TECHNICAL BULLETIN – TB073

MISCONCEPTIONS ABOUT MEMBRANE ELONGATION

15th January 2025

INTRODUCTION & SCOPE

There is a wide misconception regarding the elongation properties of waterproof membranes and their ability to bridge cracks that form post membrane application.

This bulletin endeavours to clarify the real meaning of elongation and elasticity in relation to bridging properties.

FLEXIBILITY & ELASTICITY

With membranes there are some important terms which control their properties. The terms include Flexibility, Elasticity, Elastic limit, Plasticity and Ultimate failure.

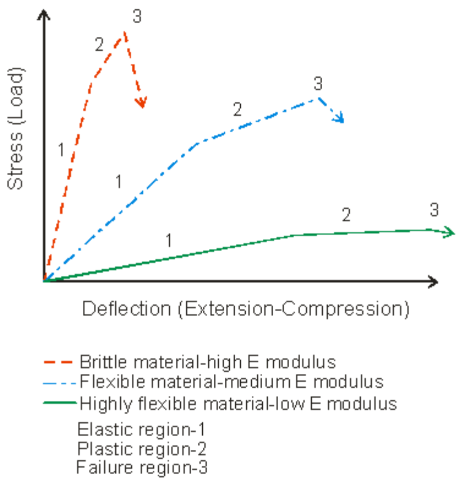
Flexibility - the quality of bending easily without breaking. In other words, bending the material without it stress or brittle cracking.

Elasticity - the ability of an object or material to resume its normal shape after being stretched or compressed, stretchiness. The E-modulus is defined as how much a sample deforms (strain) under a set of amounts of stress. An elastic material has a low E-modulus, while a brittle material has a high E-modulus.

Elastic limit – is the maximum stress or force per unit area within a solid material that can arise before the onset of permanent deformation. The material always returns back to it's original shape, deformation is reversible. Applied stresses beyond the elastic limit cause a material to yield or flow.

Plastic - Plasticity describes the deformation of a (solid) material undergoing non-reversible changes of shape in response to applied forces. The material will no longer return to its original shape, and permanent deformation has occurred.

Ultimate failure - describes the breaking of a material at maximum applied stress.



The properties described are shown at above. A high elongation Class III membrane would behave as the lowest graph (highly flexible), whilst a rigid epoxy Class I membrane would behave as the brittle material in the red dotted line.

When membranes are proof tested for elongation to AS4858, they are held in a testing jig with only the ends clamped. As such, the central section of the unrestrained membrane is placed under tensile stress as the amount of strain increases. This measures the properties of the material itself.

When a liquid membrane is applied to a concrete surface it is fully bonded to the substrate surface. Because of the elasticity and flexibility, the membrane can cope with broad span movements such as thermal expansion / contraction of the substrate as well as lateral flexing frequently experienced in construction projects. However, it needs to be recognised that the membrane is constrained on the side in contact with the rigid surface and this effectively alters the properties downward from the proof testing values.

It also needs to be that inclusion of a reinforcement matting material within the membrane causes a trade-off between the reduced elongation, against an increase in tear resistance under increased stress. This is in part because to the matting properties, but also a consequence of the membrane being thicker, and therefore having more material to yield.

Within a structure there are two basic types of movement underlying an installed membrane and these are principally handled by two different mechanisms within the membrane coating.

TYPE OF MOVEMENT	**PRINCIPAL HANDLING MECHANISM**
Free movement (unconstrained)	Flexibility
Restricted movement	Elasticity

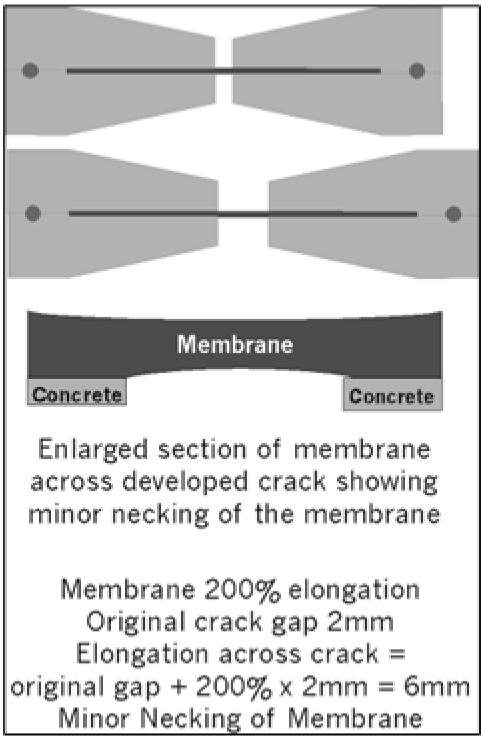
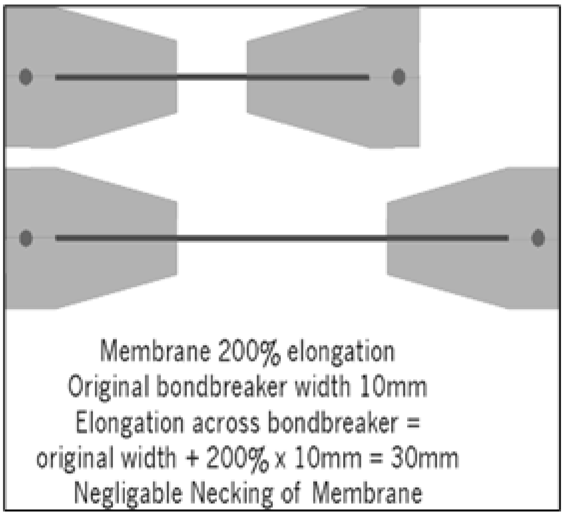
Free movement involves extensibility and deformability where the membrane is not restricted by being bonded to a rigid area of substrate, such unconstrained areas are over a bond breaker or *bridging existing cracks*.

