Concrete overlay versus Reconstructing as a repair method to damaged concrete pavement at the Durban Container Terminal

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ABSTRACT

Concrete overlays for concrete pavement have not been used locally, but there is extensive experience of the method abroad and particularly in the USA, where concrete as a paving material in port terminals, airports and highways remains popular. Asphalt overlays have been used more extensively locally, and recently in the Gauteng Freeway improvement programme, where both unreinforced, jointed and continuously reinforced, un-jointed pavements have been overlaid. For container terminals, asphalt overlays are not an option because of the high loading applied, particularly in the container stacks. The method proposed for the Durban Container Terminal (DCT) is therefore for a reinforced concrete overlay. Alternatives using steel or polypropylene fibres have been investigated but have not been pursued because of cost and other considerations. Given that the bulk of the terminal paving is intact, and severely stressed areas either have been, or are programmed to be repaired, the construction of an overlay is an option as construction time is minimized, resulting in reduced terminal disruption, the remaining capacity of the existing pavement is utilized, construction cost is lower than reconstruction and this option is more environmentally acceptable.

INTRODUCTION- BACKGROUND OF THE STUDY

The need has never been greater for engineered strategies to preserve and maintain the nation's pavements. With shrinking budgets, ever-increasing traffic volumes and loads, and the critical emerging focus on infrastructure sustainability and pavement preservation, highway agencies are being asked to do more with less in managing their pavement networks (Concrete Overlays, 2011). Concrete overlays can serve as sustainable and cost-effective solutions for improved management of pavement assets, including preservation, resurfacing, and rehabilitation. In addition, they contribute to more sustainable construction practices by preserving and extending pavement service for years beyond the original design life. Many concrete overlays have been in service for decades, effectively extending the life of the original pavement structures for 30 years or more (Guide to concrete overlays, 2014).

For successful overlaying of an existing pavement, the pavement must be free of major structural defects. Where existing slabs have failed completely or exhibit active cracks, these must be rectified before overlaying. Passive cracks, which represent the majority of cracks in the DCT terminal, do not need to be repaired.

Figure 1: Typical concrete overlay (before [left] and after concrete overlay placement [right])

OVERLAY ALTERNATIVES

Concrete overlays may be of the **bonded** or **un-bonded** type. The structural differences are substantial and are graphically illustrated in fig 2.

- Bonded overlays are constructed so as to be monolithic with the underlying slab, thereby strengthening the existing pavement. For successful application, full adhesion must be achieved and the existing concrete slabs must be essentially free from defects. The purpose of bonded concrete overlays is to add structural capacity and eliminate surface distresses on existing pavements that are in good to fair structural condition. Bonded overlays generally provide resurfacing solutions for routine or preventive pavement maintenance and for minor rehabilitation. The key to achieving desired performance is to ensure the two structures, the existing pavement and the overlay, behave as one structure (Guide to concrete overlays, 2014).
- An un-bonded overlay is separated from the existing pavement by a suitable separation layer. As there is no monolithic action with the existing slab, a thicker slab is required than in the case of a bonded overlay as illustrated in fig 2. Un-bonded overlays are however more tolerant of defects in the existing slab and prevent reflective cracking. The purpose of an un-bonded overlay is to restore structural capacity to an existing pavement that is moderately to significantly deteriorated. Un-bonded overlays are minor or major rehabilitation strategies. The term “un-bonded” simply means that bonding between the overlay and the underlying pavement is not needed to achieve the desired performance (i.e., the thickness design procedure does not consider the existing pavement as a structural component of the surfacing layer). Thus, the overlay performs as a new pavement, and the existing pavement provides a stable base. The indicated solution for DCT is therefore **un-bonded overlay.**

