

IRF –INDIA Chapter

Revolutionizing Road Infra with Modern Equipment, Technologies,
Sustainable Materials and Policy Guidelines

Development of Design Guidelines, Testing and
Implementation Methodologies for Bridge Deck Water
Proofing (BDWP) over Bridge Deck Overlays

J K Goyal

Chief Scientist & Head, Bridges
Bridge Engineering and Structures Division, CSIR-CRRI, New Delhi
jkgoyal.ccri@nic.in, 9911120339.



The water proofing in building structures is quite common and being used extensively by different manufacturers through established design guidelines and specification. However, when it comes to the Bridges and other elevated structures on highways, the prevention of super-superstructure elements from ingress of water remains a big **challenge due to followings requirements:**

- **Shear Adhesion**
- **Thermal Shock**
- **Tensile Adhesion/Bond with BC/Mastic Asphalt**
- **Crack Cycling**
- **Vibrations and Fatigue**
- **Other Operative conditions**

Poor Waterproofing on Bridge Deck



Poor Waterproofing on Bridge Deck

**IMPROPER MATERIAL
SELECTION OR
INSTALLATION OF BRIDGE
DECK WATERPROOFING
MAY NOT PROTECT THE
BRIDGE DECK AND CAUSE
LONG TERM STRUCTURAL
DAMAGE**



