ChemCo Systems

A Subsidiary of American Polymers Corp.

www.chemcosystems.com

EPOXY ASPHALT CONCRETE

Proven Performance for
Long Span Bridges,
OGFC Pavements and
Strategic Roads

ChemCo Systems

Extraordinary Fatigue Resistance & Durability

World-Class

PROVEN DURABILITY





Handles Axle Overloads with No Rutting

Extended Lifespan with Little or No Oxidation or Embrittlement

High Skid Resistance for Decades

Corrosion Protection Without a Membrane

Sustainable: Polymer Content Based on Renewable, Bio-Sourced Raw Materials

PROVEN SAFETY


Taoyaomen Bridge


Fenghua Bridge


Runyang Suspension Bridge


Coronado Bridge


New Millennium Bridge

Maintains Skid Resistance Over Life of Pavement

100 kN Marshall Stability Provides Excellent Results in Extreme Temperatures

Outstanding Fatigue Resistance Performance

Installs Quickly with Standard Paving Equipment

Sustainable & Renewable for Today & Tomorrow

EPOXY ASPHALT

What is Epoxy Asphalt?

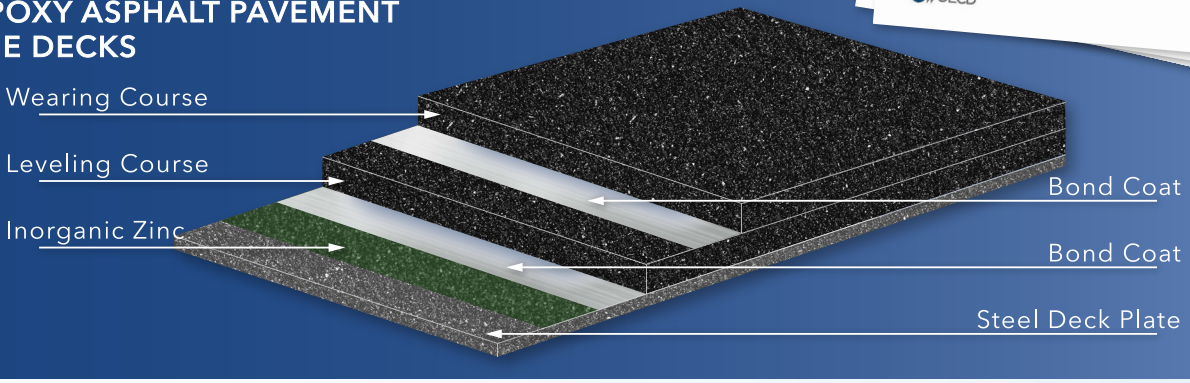
Epoxy Asphalt (EA) Concrete is a polymer concrete that is composed of a two-component reactive EA binder combined with standard asphalt concrete aggregates in the pug mill of an asphalt hot mix plant. Depending upon the application, an EA mix design can incorporate dense, SMA (Stone Matrix Asphalt) or OGFC (Open Graded Friction Course) aggregate gradations.

Upon cure, the binder transitions to two phases: a continuous phase is a mild acid cured three dimensional, highly flexible epoxy polymer and the discontinuous phase is a mixture of asphaltic materials. It is a thermoset polymer, meaning it will not melt. This binder, combined with high quality standard asphalt paving aggregates, forms a tough polymer concrete called EA Concrete.

EA Concrete has a 60 year history of successful application as an extremely durable surfacing for orthotropic bridge decks and more recently, open graded asphalt pavement used in on-grade motorways. A ¾" EA dense graded overlay on a lightweight concrete deck withstood more than 39 years of extremely heavy use (280,000 vehicles/day or over 3 billion vehicles) on the San Francisco Bay Bridge before it was replaced due to seismic structural concerns.

