-25-12	236
9		2800					235
10		3000					234

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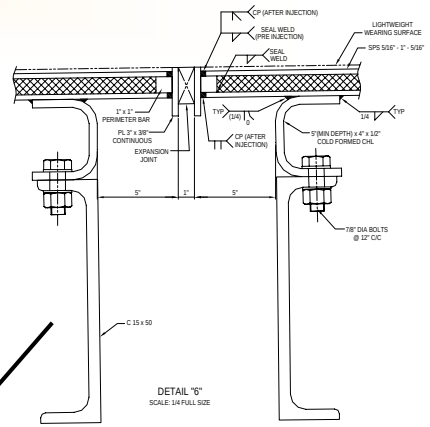
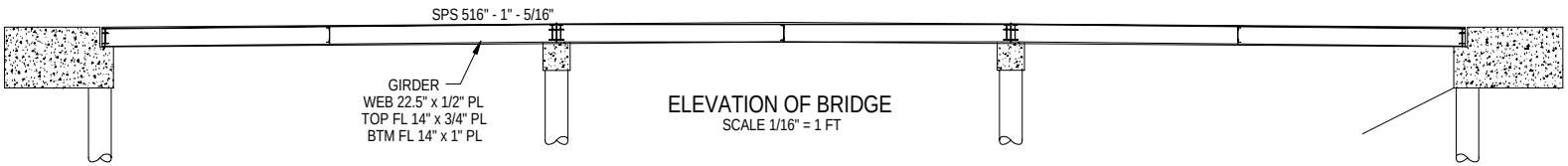
Bridge Projects

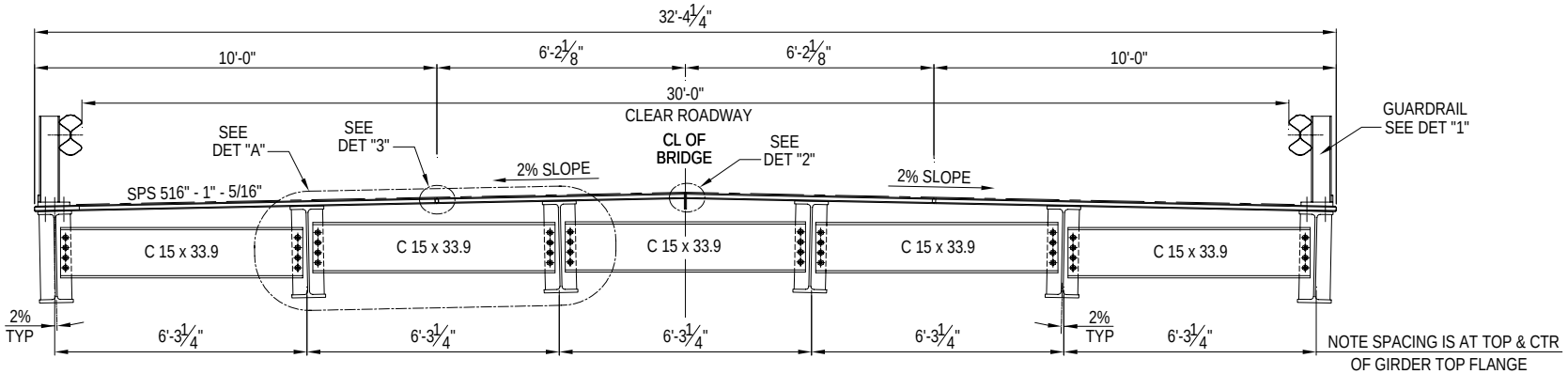
Cedar Creek - IBRC with Texas DoT

- Replace girders and deck with new construction
- SPS Deck with integrated longitudinal girders (composite action)

- 2-Lane undivided rural road
- Clear roadway is 30’
- Three 50’ spans with expansion joints







Bridge Projects

Cedar Creek - IBRC with Texas DoT

Bridge Projects
Dawson Bridge

- 5 span truss bridge (43-43-43-76-30m)
- Transverse floor beams are constant depth
- Roadway profile built up from longitudinal stringers supporting a reinforced concrete deck applied over a wood base
- Deck degraded must be replaced
- Concrete deck too heavy for existing truss structure
- Short summer close to complete replacement of deck and renovation of truss