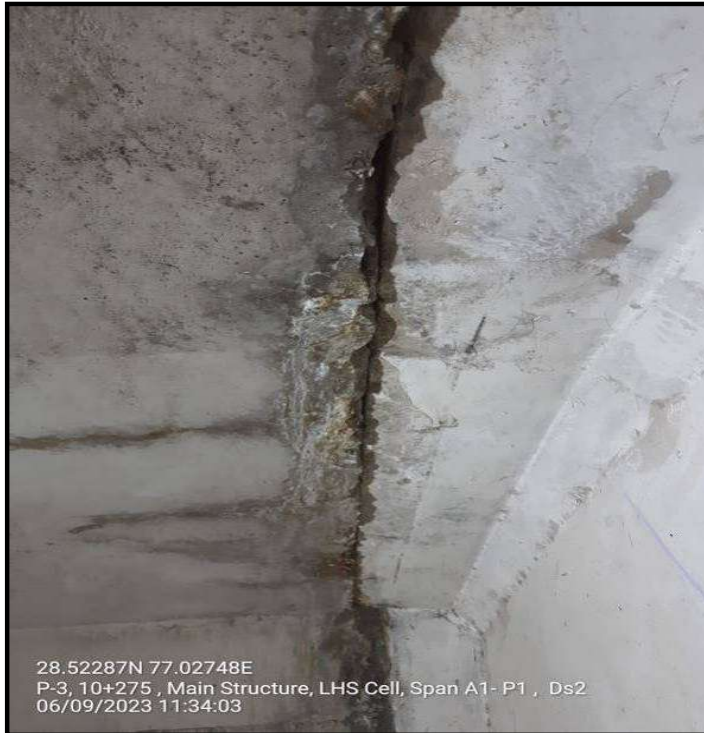
Poor Waterproofing on Bridge Deck



No Waterproofing with SMA on New Bridge Deck

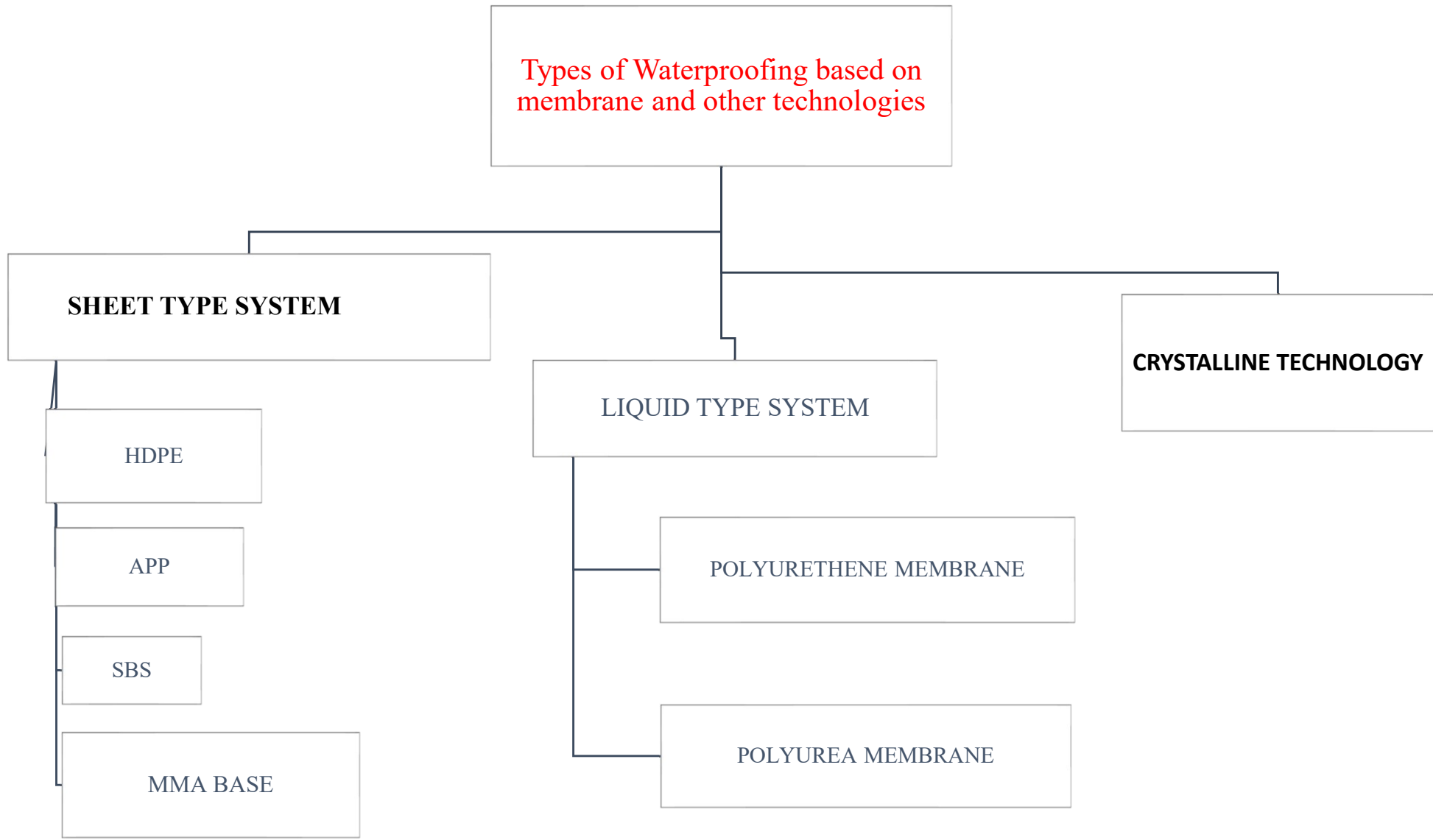


No Waterproofing with SMA on New Bridge Deck



Leakages of segmental construction joints

Study of available BSWP Systems



SoP: Bridge Deck Water Proofing (BDWP)



- Study of available BSWP Systems
- Performance Criteria for Waterproofing Materials
- Implementation Methodologies and Precautions.
- Development of Test Facilities with Testing Procedures and Tools.
- Stakeholders Workshop
- Field Trials.
- Development of Design Guidelines for Bridge Deck Water Proofing (BDWP)

Types of Waterproofing Systems on Bridge Deck

CONCRETE ADDITIVES

- **HELP WITH MINOR SHRINKAGE CRACKS BUT HAVE LIMITED SUCCESS ONCE THE CONCRETE STRUCTURE CRACKS**

IMPREGNATIONS

- **HELP AS SECONDARY PROTECTION, HAVE LIMITED SUCCESS ONCE THE CONCRETE STRUCTURE CRACKS**

SHEET MEMBRANES

- **LIMITED ELONGATION AND FLEXIBILITY**
- **MULTIPLE JOINTS**
- **TEARING UNDER SHEAR LOADS, LIMITED TEMPERATURE RESISTANCE**

HYBRID SYSTEMS

- **LIQUID APPLIED BASE**
- **TOPPING WITH MEMBRANE**
- **SHARE DRAWBACKS SAME AS SHEET MEMBRANES**

LIQUID APPLIED COATINGS

- **RIGID COATINGS OR FLEXIBLE COATINGS**
- **EASIER TO APPLY, MAY NOT HAVE REQUISITE MECHANICAL PROPERTIES**
- **BETTER COVERAGE, RIGID COATINGS MAY CRACK WITH SUBSTRATE**

