Selecting Coatings for Bridge Maintenance

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As we all know paint is an extremely complex chemically and physically engineered material which undergoes a series of changes during application, curing and weathering, during service. The manufacturers of these paints work hard to ensure the paint materials are formulated correctly and suitable for their specified uses for which they are put through rigorous testing. However, they cannot test their materials against all eventualities in the "real world" and therefore it becomes necessary to test these paint systems further in-situ, which is an important factor when consideration needs to be given to maintenance painting of existing structures, such as bridges.

Recently a Bridge Owner approached a specialised Consultancy explaining they had numerous structures ranging from gantries and small footbridges to major motorway crossings across their network, and had heard about previous trials undertaken by them to evaluate the most suitable Highways approved maintenance paint systems from various paint manufacturers, and they wished to extend these trials on to their bridges. The client also expressed their wish to produce a series of re-coating specifications/systems most suited to the bridges they had on their network, ideally concentrating on extending the life of existing coatings and which would also require compatibility to be tested during the trials.

These feasibility type trials are a sound approach to determine the optimum method of surface preparation and the extent of the requirements, and how the system performs after various methods of preparation. They also ensure a contractor tendering for future works is aware of the requirements and the difficulties in the maintenance painting, and go some way in meeting the client's requirements. However, the planned trials go a little further and evaluate paint systems which are generically the same, but produced by different manufacturers.

This article describes the testing protocol and the results obtained for specific bridge/coating specifications.

Following a review of archived documentation detailing "as built" specifications including past coating maintenance and also a physical and visual examination of a reasonable cross section of the bridge structures across the client's network, it was established that even with the changes in protective coating technology for all steel highway structures since the 1970's there were three main paint systems present. These were modified alkyds, chlorinated rubbers and the more modern epoxy coatings. Thermal Metal Spray (TMS) was identified on a number of the bridges beneath a number of the paint systems. The coating condition of these systems not only varied between themselves but also there was a marked difference between each system of the same generic type, which would have been affected by factors such as original preparation, application and environment throughout the structures' service life.

Identifying the most typical coatings across this particular network resulted in the selection of five specific bridges which were to become the basis of trials to assess which paint manufacturers maintenance coating system would perform to its full potential. These bridges comprised of:

- A modified alkyd in fair to good condition, with a slight intercoat weakness between original primer and first intermediate build coat.
- A modified alkyd in fair condition, with a slight cohesive weakness within the original intermediate build coat.
- A chlorinated rubber in good condition, with a slight cohesive weakness within the original intermediate build coat.
- A chlorinated rubber in fair to good condition, with a slight cohesive weakness within the original intermediate build coat.
- An epoxy system in good condition, with good adhesion properties throughout the original system.

Previous trials by the consultancy on other similar structures where six to eight Highways England approved coating systems had been trialled and tested, had identified three paint manufacturers who's products had performed well when applied to aged existing systems of varying condition and type, and it was these three paint manufacturers that the client wished to take forward for this current trial.

A draft specification with relevant clauses covering cleaning, surface preparation and coating application, including mixing, storage and environmental conditions, was produced. Each of the three paint manufacturers' Highways England approved paint systems selected would be applied over various methods of surface preparation and existing coatings:

- A full dry abrasive blast clean to an Sa2½ to assess general performance and as a baseline to overcoated performance.
- A dry abrasive blast in patches with a thorough sweep blast to a sound coated surface to assess compatibility and performance over original coating types.
- A mechanical hand and power tool abrade to remove unsound coatings and provide a "key" for the maintenance coatings to assess compatibility and performance over original coating types.

Each test area on the selected bridges was fully cleaned, prepared and primed during the trials in accordance with both the draft technical specification and the paint manufacturers'

recommendations and once the required overcoating period for the primer had elapsed the intermediate build coat and topcoats were applied. These coating systems were:

- Full primer coat of Item No. 115 (High Build Aluminium Epoxy – 2 pack)
- Full intermediate build coat of Item No. 116 (High Build Epoxy – 2 pack)
- Full topcoat of Item No. 169 (Polyurethane – 2 pack)

It should be noted that due to the fact these were compatibility trials to assess the optimum system for varying existing coating conditions and particular methods of preparation, the use of a stripe coat was omitted from the trials, which were undertaken on flat surfaces, with no fixings or welds. With this as the only exception, the trials were undertaken in the same manner as would a maintenance re-painting contract.