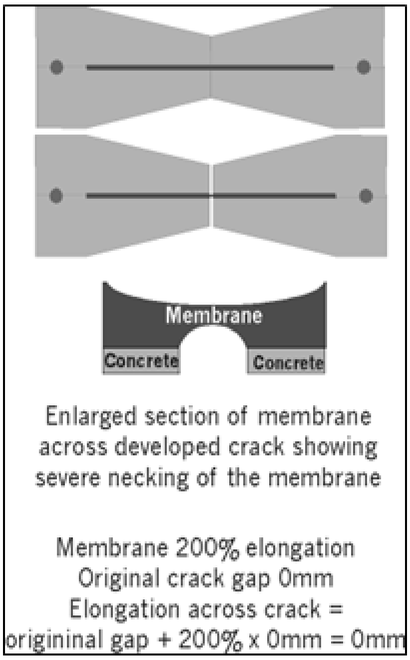
Restricted movement involves extensibility where the membrane is restricted by being fully bonded to the substrate.

The membrane's flexibility also allows it to cope with movement of cracks existing prior to the application of the membrane and the ability to cope with significant movement can be built into the application, by properly treating the crack with a bond breaker that extends the gap, where the membrane remains un-bonded to the substrate.

A membrane's elasticity or elastic modulus allows it to cope with small cracks such as hairline cracks that form because of plastic shrinkage of the concrete. It should be noted that when hairline cracks form after the application of the membrane, the membrane copes by necking or reducing its film thickness over the crack. As the crack gets larger the membrane gets thinner to a stage where it becomes ineffective as a waterproof membrane and eventually shears or tears to break completely across the crack.

The movement is principally accommodated by the membrane's elongation.

	When the un-bonded gap at the membrane installation is 2mm, a membrane with 200% elongation will extend to 6mm, should this degree of movement occur (2 x 200% = 4 mm and 2+4=6mm). There will be minor necking of the membrane across the gap as the membrane is stretched and the membrane may lose some waterproofing efficiency, however as the gap reduces again the membrane will recover because it has not exceeded it elastic limit. In this example once the gap movement extends beyond the limits of the 200% elongation, the membrane will enter the plastic area and if the joint moves back again, will not go back to shape, and be compromised. Opening the joint will further past the plastic limit, and then the membrane and fracture and fail (refer Diagram 01).
Diagram 1	
	When the same membrane is applied, so that an un-bonded gap of 10mm exists by the installation of a bond breaker to 5mm on either side of the crack, the membrane will extend to a 30mm gap with no damage. As is evident the wider the section of membrane that is not bonded to the substrate, the more absolute movement can be accommodated before the membrane suffers damage. This distance can be expanded by the installation of bond breakers over cracks to provide for greater movement capacity (refer Diagram 02).
Diagram 2	

	Cracks that form in concrete following application of the membrane, obviously have no membrane distance that is not bonded to the substrate. In other words there is no bond breaker to provide a section of unrestrained membrane. The original gap is non-existent or 0mm and regardless of the elongation properties of the membrane post application, cracks will result in damage to the membrane. At 200% elongation – 200% of 0mm is 0mm. Att 500% elongation – 500% of 0mm is 0mm. (Though in truth, there will be a very small amount of movement before failure because the membrane does not have zero thickness). (Refer Diagram 03).
Diagram 3	

Elongation and elasticity

When post application cracking occurs, the membrane will extend but the result will be serious necking of the membrane across the newly formed gap. This will seriously impair the properties of the membrane, and the membrane will tear with small movements.

Post membrane application cracks are only accommodated by the elastic modulus of the membrane. In accommodating this crack, the membrane reduces film thickness and the extent to which it will stretch without becoming ineffective as a waterproof membrane is limited.

Flexibility

The same applies where the surfaces move out of plain rather than simply extend. Where there is zero clearance the membrane stretches with the movement, necks and then fails.

Hairline cracking resulting from plastic shrinkage of the concrete can be accommodated, however more extensive cracking, such as structural building movement, will result in membrane fracture regardless of the elongation properties of the membrane.

Conclusion

The benefit from the elongation properties of the waterproof membrane is best achieved where the membrane is not directly bonded over the crack, by use of a bond breaker. The width of the free movement over the bond breaker will control the actual movement ability of the membrane.

Regardless of the elastic properties of a membrane, its performance will be reduced and can fracture with the development of cracks in the substrate which exceed its performance after the application of the membrane. As the crack widens from zero, the elasticity allows the membrane to remain a film, albeit becoming thinner and therefore less effective, until it reaches its plastic limit where it is permanently deformed and cannot move back again, or even exceeds the ultimate fracture limit.

Building tomorrow

<u>IMPORTANT</u>

This Technical Bulletin provides guideline information only and is not intended to be interpreted as a general specification for the application/installation of the products described. Since each project potentially differs in exposure/condition specific recommendations may vary from the information contained herein. For recommendations for specific applications/installations contact your nearest Ardex Australia Office.

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