Area	1,826m²
Date	Summer, 2010
Location	Edmonton, Canada
Owner	City of Edmonton
Engineer	Cohos Evamy
Contractor	Concreate


KING LIFTING
MANITOU


SIDEWALK
CLOSED

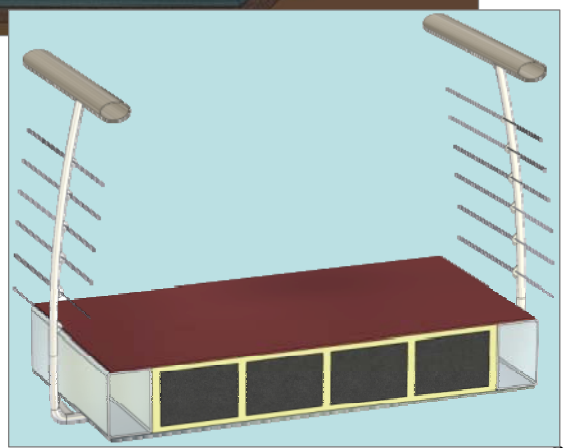
Bridge Projects

M6 Footbridges – UK Highways Agency

- Replacement of degraded existing precast concrete plank decks
- SPS 5-20-5 plates with stainless steel AISI 304L faceplates
- SPS: 115 kg/m^2 (concrete: 300 kg/m^2)
- SPS plates are supported on existing concrete girders and abutments
- RHS on underside of SPS plates to match the existing elevations
- Thin Bimagrip wearing surface
- Designed to British Standards.
- Installation for 2 bridges completed in single night closure of freeway

Bridge Projects

SPS Pedestrian Bridge Scheme



- Lighter, simpler and more slender
- Single span pedestrian bridge
- 26m span, 1.5m wide, 164mm deep
- SPS 6-154C-6 deck with integral girders

- Lightweight – deck and girders 200kg/m^2 (approx 30% lighter than concrete)
- Low deflections and acceleration
- Quiet bridge
- Tough wearing surface

- Factory production delivers high quality and increased production efficiency
- Single lift erection & simple connections

- Improved build & through-life economics

Bridge Projects

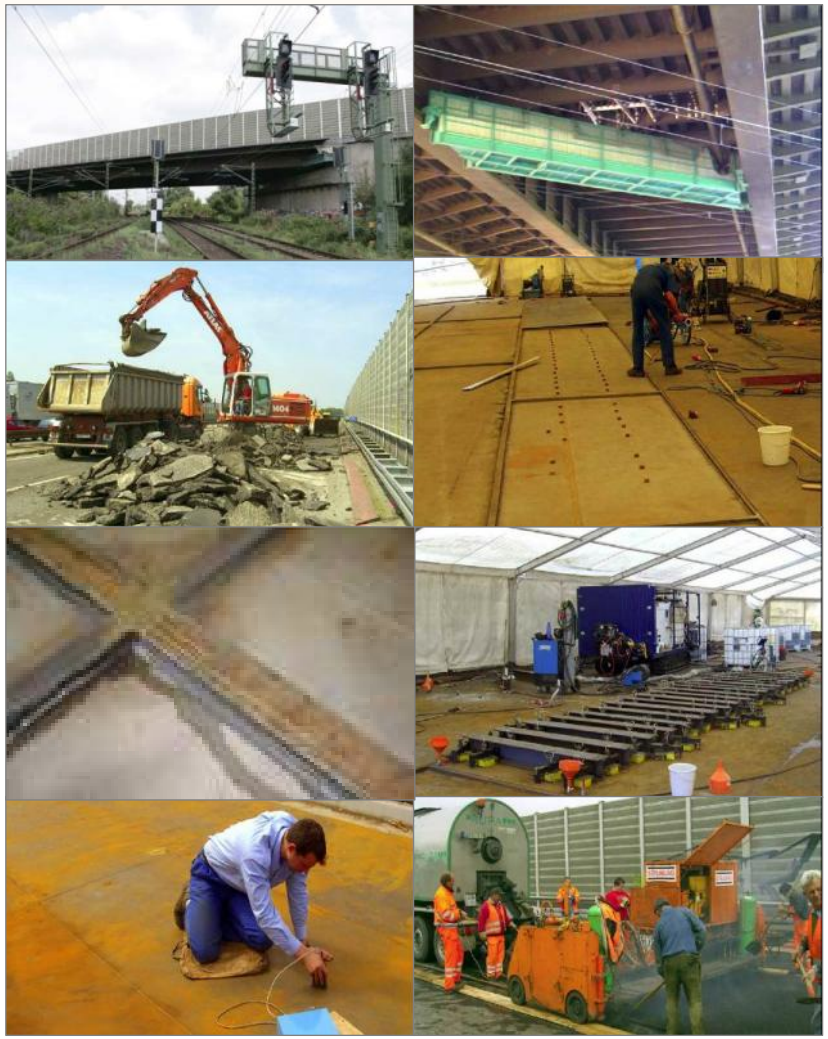
Deck strengthening - Krefeld Bridge - Germany