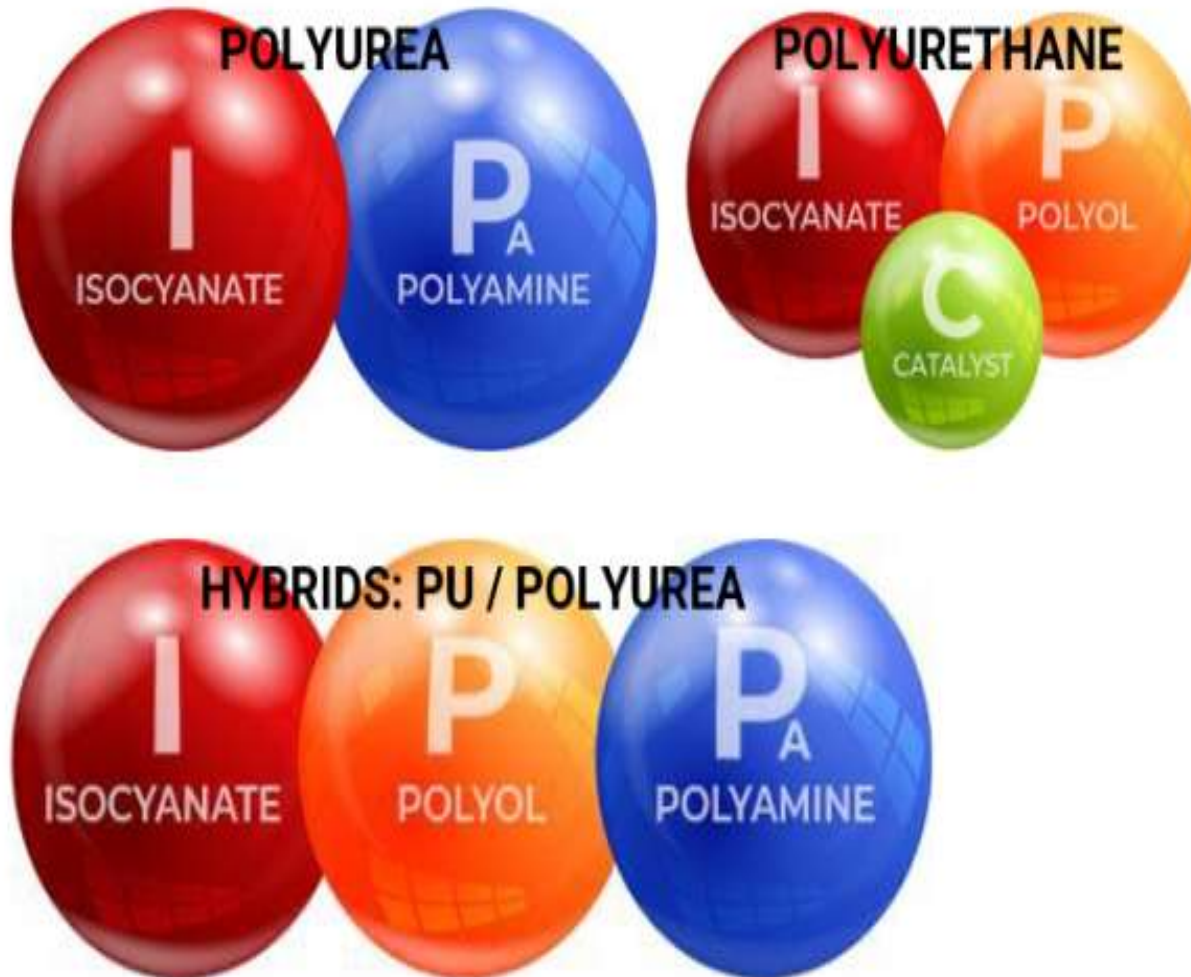
Tender Specifications for Waterproofing of Bridge Deck



