# Weatherability of coated fabrics as roofing material in tropical environment

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The application of fabrics in construction ranges from temporary sca7olding sheeting to permanent lightweight membrane roof for structures covering large areas. Di7erent types of fabrics are used primarily as roo$ng material for sport and shopping facilities, pavilions, atriums, passageways between buildings, gate entrances, shops and restaurant overhangs. The advantages of fabrics, which are widely recognized by designers when prescribing their use in buildings, are rapid construction due to o7 site manufacture, light modulation more easily regulated than with glass panes, durability of over 15 years for woven fabrics, architectural =exibility adapted to building constraints and the aesthetic aspects of being able to obtain smooth shapes and curvatures.

It was only during the last century that fabrics were speci$cally designed for structures able to bear loads arising from snow, wind and temperature. The development of rigid airships comprising of lightweight framework and synthetic fabric cladding marked the beginning of research work on fabric properties and its stress–strain behaviour. More recently, the application of surface-curvature principle in conjunction with prestressing made it possible to use fabrics to meet architectural requirements for covering areas larger than those conventional towing tents or circuses. These structures which are referred to as membrane or tension structures utilises coated fabrics which are composites comprising of synthetic $bres as the base and a compatible coating, as illustrated in Fig. 1. Among the numerous compatible combinations of $bres and coating, only three are readily commercially available. These are polyvinyl chloride (PVC-) coated polyester fabric, polytetra=uoroethylene (PTFE-) coated glass $bre fabric and silicone-coated glass; the last one being only recently introduced and used in the last 5 years.

Weatherability refers to the various changes in appearance and functional value of exposed surfaces. It includes all parameters of exterior serviceability such as retention of colour and gloss, chalking, blistering, =aking, peeling, cracking and erosion. Resistance against dirt and surface degradation are probably the most important material characteristics of fabrics for membrane roofs to ensure life long aesthetic worthiness. In recent years, various types

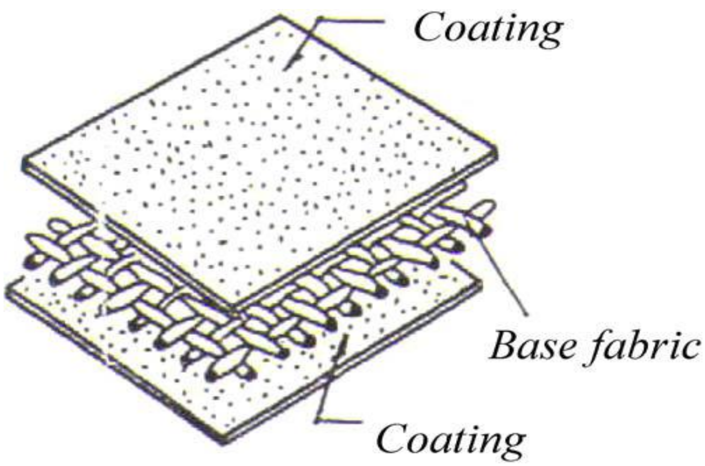



Fig. 1. General structure of coated fabric.

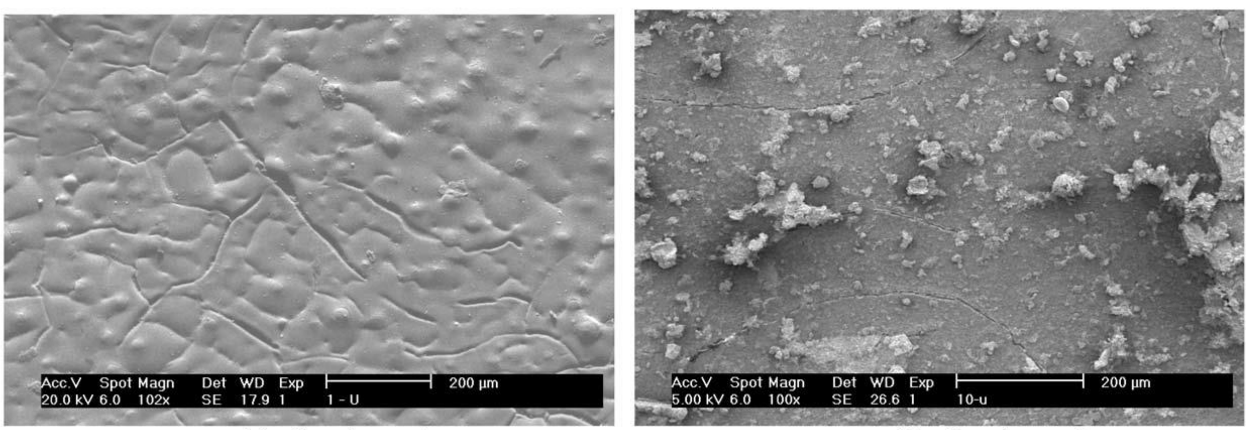
of new coating and surface treatment for the fabrics have been developed and their e7ectiveness evaluated based on long-term exposure tests. PTFE-coated glass $bre fabrics have been known to be durable with a life expectancy of more than 20 years and often become the popular choice for the construction of permanent membrane roofs. In contrast, PVC-coated polyester $bre fabrics have a shorter service life. These fabrics are sometimes surface treated with a thin $lm of various other compounds to enhance durability. The performance of the coatings or $lms is best evaluated through exposure studies over a range of representative climatic conditions. In the past decade, many experiments and studies have been conducted on coated fabric materials but mostly in Japan [1–3]. However, the performances of these materials, which are subjected to temperate climatic conditions in past investigations might be insuGcient to indicate its suitability under di7erent weather conditions.