In recent decades, EA binder was extensively researched and field tested in a multi-phase evaluation by the International Transport Forum of OECD in a multi-country evaluation seeking long life pavements for strategic roads. This application of the highly oxidation resistant EA binder has focused on open graded, permeable surface pavements (>20% air voids), (also called OGFC pavements) for use in on-grade roadway installations with the goal of significant life-cycle extension. OGFC pavements offer significant safety advantages along with 6-8 decibel tire noise reduction versus dense graded flexible pavements or concrete. Permeable pavements also offer environmental benefits. Full scale test programs and projects are active in several countries including the U.S., the U.K., New Zealand and the Netherlands. Most of these installations involve a slightly diluted EA binder where a local bitumen is added to lower costs. Nearly 25% of New Zealand's motorway surfaces now consist of epoxy modified open graded asphalt. The change to epoxy (from SBS modified binders) was based on life cycle cost reduction due to the EA binder's outstanding durability and oxidation resistance.

TYPICAL EPOXY ASPHALT PAVEMENT FOR BRIDGE DECKS



ADVANTAGES PROVEN SAFETY • PROVEN DURABILITY

Skid Resistance
EA binders do not "bleed" as do thermoplastic bituminous paving materials when the pavement gets hot. As soon as the binder on the aggregate exposed to traffic wears off, vehicle tires contact only the aggregate.

Record-Setting Stability, no Rutting
The current generation EA binder, Type IX, has tested in excess of 100 kN (22,500 lbf) Marshall stability in several applications (from production batches at full strength). This eliminates rutting, shoving and raveling even in hot climate bridge deck and road applications offering an exceptional value if excess axle loads are common.

Oxidation Resistance
In open graded and SMA pavements where binder oxidation occurs more rapidly in conventional binders, EA binders offer outstanding protection to the encapsulated asphalt to preserve its flexibility for decades longer.

Renewable
EA uses bio-sourced polymer components.

Energy Saving
EA hot mixes are manufactured at very low asphalt plant temperatures (as low as 212°F), compared to 302°F or more for SBS or rubber modified pavements. At these low temperatures, there is no smoke or odor associated with paving operations.

Fatigue Resistance
The excellent fatigue resistance of EA enables it to maintain its integrity on orthotropic steel bridge decks without cracking even after the deflections caused by millions of heavy axle wheel loads.

No Raveling
Outstanding performance on Cantabro (ASTM D7064).

No Delamination
Because EA tack coats are also a thermoset polymer (as opposed to a thermoplastic polymer such as conventional polymer and rubber-modified asphalt), it provides a superior tensile bond strength to the substrate (508 psi).

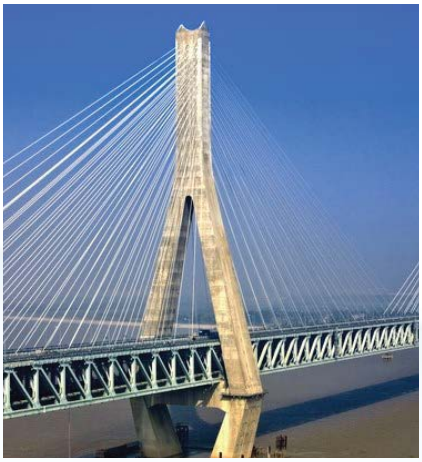
APPLICATIONS

Open Graded Pavement (OGFC)

OGFC (Open Graded Friction Course) pavement is becoming more widely used on high-speed motorways. Why? Noise reduction (6-8 dB), less mist, fast draining and high skid number. Conventional and SBS binders for OGFC come with a drawback: a short 7-9 year lifespan due to binder oxidation induced raveling. EA Binder combined (extended) with local bitumen provides cost effective reduced binder oxidation and extends OGFC lifespan. EA OGFC produces a long-life surfacing with the potential for 20-40 years of service.

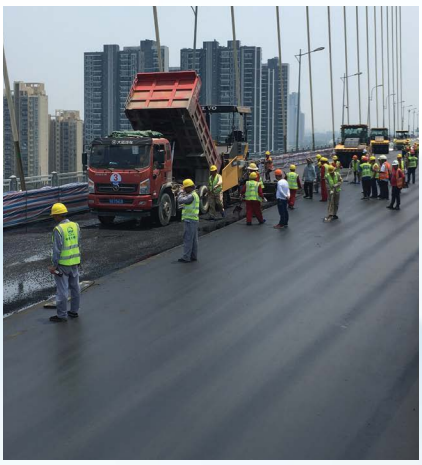
ChemCo Systems has large OGFC motorway projects underway in the Netherlands and New Zealand. Approximately 25% of NZ motorways now use epoxy modified OGPA (open graded permeable asphalt) with 20% air voids. Netherlands has also placed EA SMA roadways in less trafficked applications. The UK also has employed Epoxy SMA designs successfully in the past 20 years.