During these trials, the consultancy provided full time inspection and Quality Control (QC) at each process step to ensure the specified criteria were being met, including visual assessment of preparation standard, surface cleanliness prior to any coating being applied, and wet film and dry film thicknesses of each coating. Mixing of the 2 pack paints was also carefully monitored. Each of the paint manufacturers were also invited along to confirm their products were mixed correctly and systems applied to their recommendations, and to a suitably prepared surface.

Once the preparation and application trials had been completed to the satisfaction of the client, paint manufacturer and the consultancy, they were left to cure and would be evaluated every 6 months for a total of two years, to assess overall performance.

On returning to the test patches after 6 months, a detailed survey and assessment was carried out on each patch at each location. This worked out at typically 18 patches per bridge to be evaluated by careful visual examination, non-destructive testing and also micro-destructive testing, along with removal of paint flakes for further microscopic examination. After this initial testing period, it was clear that there was very little difference between the manufacturers' systems. All remained slightly soft and "cheesy" where overcoating had occurred, and a strong smell of solvent remained. St Andrews Cross-cut testing was

Table 1: Summary of Findings at 24 months

Original System	Paint Manufacturer	Sa2½	Sweep Blast	Abraded
A modified alkyd in fair to good condition, with a slight intercoat weakness between original primer and first intermediate build coat	PM 1	FAIR/GOOD	POOR	POOR
	PM 2	VERY GOOD	POOR	POOR
	PM 3	FAIR/GOOD	POOR/FAIR	FAIR
Comments: Although all three systems appear to have emphasised the intercoat weakness within the original system when overcoated there is far less effect from the PM 3 system.				
A modified in fair condition, with a slight cohesive weakness within the original intermediate build coat	PM 1	FAIR	POOR	POOR
	PM 2	GOOD	POOR	POOR
	PM 3	FAIR	POOR	POOR/FAIR
Comments: PM 2 performed best on the blast cleaned steel. There was little difference between the systems when overcoating the sweep blast surfaces as all performed poorly and appeared to emphasise the cohesive weakness within the original coating system, similar to the abraded surfaces but PM 3 had less impact.				
A chlorinated rubber in good condition, with a slight cohesive weakness within the original intermediate build coat	PM 1	GOOD	FAIR	POOR
	PM 2	GOOD	GOOD	GOOD
	PM 3	GOOD	FAIR	FAIR/GOOD
Comments: PM 2 performed best on all three trial patches.				
A chlorinated rubber in fair to good condition, with a slight cohesive weakness within the original intermediate build cost	PM 1	FAIR/GOOD	FAIR	POOR/FAIR
	PM 2	GOOD	FAIR	POOR/FAIR
	PM 3	POOR/FAIR	GOOD	FAIR/GOOD
Comments: PM 3 performed best on the overcoating patches but poorly on the blast cleaned steel, there was a significant embrittlement noted on this patch.				
An epoxy system in good condition, with good adhesion properties throughout the original system	PM 1	GOOD	VERY GOOD	VERY GOOD
	PM 2	GOOD	VERY GOOD	VERY GOOD
	PM 3	FAIR	FAIR/GOOD	FAIR/GOOD
Comments: PM 1 & 2 performed equally well, but PM 3 had some embrittlement throughout all patches.				

used to assess adhesion and cohesion strengths and weaknesses. Solvent swab testing was used to ascertain the degree of cure and although 6+ months had elapsed since topcoat application it was interesting to find that two of the manufacturers products had not cured as fully as the third.

The removed paint flake samples were examined in both plan and cross section perspective under a microscope at 50X and 400X magnification. This found very little variance across the trialled topcoats but in cross section some differences were noted such as vacuoles within one manufacturers intermediate build coats and although relatively small could potentially impact the overall permeability of the full coating system.

After 12 months in service the trial areas were re-examined and tested. Again, there was very little difference between

Figure 1: Typical trial patch layout [S=Sweep B=Blast A=Abrade].