Type of Material	Polymer waterproofing membrane free from Isocyanates
Thickness	Minimum thickness of 3 mm included the tack coat
Approved Certification	BBA certificate with the UK Product Approval Scheme (HAPAS)
	INDIAN ROADS CONGRESS Accreditation
	International track record of minimum 20 years use in Bridge Deck Application
Test Report Required	Resistance to Sea Water, Fuel Oils, Diesel, Lubricants, Acid Rain
	30% Concentrated Sulphuric acid
	Chisel Impact at 40 Degrees C,
	Chloride Ion Penetration max 0.04%;
	Heat Ageing In accordance to BS 903 Part A2 and BS 2782 confirming minimal change of less than 10% in tensile strength @ 37degC and @ 80 Degrees C temperatures.
	Resistance to aggregate indentation @ 80 Degrees C under 500N Force to confirm less than 50% indentation as per original thickness.
	Minimum Tensile Strength of 9MPa as per ASTM D412;
	Minimum Elongation at break should be 100% as per ASTM D412;
	Property having a minimum 2 mm dynamic crack bridging ability

Water Proofing Membrane (APP/SBS types)

Identification of WPM	Description
APP-1	4 mm thick APP plastomeric bitumen based WPM with non-woven polyester felt reinforcement , finished with polyethylene film on both sides and available in rolls of 10x1 m.
APP-2	4 mm thick APP WPM reinforced 50gm/m² fiber glass and 180 gm /m² polyester mat and available in rolls of 10x1 m.
APP-3	4 mm thick APP with reinforcement of 160g/m² polyester core coated on both sides and finally finished with thermo fusible polyethylene film.
APP-4	3 mm thick APP based WPM with spun bonded non-woven polyester felt reinforcement of 160 gsm , PE film on both sides and available in rolls of 10x1 m.
SBS-1	4 mm thick SBS elastomeric bitumen based WPM with non-woven polyester felt reinforcement with both side PE film and available in rolls of 8x1 m.



RECOMMENDED DUE TO:

- **HIGH ELONGATION & TENSILE STRENGTH**
- **EASE OF APPLICATION**
- **EXCELLENT CRACK BRIDGING PROPERTIES**
- **HIGH FLEXIBILITY TO ACCOMMODATE MOVEMENTS**
- **RESISTANT TO HEAT AND UV**
- **SEAMLESS**
- **PERFORMANCE**

Tests for Liquid Waterproofing

Material to be tested for 10 performance Properties

BOND TO
SUPPORT

CRACK BRIDGING
AT LOW TEMP.

RESISTANCE TO
DYNAMIC
ACTION

RESISTANCE TO
HEAT IMPACT

RESISTANCE TO
PERFORATION

RESISTANCE TO
SHEAR
[OVERLAYS]