EA OGFC is currently being investigated in the U.S. by pavement research programs, underway nationally with Auburn University (NCAT) (on behalf of FHWA and Florida DOT), LSU (on behalf of Louisiana DOT), as well as in the Netherlands, UK, Ethiopia and other countries.



Orthotropic Steel Deck Bridges

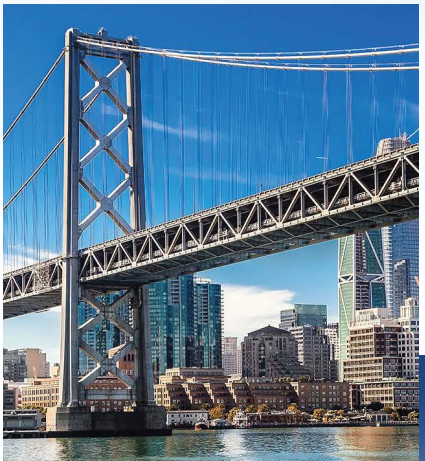
EA in dense graded mix designs has been used on orthotropic steel for over 55 years on long span bridges ranging from the San Mateo-Hayward Bridge in California, paved in 1967, to the Tianxingzhou Bridge in Wuhan, China. In Long Beach, California, the Queensway Bridge has a 52-year-old EA pavement. Why EA for bridges? The lightweight steel decks are known to engineers as one of the most tortuous paving applications due to the significant deflection of the deck plate during a heavy axle passage. EA offers 4 magnitudes better fatigue resistance than any other flexible pavement in the world. EA applications on orthotropic decks include bridges in Australia, Brazil, Canada, Thailand, Viet Nam, Korea and China.



On 5 older bridges, creative engineering has provided opportunities for EA to be pre-placed and used for complete deck replacements while the bridge is kept open for continuous service during daytime commute hours. These projects include the Golden Gate Bridge in California, the Ben Franklin Bridge in Philadelphia and most recently, the Macdonald Bridge in Halifax, Canada.

Overlays on Concrete

EA offers exceptional life span benefits for concrete overlays. In 1976, a ¾" dense grade overlay was installed over the lightweight concrete deck of the San Francisco Bay Bridge. This unique mix design used an innovative soft/hard aggregate blend, was in service for 37 years and maintained an acceptable skid number through its lifespan despite handling 280,000 vehicles/day or more than 3 billion vehicles total. The bridge was replaced by new bridge designed with today's seismic requirements.



INSTALLATION

EA hot mixes (dense and sma graded) for long span bridge projects use standard asphalt batch plants, paving machines and rollers. ChemCo provides custom automated mass flow metering equipment to process the two-component EA bond coat and binder. This paving system provides optimized quality and performance.

Reducing dead loads is particularly advantageous for older bridges with replacement paving. For this application, we can offer special mix designs with ~2.0 densities and substantially lower lift thicknesses compared to standard and polymer mixes.
No other flexible pavement binder can deliver Marshall stability of 100kN (22,500 lbf) or greater from production dense mixes. No other flexible pavement has lasted more than 50 years in daily service use on a major bridge.


BOND COAT


BATCH PLANT


LOADING


PLACEMENT


COMPACTION

Bond Coat
A Spray Distributor machine, heats, mixes and sprays an EA bond coat onto the zinc rich primer painted steel at about 302°F. Depending on job requirements, the Zn primer is either shop or field applied. The Epoxy bond coat is about 1/32" thick and is thermoset. Over steel and concrete substrates, Epoxy bond coats can deliver 508 psi pull off strength.

Batch Plant
At the batch plant, a Meter/Mix machine proportions and mixes the two binder components and injects into the pugmill the exact amount of mixed hot EA binder components required for each batch of EA concrete.

Loading
A batch plant discharges the 221-248°F EA mix into haul trucks for transport to the bridge deck.

Placement
An asphalt paving machine distributes the paving for the base course of EA concrete at the required thickness to achieve an approximately 1" compacted layer. Average paving rates generally exceed a 1.24 mi. lane in an 8-hour shift.