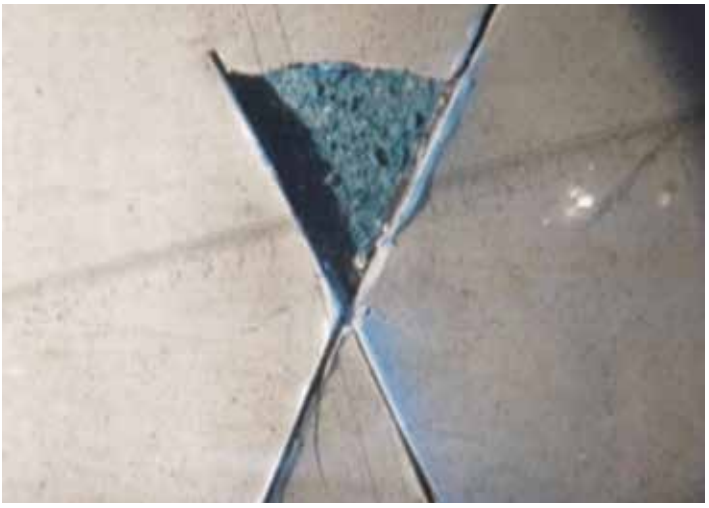

Figure 3(b): Abraded and overcoated with PM 1 system emphasising the cohesive weakness within original.

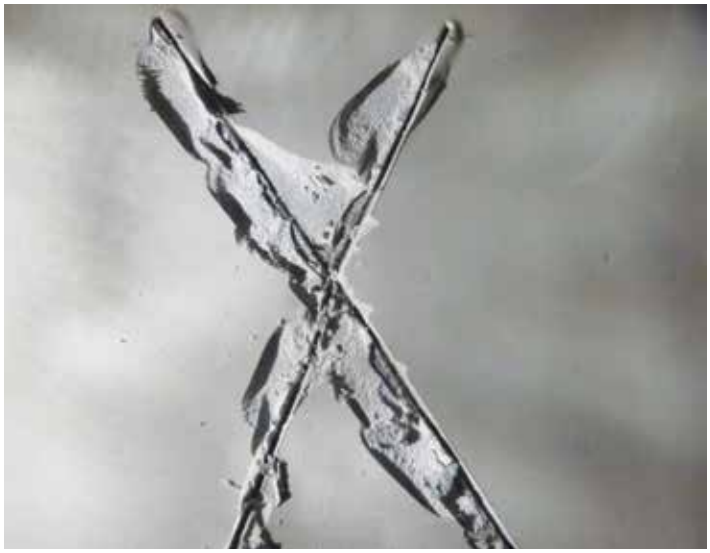

Figure 2: Embrittlement of paint system applied to Sa2½ after 24 months service.

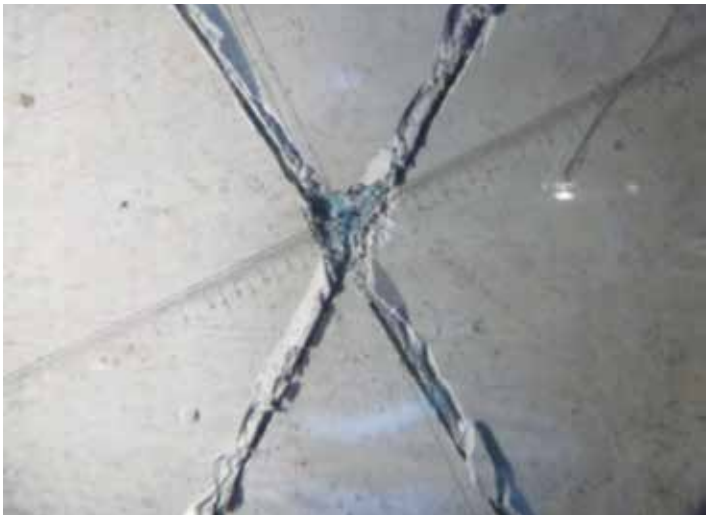

Figure 3(c): Abraded and overcoated with PM 3 system with significant reduction in the cohesive weakness within original.

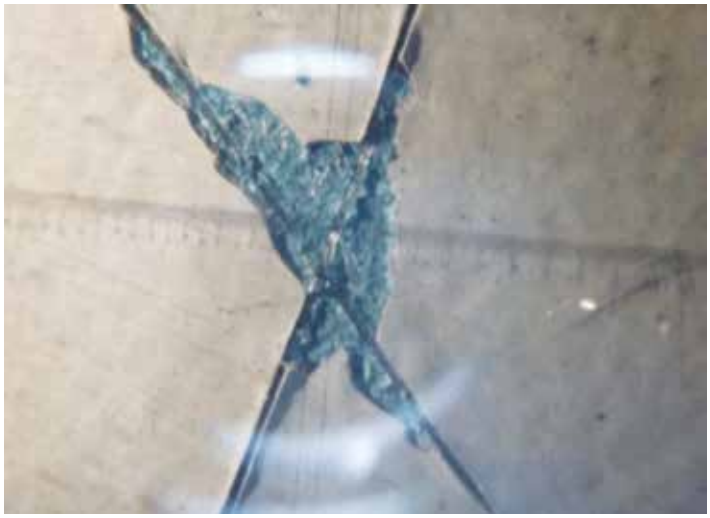

Figure 3(a): Original system with cohesive weakness.