Existing Bridge

- 2 lane highway bridge
- Original steel orthotropic deck structure constructed in 1970's
- Up to 100,000 vehicles / day

SPS Overlay

- SPS 6-30-Existing Overlay applied across full bridge
- 800m^2 in 6 weeks
- 70m long by 11.5m wide
- 50 Cavities
- Fatigue life increased by 32 times

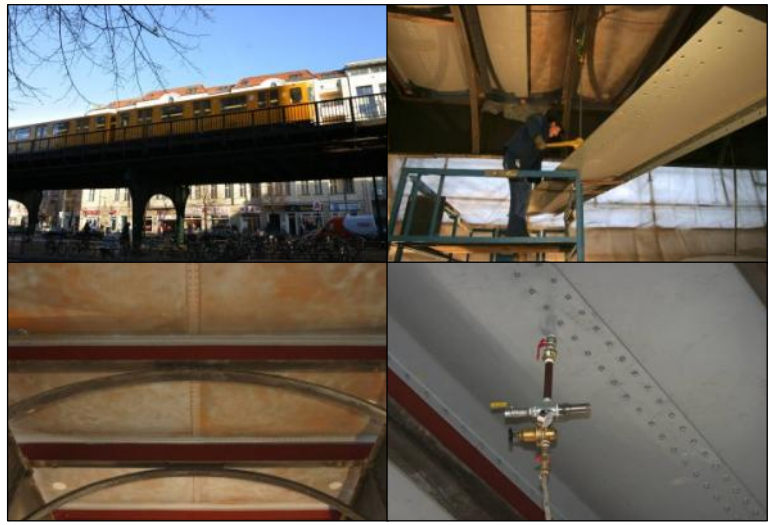


Bridge Projects

Deck strengthening from below - Berlin U-Bahn - Germany

Existing Bridge

- Curved ballast plates are thinned
- Fatigue cracks developing from above
- Riveted steel construction



SPS Solution

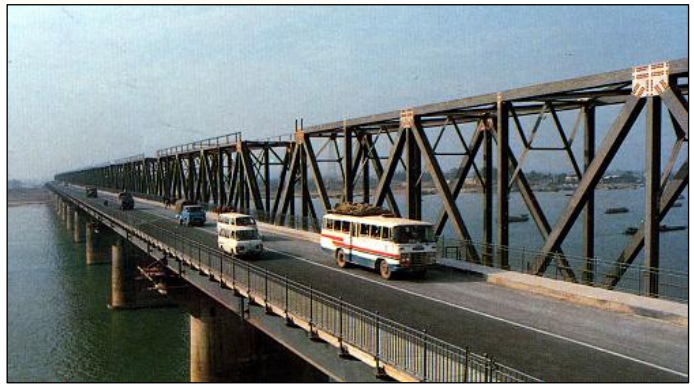
- Create SPS composite in-situ from below using existing deck plates as one faceplate
- Fast, simple and non-intrusive
- No downtime - No public inconvenience
- Retains historical look
- Quietens bridge: -3dB
- Fatigue life increased by 100 times