Compaction
A combination of pneumatic tired and 10 ton steel rollers provides the compaction, which is completed before the temperature of the mat has dropped below 149°F. For the second (wear course) lift, an application of EA Bond onto the leveling course, precedes the laying of the 1" wearing course. The bond coat will be about 1/64" thick.

PHYSICAL PROPERTIES of EPOXY ASPHALT

SPOTLIGHT TEST METHOD

Dynamic testing conducted by independent labs demonstrate that EA pavements resist fatigue cracking over a wide range of conditions.

These accelerated cyclic fatigue (3-point bending) tests on a composite beam (pavement on steel plate) are designed to simulate fatigue cracking in the negative moment area above the longitudinal stiffeners for bridge decks.

For roadway uses, a 4-point bending beam test (AASHTO T321) compares EA to a polymer modified PG64 at different constant strains (see Rutgers testing below right).

ChemCo Systems uses the latest generation electromagnetic dynamic tester for programable cyclic fatigue analysis, Instron's E10,000 (below).

Asphalt Concrete vs. Epoxy Asphalt Concrete

Typical Properties for 0.5" dense graded mix	Test Method (ASTM)	Asphalt Concrete (PG64)	Epoxy Asphalt Concrete (BIX)
Marshall Stability @ 140°F, lbf	D1559	2500	22500
Marshall Stability @ 392°F, lbf	D1559	melts	7900
Flow value @ 140°F, in.	D1559	0.22	0.165
Recovery % min.	D1559	0	81
Compressive strength @ 77°F, psi	D695		4350
Comp. modulus of elasticity @ 77°F, psi	D695		212000
Flex. Modulus of rupture @ 77°F, psi	D293	72.5	812
Flex. Modulus of elasticity @ 77°F, psi	D293		479000
Max. deflection, in.	D293	0.003	0.005
Air voids, %	D2041	3 to 5	2 to 3

Epoxy Asphalt Binder and Bond Coat (neat)

Property	Test Method (ASTM)	Binder	Bond Coat
Tensile Strength, psi	D412	1100	1800
Tensile Elongation, %	D412	250	200
Heat Deflection Temperature, °F	D648	-20.2	-13.9

Epoxy Asphalt Concrete/Binder – Bond Strength

Property	Test Method (ACI)	Value	Failure Location
Tensile Bond Strength to Inorganic Zinc Coated Steel, psi	ACI 503R	508	Bond Coat
Tensile Bond Strength to PCC, psi	ACI 503R	435	Portland Cement Concrete

Deck Deflection Comparison[1]

Load, kN	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0
Deflection, Bare Steel Plate, in.	0.024	0.006	0.01	0.014	0.018	0.022	0.026	0.031
Deflection, Epoxy Asphalt/ Steel Composite, in.	0.001	0.0047	0.007	0.010	0.013	0.017	0.02	0.02

Fatigue Test Results of Epoxy Asphalt – Steel Deck Composite [1, 2]

Temperature °F	Static Deflection, in.	Dynamic Deflection, in.	Cycles to Failure
32	0.0098	0.0007	$12x10^6$ with no failure
64	0.014	0.007	$12x10^6$ with no failure
140	0.024	0.022	$12x10^6$ with no failure

Fatigue Comparison Test by Rutgers University[3]

Tensile Strain (μ-strain)	Air Voids		Cycles to Failure		Initial Stiffness, S_o, psi	
	Epoxy Asphalt	PG 76-22 Polymer Modified AC	Epoxy Asphalt	PG 76-22 Polymer Modified AC	Epoxy Asphalt	PG 76-22 Polymer Modified AC
200	1.3	5.2	225,194,016	6,123,983	10,600	5,370
400	1.8	5.1	159,818,123	1,216,219	10,300	4,210
900	1.4	5.1	16,626,222	17,712	7,900	2,760

Above test results from study conducted by Transportation College of Southeast University, Nanjing, China, 2000.
1) Test specimen: 0.551" plate 3.93" wide, center point load from under side
2) Test load: 5kN load @ 10 Hz frequency
3) Above test results from Rutgers University study in 2007 comparing EA vs. Superpave standard HMA specimens, AASHTO T321

At ChemCo Systems, we believe that expertise and dedicated responsiveness make all the difference to our customers.