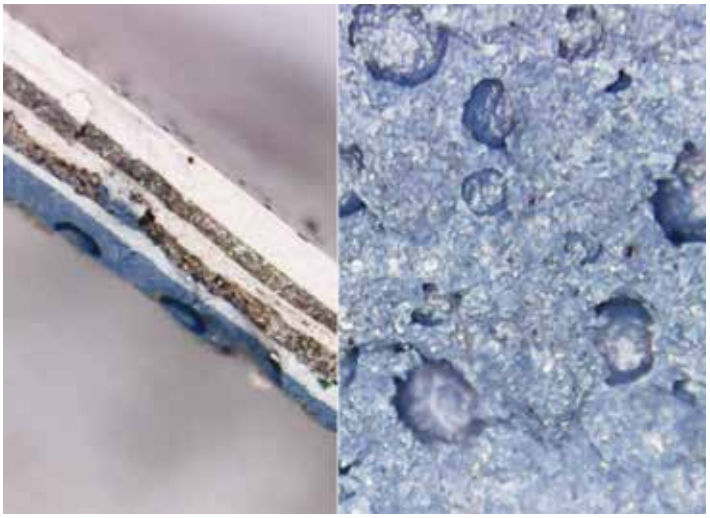

Figure 4: Vacuoles within original coating where cohesive weakness was identified {Cross section and plan views].

Figure 5: General view of typical bridge beam configuration.

Figure 6: General view of footbridge configuration.

the topcoats' condition and only some "cheesiness" remained when micro-destructively testing the systems on the overcoated areas, although the smell of solvent was less, compared to the trial patches on the bare steel areas. Adhesion and cohesion properties were similar to that found during first test period, with good adhesion throughout each system on the bare steel areas and only some slight detachment where overcoating had occurred to the chlorinated rubber and alkyd systems, the existing overcoated epoxy was found to be good throughout the three manufacturers at this time.

At 18 and 24 months was when significant differences were identified after micro-destructive examination. It became clear that one of the manufacturers systems had now fully cured and had become slightly brittle in a number of instances, both on overcoated and bare steel applications. Another of the manufacturers' products remained similar to the 12 month trial with generally good adhesion to the bare steel but some detachment where the chlorinated rubber and alkyd paints had been overcoated. In some cases, it appeared that the properties within the original coatings had improved with the inherent weaknesses reduced slightly, some had no impact and others had emphasised the weaknesses.

It is these slight differences that the specialised consultancy were interested in, and during the full detailed evaluation of the bridge trials and laboratory examination of paint flakes a "Horses for Courses" type specification with recommended preparation and paint manufacturers systems could therefore be produced. Going forward, a coating condition survey will be used to classify each bridge structure, so the correct method of preparation and optimum paint manufacturers products can be selected at the ideal intervention period, without the requirement for further feasibility trails in the future, and thus providing best value for money.

A summary of the coating systems performance on each of the substrates and existing coatings is given in Table 1. The patch layout is shown in Figure 1 and the embrittlement seen after 24 months is shown in Figure 2. The influence of the original weaknesses can be seen in Figure 3 (a-c).

Figure 4 is an example of the vacuoles seen in the existing coating.

In conclusion, the consultancy was able to obtain meaningful information following the trials and to produce a menu of paint manufacturers maintenance systems for a particular method of preparation, depending on the existing coating type and condition.

It is obviously essential to determine the condition of the existing paint on a bridge structure before specifying and applying a new more highly stressed overcoating material to ensure the optimum life to next major maintenance is achieved. Unfortunately though the coating condition of some bridge structures do not lend themselves to maintenance overcoating and will require complete removal. Once the bridge coating condition has been established the recommendations can be made for the way forward by selecting the most suitable method of preparation and the accompanying coating system from the bridge owner's "a la carte" type menu.

It should be noted that the three paint manufacturers selected were purely based on performance in previous trials on similar coatings of the types and conditions to be maintained by this particular client. If the coating condition and type of coatings to be maintained had a different criteria, then an alternative list of paint manufacturers could have been selected.