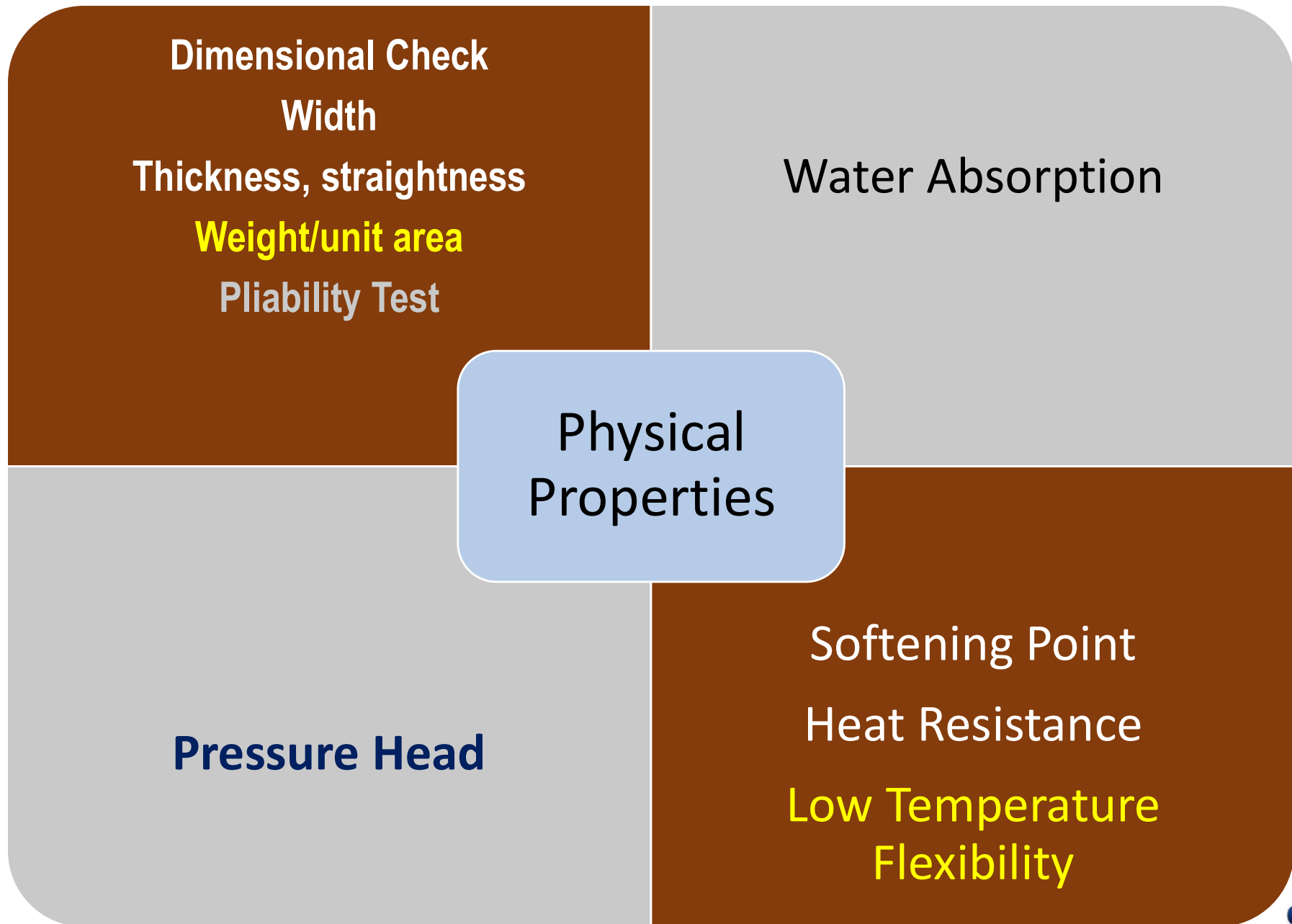
RESISTANCE TO
WATER INGRESS
[5 BAR]

WATER
ABSORPTION
[WITH INDENTS]

RESISTANCE TO
HIGH HEAT
IMPACT > 220C

SKID
RESISTANCE

Water Proofing Material Tests



Standards for Waterproofing Membrane Tests

Waterproofing Membrane Test Facility:			
S. No.	Detail of Equipment	Facility Available in CRR I (Yes/No)	Standard
For Raw Material:			
1.	Universal Testing Machine, Capacity 5kN: - Tensile & Elongation - Tear Strength - Puncture Resistance Test - Shear Resistance of Joint	Yes (A new Machine is being installed)	EN 12311-1 ASTM D4073 ASTM E154 EN 12317-1
2.	- Flexibility at Low Temperature	Yes	ASTM D5147
3.	- Softening Point (FPD)	Yes	ASTM D36
4.	- Pliability Test Apparatus	Yes	IS 13826 (Part2)
5.	- Pressure Head Test Apparatus	Yes	IS 13826 (Part4)
6.	- Water absorption Test	Yes	IS 13826 (Part6)
7.	- Mass per unit area	Yes	ASTM D5147
8.	- Heat Resistance Test	Yes	IS 13826 (Part5)

Standards for Waterproofing Membrane Tests



Waterproofing Membrane Test Facility:			
S. No.	Detail of Equipment	Facility Available in CRRRI (Yes/No)	Standard
For Durability Test:			
6.	Tensile Adhesion Test (Under UTM, 5kN)	Yes	BD47/99
7.	Resistance to Chisel Impact Test	Yes	BD47/99
8.	Resistance to Aggregate Indentation Test	Yes	BD47/99
9.	Resistance to Chloride Ion Penetration Test	Yes	BD47/99
10.	Resistance to Heat Ageing	Yes	BD47/99
11.	Surfacing to Waterproofing System Interface Shear Adhesion Test	No (Fixtures shall be designed as per NEW UTM)	BD47/99
12.	Thermal Shock, Heat Ageing and Crack Cycling Test	No	BD47/99
13.	Surfacing to Waterproofing System Interface Tensile Bond Test	YES	BD47/99
14.	Crack Cycling	YES (developed)	BD47/99