Bridge Projects

Deck strengthening - Mafang Bridge - China

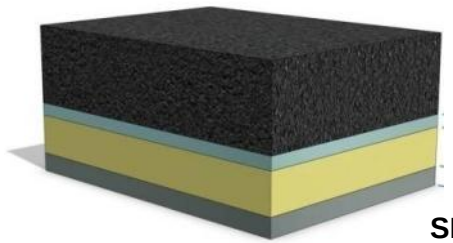
Existing Bridge

- Steel orthotropic bridge deck (1984)
- 14 – 64ft long spans, total length is 920ft
- 2 lanes, 9m wide



SPS Overlay

- 36 cavities, 510m^2
- 10 day project
- Traffic flow maintained at all times
- Load tests confirmed fatigue life extension



SPS 8-25-12

Bridge Projects

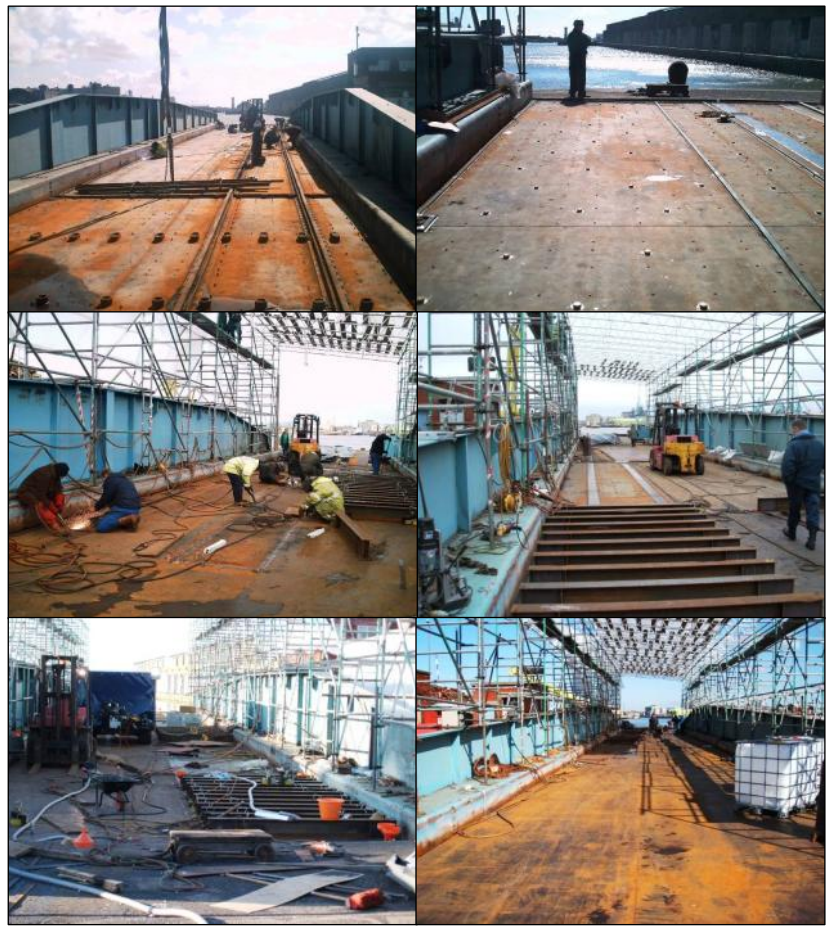
Deck strengthening - Huskisson Swing Bridge - UK

Existing Bridge

- 2 lane port swing bridge
- Original steel orthotropic deck
- Strengthening required to carry heavier excavators (85 tonnes)
- Only access to busy scrap depot

SPS Overlay

- SPS 6-25-Existing Overlay applied across full bridge
- 300m^2 in 9 days (1 day early)
- Asphalt wearing surface
- Selected over conventional steel and modern carbon fibre strengthening