Membrane roofs have become increasingly popular in Malaysia during the last few years, the most recent and major project being the construction of the sports stadium for the Commonwealth Games in 1998 as shown in Fig. 2. Malaysia has a hot and humid climate being situated about $2^\circ$N of the Equator. Day temperatures normally rise above $30^\circ$C, while during the nights they rarely drop below $23^\circ$C. Solar radiation which is closely related to the sunshine duration is seasonal and spatial variations occur very much the same as in the case of sunshine, which on average is about 6 h=day. The climate is dominated by the e7ect of two monsoons or “rainy seasons”, which a7ect di7erent parts of Malaysia to varying degrees giving very large variations in monthly average rainfall throughout the country. Thus with much harsher weather conditions, it is expected that the weatherability of the fabrics will be put to much greater trials. Moreover, the results obtained from exposure test conducted in Malaysia would supplement existing data and information from previous exposure tests. Thus the main objective of this study is to establish the performance characteristics of various coated fabrics exposed to typical tropical weathering conditions. The performance characteristics are related to changes in appearance and functional aspects of the exposed surfaces, which includes dirt repellency, discolouration and coating condition, and the results obtained during the $rst two years of exposure are presented in this paper.

## Test programme

A total of 10 di7erent types of commercially manufactured fabrics for membrane roofs which include four PTFE-coated glass $bre fabrics and six PVC-coated

Fig. 2. Commonwealth sports stadium, Bukit Jalil, Malaysia.




**(a) Specimen A** **(b) Specimen J**

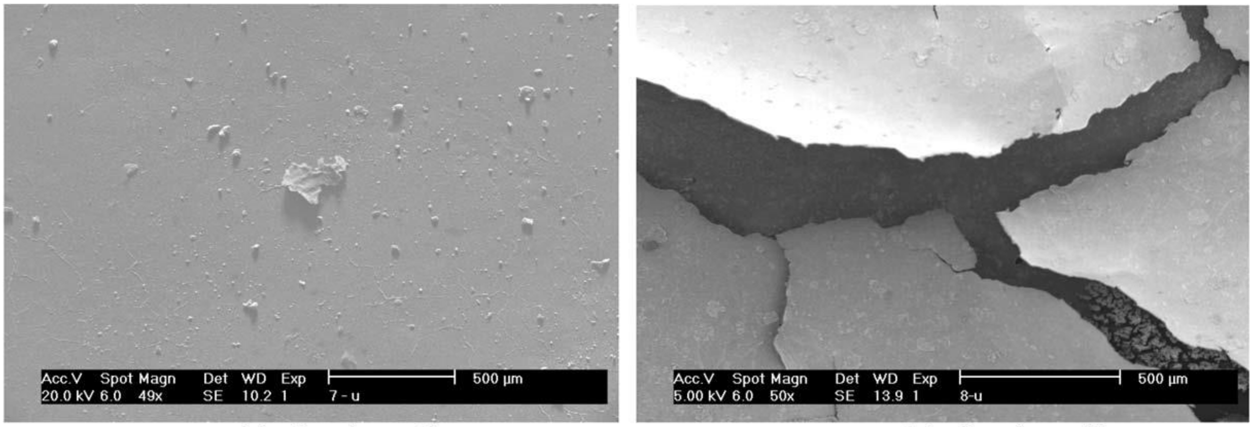
Fig. 7. Dirt repellency of fabrics, (a) specimen A, (b) specimen J.

PVF (specimen E and I) and PVDF (specimen G). In contrast, insuGcient thickness of surface treatment material, as in the case of specimen H (5 _m PVDF compared to 20 _m PVDF for specimen G), makes it very susceptible to weathering and surface degradation. As a consequence, the adherence of dirt and other airborne particulates becomes very signi$cant which accounts for its poor performance compared to other fabric specimens. The dirt repellency of the PTFE-coated fabrics is generally comparable with the surface treated PVC-coated fabrics. PTFE is well known for its low coeGcient of friction, such that dirt or particulate that adhere on to its surface, can be easily washed o7 when it rains.

