BRIDGE DECK WATERPROOFING

Introduction

The waterproofing of bridge decks is recognised in UK as a vital and necessary operation to enhance the longevity and durability of the structure. It represents the first line of defence against the ingress of water, road de-icing salts and aggressive chemicals which would corrode the steel reinforcing bar in the concrete causing severe damage and eventual destruction.

Second Severn Crossing (Courtesy: Pitchmastic)

Some countries with mainly warm and dry climates may choose not to waterproof their bridge decks but, in the USA for example, they are now counting the cost. A recent analysis showed that almost 200,000 decks are suffering from corrosion resulting in a direct cost of $2 billion for replacement or refurbishment.

Background

The earliest attempts to waterproof bridge decks included the "waddle and daub" technique and the primitive use of pitch as a sealing medium.

In 1945 the Ministry of War Transport published a **Memorandum No 577** on Design and Construction of Bridges which included mastic asphalt as an acceptable waterproofing material. In practice it was proved not to be the case.

The increasing awareness and use of de-icing salts in the 1960s initiated a response by the Ministry of Transport who published Technical Memorandum (Bridges) BE1: Waterproofing of Bridge Decks, in December 1965, directing that the waterproofing of motorway and trunk road bridges be mandatory.

In 1971, waterproofing materials and systems had to meet the requirements of DoT Technical Memorandum **BE27 1970** with the Specification for Road and Bridge works (DoE 1976) and, later, the Specification for Highway Works (DoT 1986) providing contract requirements.

In 1994 BA47 and BD47 were introduced by the Department of Transport and were reissued in 1999 pending the completion and imposition of European Standards.

In addition, since 1975, materials used in the deck waterproofing operation have been subjected to a series of tests in order to obtain a British Board of Agrément Roads and Bridges Certificate, necessary to comply with the prevailing standards.

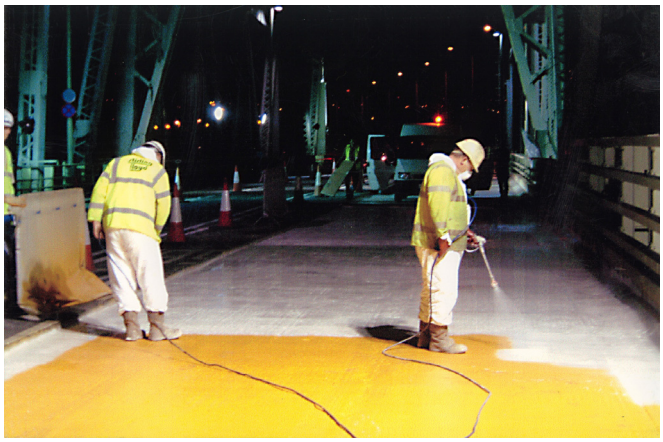
Corrosion

Reinforced concrete is one of the most versatile of structural materials and is extremely durable if properly constructed.

It is recognised however that a degree of porosity will always occur and this, allied to surface wear and hairline cracking, will allow water and corrosive materials, especially carbon dioxide from the air and chlorides from de-icing salts, to penetrate the concrete and attack the steel reinforcement bar. Concrete is naturally alkaline and therefore protects the steel, but the effect of contact with these materials is to reduce the alkaline environment and allow an electrolytic process to start, corroding the steel. The concrete effectively becomes a battery.

The result of the corrosion and rusting is to expand the steel which then damages, and eventually destroys, the surrounding concrete.

The primary defence against these destructive agents is good, dense concrete allied to a proven waterproofing membrane installed by a qualified and responsible contractor.



Runcorn Bridge (Courtesy Stirling Lloyd)

Deck Waterproofing Systems

The bridge deck waterproofing industry has developed beyond recognition and is continually producing new products and advanced techniques to comply with the latest standards and levels of competence demanded by bridge owners.

The products currently available can be divided into two main categories:

Sheet Systems

These basically consist of pre formed sheets based mainly on bituminous polymeric and elastomeric materials. They are bonded to the bridge deck, to form a continuous membrane, using bitumen adhesive (or they are self adhesive).