SPS Bride Decks
Summary

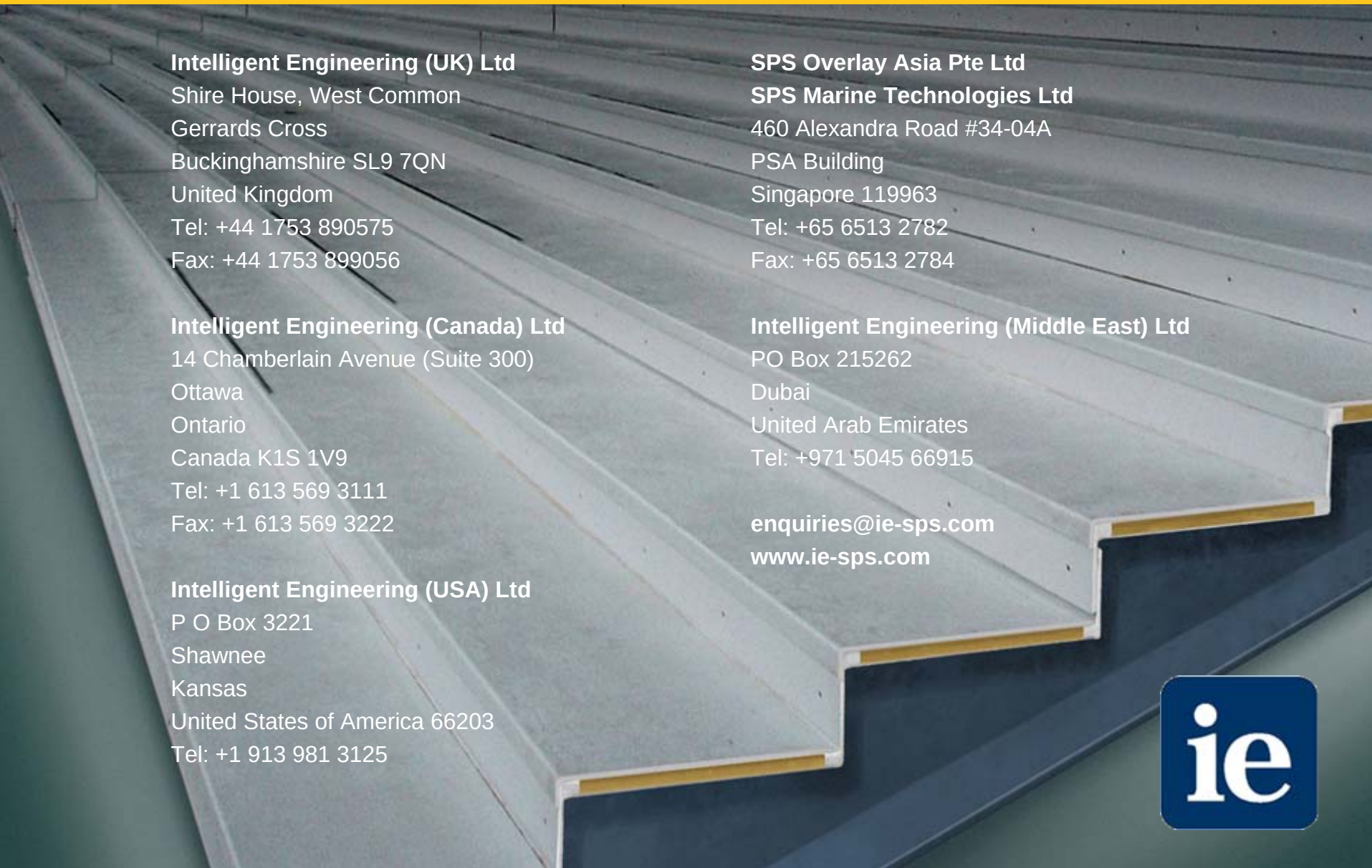
- Complete structural bridge deck solution for new or replacement decks as well as orthotropic deck strengthening
- Alternative concrete, grating and orthotropic decks

- Lighter deck
- Lighter superstructures and substructure
- Faster installation with less weather risk
- Options for complete bridge lifts and other alternate/accelerated build schemes

- Adaptable to different bridge types
- Easy to design with excellent dimensional control and quality
- Readily incorporated into current schemes and construction practices
- Proven, approved and tested solutions

- Ideal for bridge projects: demanding structures and schedules
  bridge deck renovations
  orthotropic deck strengthening and life extensions

SPS Bridge Decks



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