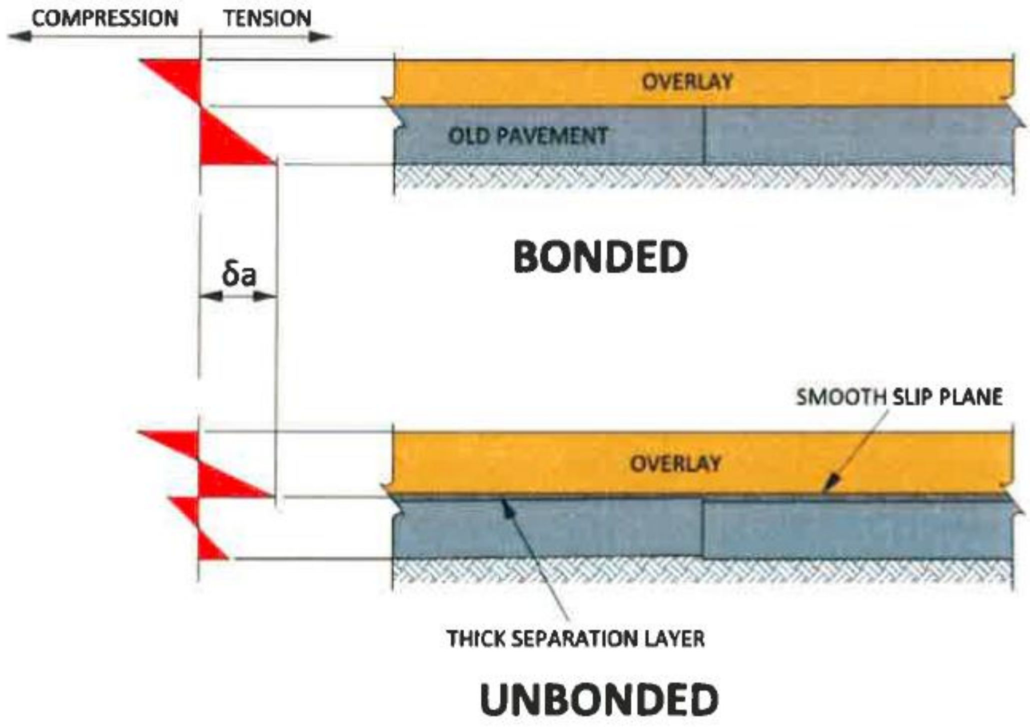

Figure 2: Structural difference between Bonded and Un-bonded overlays

STRUCTURAL OVERLAY RECOMMENDATION

With reference to the performance of overlays the most appropriate overlay for DCT is an un-bonded concrete overlay. The use of an un-jointed (in the longitudinal direction) continuously reinforced concrete overlay increases the tolerance of the overlay to defects in the existing slab, obviates the need for transverse joints in the paving, and can be more quickly constructed if the required paving equipment is available. A comparison of the construction costs for reconstructing the pavement or overlaying the existing pavement indicates a significant cost saving for overlaying (Table 1). The estimates are based on the assumption that the concrete rubble can be used as backfill to the gravity wall structure. Should this not be possible, for whatever reason, dumping costs could add significantly to the cost of reconstruction, and create an environmental problem.

Table 1: Cost of reconstruction vs overlay

Area /Phase	Remedial Measure	Unit cost	Discount factor	Period (Years)	NPV factor	Unit	Quantity		Overlay	Reconst
							Overlay	Reconst		
Berths 203-205	Reconstruct paving	1775			1.00	m²		442740	0	785 774 952
	Overlay Paving	954	1.08	0	1.00	m²	442740		422 152 590	0
	Repair existing paving for overlay (5%)	89	1.08	0	1.00	m²	442740		39 288 748	0

	Maintain new paving (@ 0.1% of reconstruct)	2	1.08	20	9.818	m²	442740	442740	4 144 694	7 714 738
	Replace slot drains with paving reconstruction	6799	1.08	0	1.00	m		14670	0	99 744 264
	Replace slot drains with paving overlay	7840	1.08	0	1.00	m	14670		115 012 800	0
	Maintain new slot drains (@5% of reconstruct)	34	1.08	20	9.818	m	14670	14670	4 896 446	4 896 446
	Sub Total								585 495 278	898 130 400
	P&G Costs (30%)					Sum			175 648 583	269 439 120
	Contingencies (20%)					Sum			117 098 056	179 626 080
	EPCM Costs (12%)					Sum			70 259 433	107 775 648
	Unit Cost (R/m²)								2142	3296
	Total								948 502 350	1 454 971 249

The cost of reconstructing the pavement is seen to be substantially higher than the cost of overlaying by approximately 50%. Overlaying the existing pavement is accordingly adopted in preference to reconstruction in considering the various operation options.

Construction time and operational disruption are also minimized. The use of a continuously reinforced, slip formed reinforced concrete overlay is accordingly recommended solution for continued use of straddle carriers (SC), particularly for the heavier 1/3 machines. Overlaying is also an option for Rubber Tyred Gantry (RTG) operation. A slightly thicker overlay is required for the 5 high stacking associated with RTG operation. The marginal cost of increasing the overlay thickness is however minimal.

The recommended separation layer, dictated by the condition of the existing slabs, is for a 25mm asphalt layer. Apart from performing the debonding function, this separation layer facilitates the accommodation of moderate faulting, surface spalling and joint spalling in the existing slab without having to repair these defects.