ChemCo Systems manufactures a diverse selection of extremely durable polymer systems for use in civil infrastructure and construction repair applications. Our products are designed to install, protect and repair architectural and structural concrete and bond and protect substrates including steel, wood and carbon and glass fiber composite systems.

ChemCo Systems' products are available for: structural crack repair, anchor bolts, coatings and sealants for corrosives, machine bases, old-to-new pours, joint nosing, control joint filling, seismic upgrades, plate bonding reinforcement, spall and void repair, underwater (marine) and extreme environments including coatings that can protect against concentrated sulfuric acid spills. Polyurethane chemical grouts provide for waterproofing and soil stabilization, slab jacking and containment. Industry leading applicator training and metering pump equipment is offered to contractors in our Kemko® applicator program.

ChemCo Systems offers a highly experienced technical service and R&D team to provide quick response to customize products for difficult applications. Our in-house testing lab is well equipped to handle most AASHTO, ACI, ASTM, CSI, DOT, ICRI, and International standards.

Recent Innovations Include:

- InsulPOX® for protecting plant environments, reduce explosion and cold cloud hazards from spills of cryogenic liquids including LNG, H_2, O_2, N_2, Ar, He, and the new clean fuel, green H_2.
- Acrylic, polyurea and epoxy line striping for pavements
- High friction surface treatment (HFST) epoxies for highways
- Street demarcation technologies using colored recycled glass for smart cities
- Ambient temperature EA (1:1) tack coat and repair binder

ChemCo Systems extensive product line is manufactured in strategic locations across the United States including California, Texas, Chicago, and Atlanta. We maintain substantial inventory of raw materials and finished goods to serve contractor needs quickly, particularly in these times with unpredictable shortages.

- AASHTO - American Association of State Highway and Transportation Officials
- ACI - American Concrete Institute
- ASTM - American Society for Testing and Materials
- CSI - Construction Specifications Institute
- DOT - Dept. of Transportation
- ICRI - International Concrete Repair Institute

WORLDWIDE INSTALLATIONS OF EPOXY ASPHALT CONCRETE

Brazil
- Costa de Silva

Canada
- Champlain
- Lions Gate
- MacDonald
- McKay
- Mercer

United States
- 1-94 Bridges
- Ben Franklin
- Coronado
- Evergreen Point
- Fremont Bridge
- Golden Gate
- Luling
- Maritime
- Oakland Bay Bridge
- San Mateo-Hayward
- San Diego-Coronado
- Oakland Bay Bridge
- Queensway A
- Ross Island
- Sellwood
- San Francisisco Bay

Korea
- Gogunsan Bridge
- Chensa Bridge
- Ulsan Grand Harbor

Thailand
- Banpald
- Pong Pech
- Rama IV

China
- Hangzhou Bay (2 bridges)
- Baishazhou
- Balinghe Bridge
- Chifeng Bridge
- Chong Qi Bridge
- Dagu
- Edong Bridge
- Fenghua Bridge
- Fumin Bridge
- Houhai
- Huang Pu (2 bridges)
- Jing yue Bridge
- Jintang
- Jishan-Haihe
- Jiu jiang Second Bridge
- Ligonglou Bridge
- Nanhuan
- Pingsheng
- Qing dao Bay Bridge (2 bridge spans)
- Runyang (Cable-stay)
- Runyang (Suspension)
- SiHai Bridge
- Sutong
- South Train Station Bridge
- Taohuayu Bridge
- Taoyaomen
- Tianxingzhou
- Nanjing 2nd Yangtze Bridge
- Nanjing 3nd Yangtze Bridge
- JInan 3rd Yellow River
- Xiangluowan
- Xihoumen
- Xinshiji
- Yangluo
- YuZui
- Zhanjiang Bay

Vietnam
- Thuon Phuoc

MANUFACTURED IN USA

ChemCo Systems
A Subsidiary of American Polymers Corp.

2800 Bay Road · Redwood City, CA 94073
Tel. 650-261-3790 · Fax. 650-261-3799
www.chemcosystems.com