Examination of the specimens under high-magni$cation using a scanning electron microscope, revealed the occurrence of cracks, peeling and fungus. The results are summarized in Table 2, and it is apparent that several of the fabrics experienced some form of surface degradation. The severity and extent of the deterioration especially for the PVC-coated fabrics was very much dependant on the type of surface treatment. Cracking of the surface treatment layer were observed on all the PVC-coated fabrics with specimens F,G,I and J showing the least severity. The occurrence of cracks on specimens E and H was rather widespread and this promoted dirt adherence and growth of fungus within the cracks. Generally the morphological changes on the PTFE-coated fabrics are insigni$cant and very little signs of degradation due to the e7ect of weathering existed. Thus it is evident from the results of this investigation that the PTFE-coated fabrics are more stable when exposed to tropical weather.

The micrographs shown in Fig. 7 highlight the selfcleaning properties of both PTFE-coated (specimen A) and PVC-coated (specimen J) fabrics. Both the specimens are not surface treated but it is evident that there is visually no signs of dirt or adherence of large particulates on specimen A, while on specimen J the presence of airborne particulates is rather extensive.

The e7ect of di7erent thickness of $lm on the stability of the materials can be observed in Fig. 8. Specimen G with a thicker layer of PVDF film is less susceptible to cracking as compared to specimen H which was cracked and had peeled o7. Furthermore, the occurrence of wide cracks on specimen H promoted the growth of fungus as shown in




(a) **Specimen G** (b) **Specimen H**

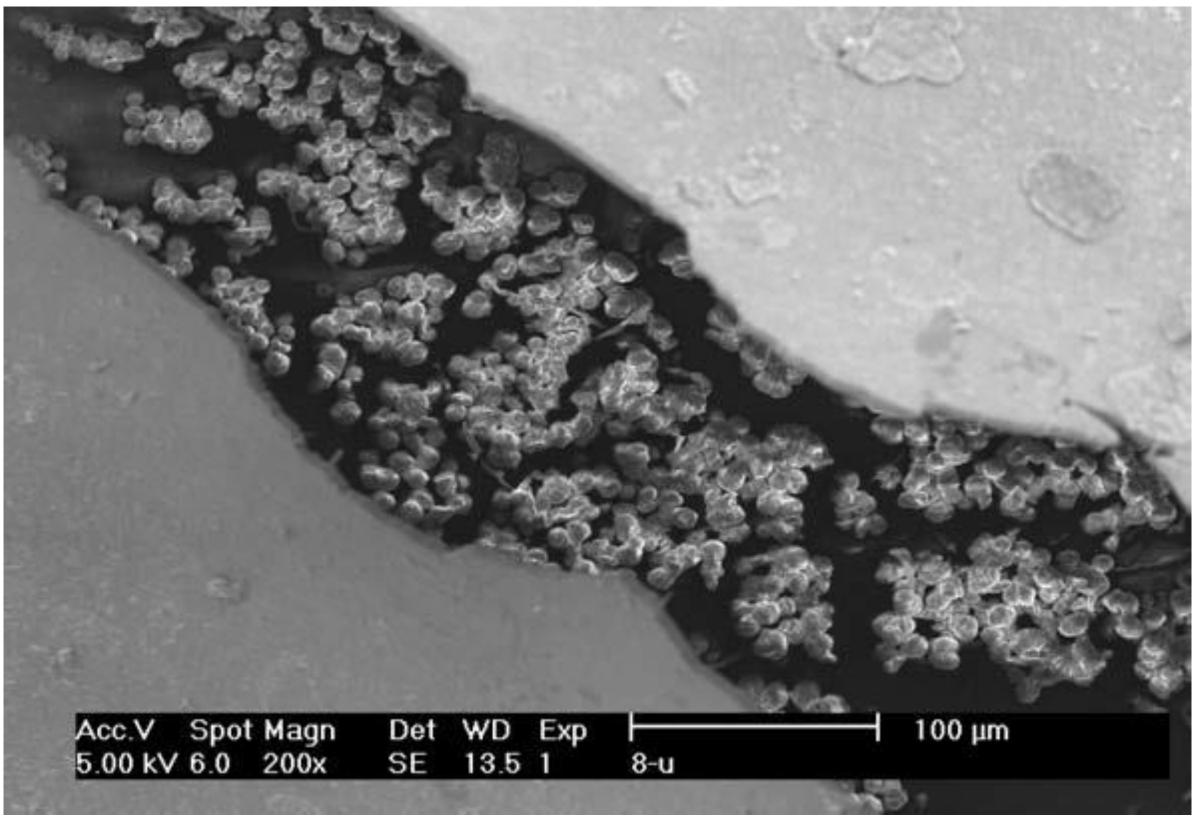



Fig. 9. Fungal growth in crack.

Fig. 9. This contributed to the exceptionally high colour di7erence and particulate density values as given in Fig. 5.

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