Originated from simple roofing membranes, manufacturers have endeavoured to develop systems that would satisfy the specific and enhanced requirements of the bridge deck waterproofing market. Generally, however, they have now been superseded by the more modem liquid sprayed systems.

Liquid (Sprayed) Systems

These systems represent a new generation of deck waterproofing applications developed over the last 25 years to meet the higher technological demands and standards imposed on the industry. Technology has also been developed to allow the application of most preferred systems by spray which offers consistency and continuity. They largely fall into two categories, acrylics and polyurethanes.

The systems normally consist of three elements:

i) Primer

Used to penetrate and seal the concrete substrate, enhancing the bond of the subsequent membrane

ii) Membrane

The waterproofing element of the system. Applied in one or two coats

iii) Tack/Bond Coat

Specially developed tack coats to enhance the bond of the membrane to the wide variety of surfacing mixes encountered around the globe.

These systems offer rapid cure and application and form a tough flexible seamless coating with no vulnerable joints. They also offer ease of detailing and can cope with the uneven surfaces usually encountered on bridge decks.

Systems based on methyl methacrylate and polyurethane resins have proved successful and can offer a world wide track record of success.

Performance Requirements

Irrespective of the system used, it is essential that the following performance criteria must apply in order to negate potential concerns surrounding leakage, poor bonding and embrittlement or softening of the membrane.

- Impermeable to water
- Good adhesion to the deck
- Good adhesion to surfacing
- Capable of bridging shrinkage cracks in concrete
- Tolerant of deck texture and detail
- Tough to withstand site damage including paving equipment
- Safe to apply
- Able to withstand elevated surfacing temperatures
- Applied over a wide range of ambient conditions
- Non degradable

Smeaton Arches (Courtesy: Stirling Lloyd)

Site Practice and Application

The success of the bridge deck waterproofing operation is often reliant on site procedures, workmanship and the prevailing weather condition. Good, professional preparation is as important as the properties of the product, or system, to be used.

The following represents the major issues to be addressed before work commences on site:

- the availability of design, detailing, construction and material records from the employer's site engineer
- the availability of an approved and properly trained workforce and experienced, qualified supervision
- facilities for adequate and protected storage of materials to be used
- suitable, safe access to the bridge deck for equipment, materials and personnel
- agreement and discussion by all parties to establish an acceptable method statement and programme
- the condition and preparation of the concrete deck which should be sound, even, uncontaminated, dry and dust free and be laid to provide a U4 finish, thereby offering optimum opportunity for a strong and durable bond to the waterproofing membrane
- review of the weather conditions likely to affect the waterproofing operation
- the use of an appropriate primer
- the choice and application of an appropriate, approved and certificated waterproofing system in compliance with current Highways Agency standards
- proper time allowance for the curing process
- adequate protection of the membrane at all times prior to the application of the asphalt road surface
- the use of an appropriate tack coat where necessary
- the application of an approved asphaltic road surface in compliance with current UK Standards, utilising low void content mix designs.

Redhenge Bridge (Courtesy: Universal Sealants (UK) Ltd)

References & Further Reading

1. BS5400 Part 4 : Code of Practice for concrete bridges
2. BD47/99 : Waterproofing and Surfacing of Concrete Bridge Decks. HMSO, London.
3. DoT Specification for Highways Works Part 5. HMSO, London.
4. DoT/TRRL Report LR636: Waterproofing concrete bridge decks: materials and methods. TRL, Crowthorne. (M D MacDonald: 1934)
5. DoT/TRL Report 185: A field trial of waterproofing systems for concrete bridge decks. TRL, Crowthorne (A R Price: 1989)
6. DoT/TRI, Report 248: Laboratory tests on waterproofing systems for concrete bridge decks. TRL, Crowthorne (A R Price: 1989)
7. DoT/TRI, Report 317: Waterproofing of concrete bridge decks: site practice and failures. TRL, Crowthorne (A R Price: 1989)