Testing Facilities proposed to be developed



S. No.	Test Description	Test Standard	Future Requirement	Remarks
1.	Shear Strength	BD47/99 OR ETAG033 : EN13653 OR GBT 19250-2013	Fixture has to be designed and fabricate. (Fixtures has been designed as per NEW UTM)	Application of waterproofing system on concrete specimen, if waterproofing system is in liquid form.
2.	Tensile Bond Strength	BD 47/99 OR ETAG 033: EN 13596/EN13375 OR EN 1542	YES.	Application of waterproofing system on concrete specimen, if waterproofing system is in liquid form.
3.	Puncture Resistance Test	EN 12310	YES	Sample required in the form of sheet, if waterproofing system is in liquid form.
4.	Low Flexibility Temperature	EN1109	YES.	Sample required in the form of sheet, if waterproofing system is in liquid form.
5.	Resistance to Tearing (Nail Shank)	EN 12310-1	YES.	Sample required in the form of sheet, if waterproofing system is in liquid form.

Equipments/Fixtures available with CRRRI

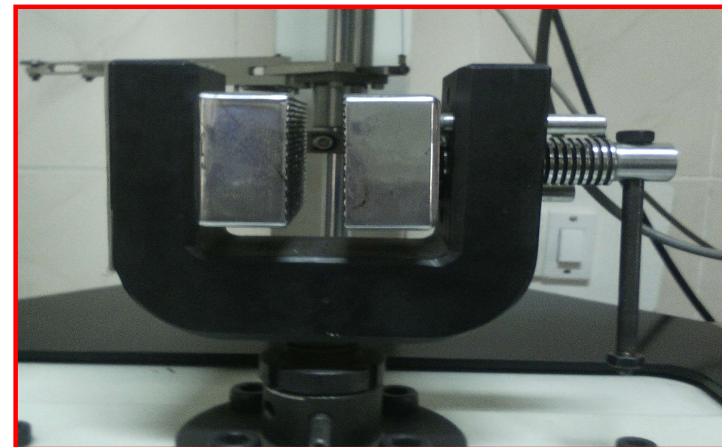
Pressure Head Test Equipment



Pliability Test Equipment



Grips for holding sample



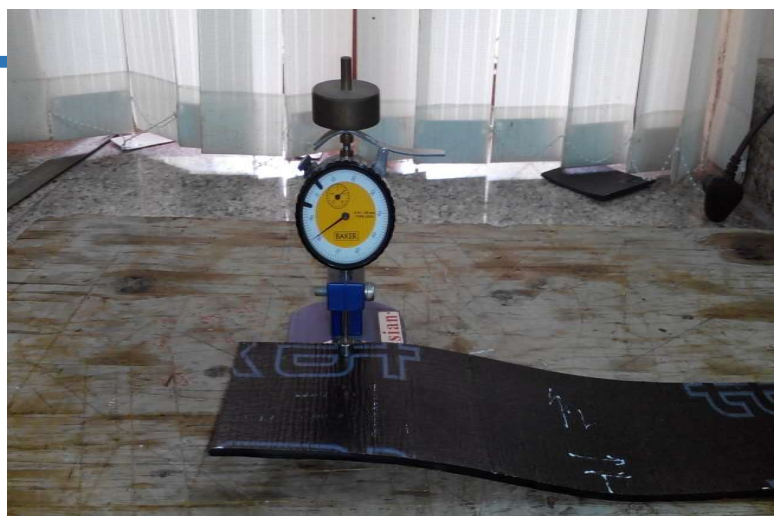
Adhesion Test Fixture



Puncture Resistance Fixture



Dimensional Check-Thickness



Thickness of WPM affects Strength properties (tensile, tear, elongation) Temperature based properties (softening point)