The thickness of the overlay, which is dictated by the condition of the existing pavement and the thickness of the monolithic pavement required for the design load on the existing support, is calculated at 300mm for 5 high stacking. This is based on the assumption that major defects in the existing slab will be rectified before overlaying. The thickness of the required overlay slab is based on the Pier 1 slab design which was designed for the loading which is assumed to be appropriate for Pier 2 i.e. either 1/3 straddle operation or RTG operation with 5-high stacking. Slab reinforcement is designed on the basis of crack control. As it is desirable to limit crack spacing and crack width for the purpose of minimizing moisture ingress and shear transfer in the slab, the reinforcing content is selected accordingly.

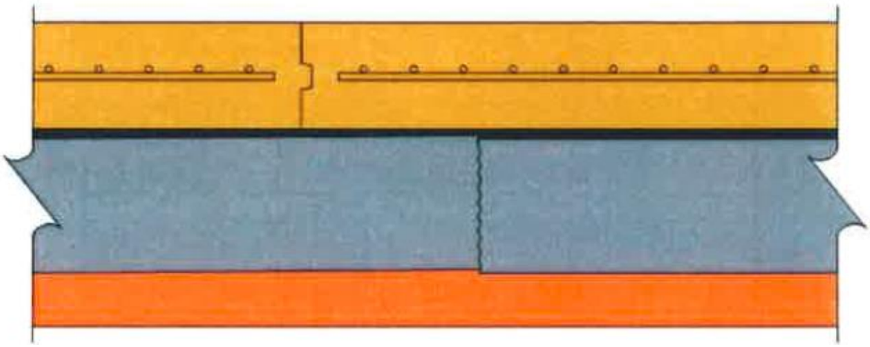

Figure 3: Concrete overlay of existing pavement

Drainage

The existing terminal is drained by way of slot drains running the length of the terminal at intervals of approximately 30m. The average drain length is approximately 1000m. As there are approximately 7 drains, the total length of the slot drains in the terminal is of the order of 7km in berth 203-205 terminal. The drains comprise of a precast top which incorporates the drainage slot, supported on a precast concrete base slab 2m wide as shown if Fig 4. As the buttresses across the slots are inadequate to resist compressive forces arising from slab expansion, expansion joints are provided on either side of the drain as shown.

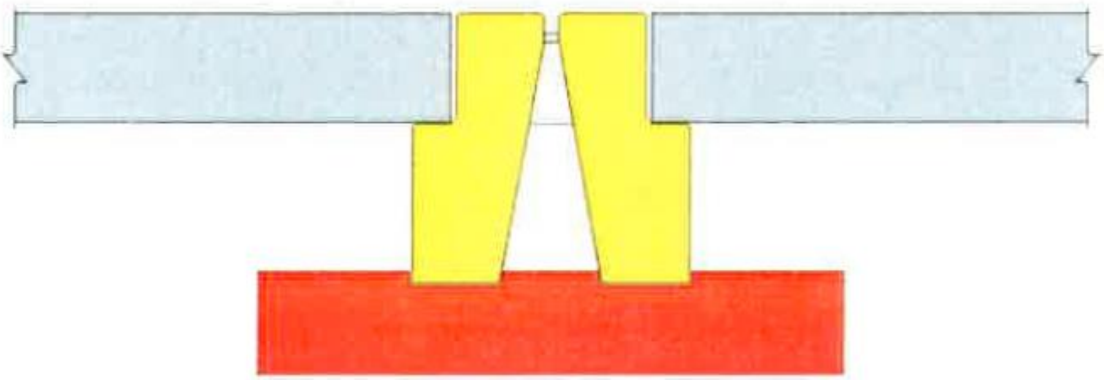

Figure 4: Profile of Original Slot Drain

As a result of the flat soffit and the fact that there is no longitudinal gradient on the drains, flow rates in the drains are insufficient to carry sand to the catch-pits for removal. Consequently many of the drains have become silted up and dysfunctional. Some of the pavement failure is attributed to saturation of the subgrade as a result of blocked drains. Another problem with these drains is there susceptibility to spalling. Although efforts to unblock the drain have been made, the difficulties are reported to have resulted in abandonment of cleaning efforts, and many of the drains remain blocked.

Conclusion and recommendations

Concrete overlays can serve as sustainable and cost-effective solutions for improved management of pavement assets, including preservation, resurfacing, and rehabilitation. In addition, they contribute to more sustainable construction practices by preserving and extending pavement service for years beyond the original design life.

I would recommend that the **un-bonded overlay** option be implemented based on the above research as opposed to reconstruction.

References

1) *Guide to concrete overlays* (online). (2014). Available: http://www.cptechcenter.org/technicallibrary/documents/Overlays_3rd_edition.pdf (Accessed 11 September 2015).
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