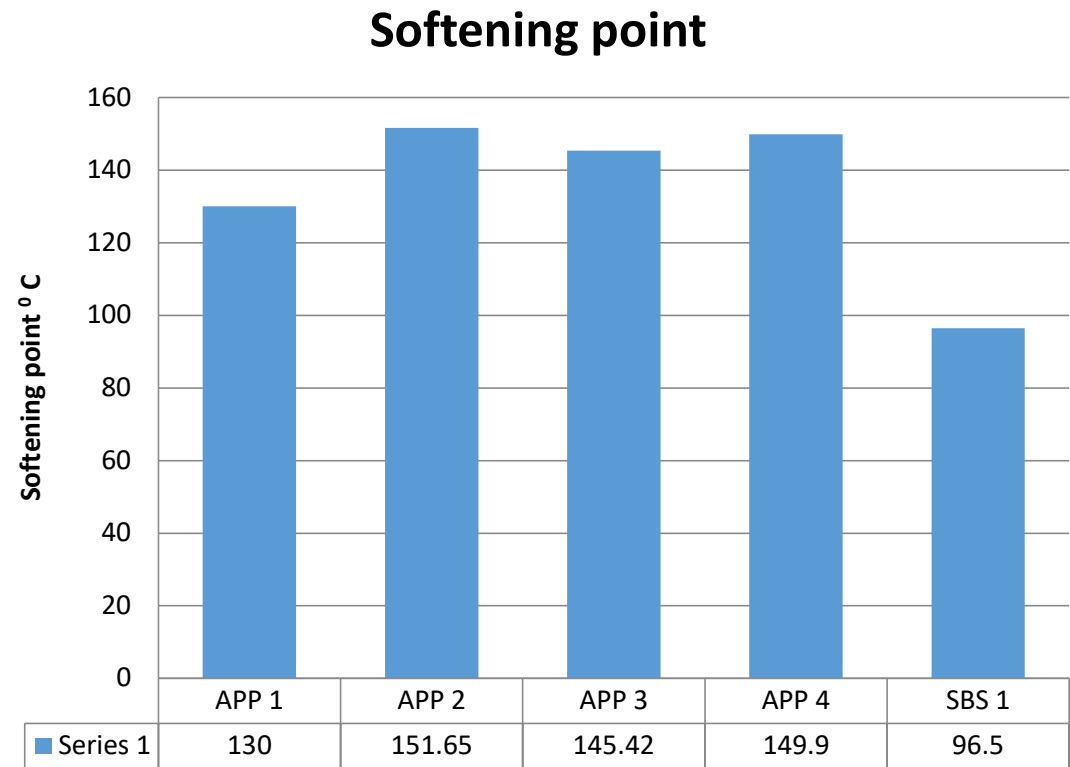
Identification of WPM Sample	Direction of measurement	Mean Thickness (mm)
APP1	Selvage	3.50
	Sheet	3.97
APP2	Selvage	4.2
	Sheet	4.31
APP3	Selvage	3.87
	Sheet	4.03
APP4	Selvage	3.054
	Sheet	3.086
SBS1	Selvage	3.565
	Sheet	3.935

As per Part 4 BD 47/99, for sheet and selvage the thickness at any location shall be within $\pm 10\%$ of the nominal thickness.

Softening Point (ASTM D36)



Ring Ball Apparatus with bath liquid Glycerin



Softening point is an indicative of the tendency of bitumen in the sheet to flow at elevated temperature. Therefore, this test helps in selection of appropriate WPM samples for use on bridge decks.

Tensile Strength Test(EN12311)



(a)



(b)



(c)

Tensile strength test is used to determine how well a membrane can resist and accommodate movement of the concrete deck.

EN 12311 stipulates 50mm wide x 300mm long specimen, test temp 23 deg, preconditioning at 23deg, 50% RH for 20Hours, jaw separation rate 100mm/min for both EN and ASTM



Tensile and Shear Adhesion Test



(a)



(b)



(c)



(d)

**General view of Aggregate Indentation Test Setup
in UTM (a & b)**
Marks of Indentation at 80 and 125 °C (c) & (d).



RCPT and Water Penetration Test Setup.



Crack Bridging and Chisel Impact Test Setup



Potentiometric Titrator and Crack Sealing Test Setup.

Engagements with the Industries



- An International Agency namely M/s Alcasa (Australian) has sponsored the study The product named “**Radcrete Formula # 7**” is a unique product from Australia.
- Study for **Master Builder** has been completed for use of the product in MTHL Mumbai.
- Study for **M/s Technopol**, (Spain) has been done
- Other Agencies namely, **M/s FOSROC and M/s Conchem** .
- Additionally, efforts are being made with Indian Roads Congress to initiate the draft specification for this technology on Pan India basis.

Waterproofing Technology



Thanks