A ROAD PAVEMENT FOR VERY RAPID CONSTRUCTION – 25 to 35 YEARS OF SUCCESS

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Australian Asphalt Pavement Association
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RTA NSW

WHY THIS PAPER?

- Full Depth Asphaltic Concrete (FDAC) pavements constructed at a Sydney western suburbs urban Council commencing in the mid 1970 decade.
- Construction on heavily trafficked roads in commercial areas on clay subgrades - approx 4 day soaked CBR = 1 to 4%.
- Construction very fast – often in one weekend.
- Used 28 – 40mm aggregate in base AC layer.
- Grader laid AC base layer – 1,000t/shift/grader is achievable.
- Simple QA procedure.
- Performing well after 36 -23 years.
- Positive feedback from the community and motorists.
- Many engineers and contract staff do not know of the process' used then and are sceptical.
- The knowledge of these FDAC pavements is disappearing as people retire or die.
- Detailed testing now undertaken of 6 of these roads with this Paper presenting the findings and comparing the estimated cost & construction times for comparable 'standard' pavements.
- NB The author has no affiliations with any asphalt Co or organisation.

HISTORY - A

- Early 1970 decade:
  - Bankstown Council considered a FDAC construction within its main shopping centre – Fetherstone Street.
  - On a clay subgrade – approx 4 day soaked CBR = 3%.
  - Decided instead to use 150-200mm cement bound base + 150 AC.
  - Rained and major problems encountered.
  - Over time and over budget.
- Mid 1970 decade:
  - Blacktown Council learning from the above experience reconstructed a road in its main shopping centre with 250mm FDAC (base AC – 40mm stone) – Alpha Street (ESA = $1.6x10^6$)
  - On a clay subgrade – 4 day soaked CBR = 3.1%, no concern regarding plasticity Index (PI).
  - Nil to negligible subsoil drainage.
  - Pavement completed within one weekend, with final AC on a later weekend.
  - Base AC laid by grader. This was important as use of a paver overstresses the clay subgrade, particularly by the delivery trucks loading into the hopper of the paving machine.
  - No subgrade left open for more than 4 hours.
  - Very successful, and within budget.
  - Deflection testing a few months later indicated an excellent result.
  - Only compliments from the community and motorists.
  - At that time, cost was approx 15% higher than a 'standard' road base pavement, but higher cost was deemed acceptable due to reduced effect on the community.
  - Based on this success, the Council went on to construct many more of which 6 are the subject of this Paper and indicated in the following photographs.

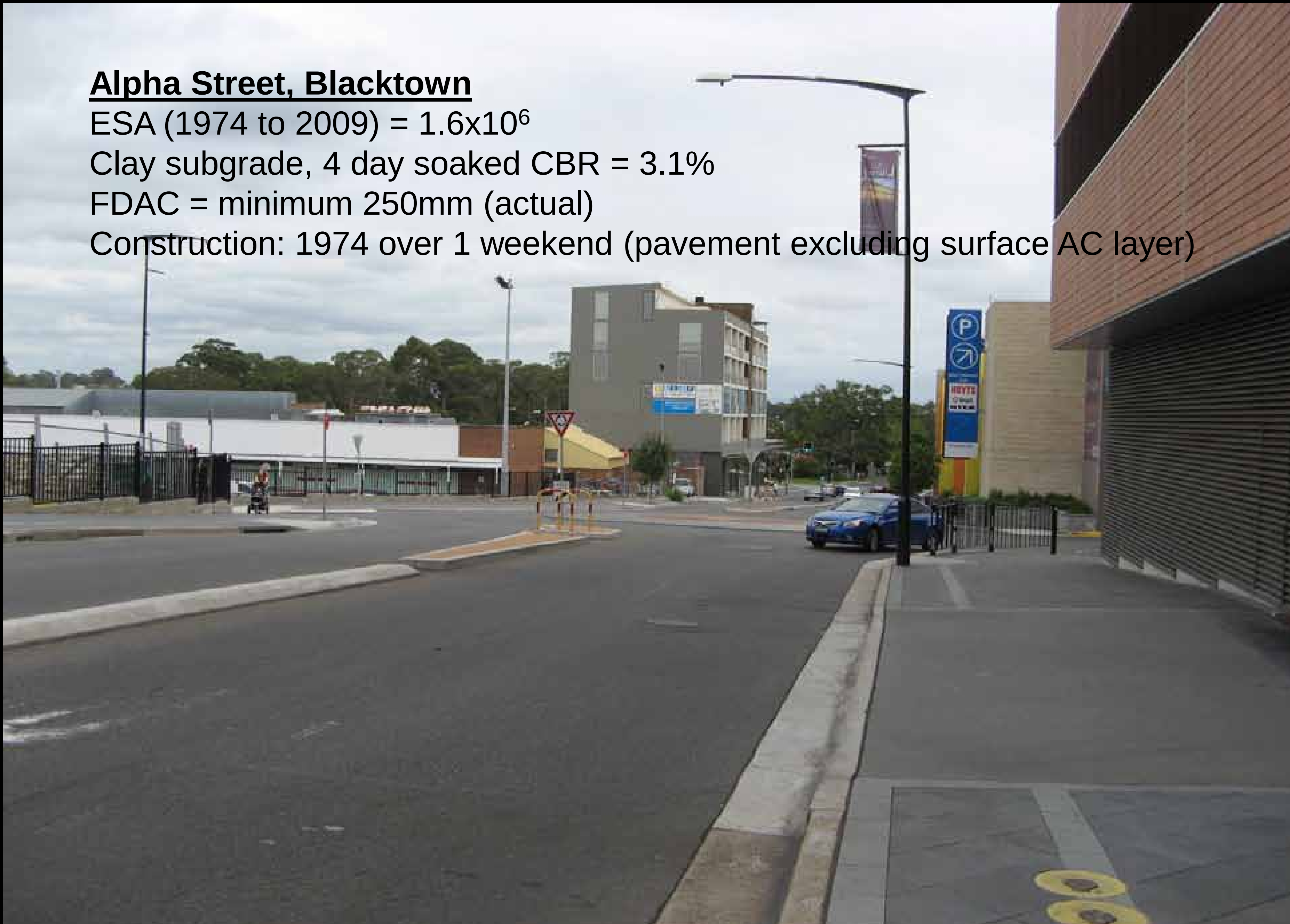
<u>Alpha Street, Blacktown</u>

ESA (1974 to 2009) = 1.6×10^6

Clay subgrade, 4 day soaked CBR = 3.1%

FDAC = minimum 250mm (actual)

Construction: 1974 over 1 weekend (pavement excluding surface AC layer)



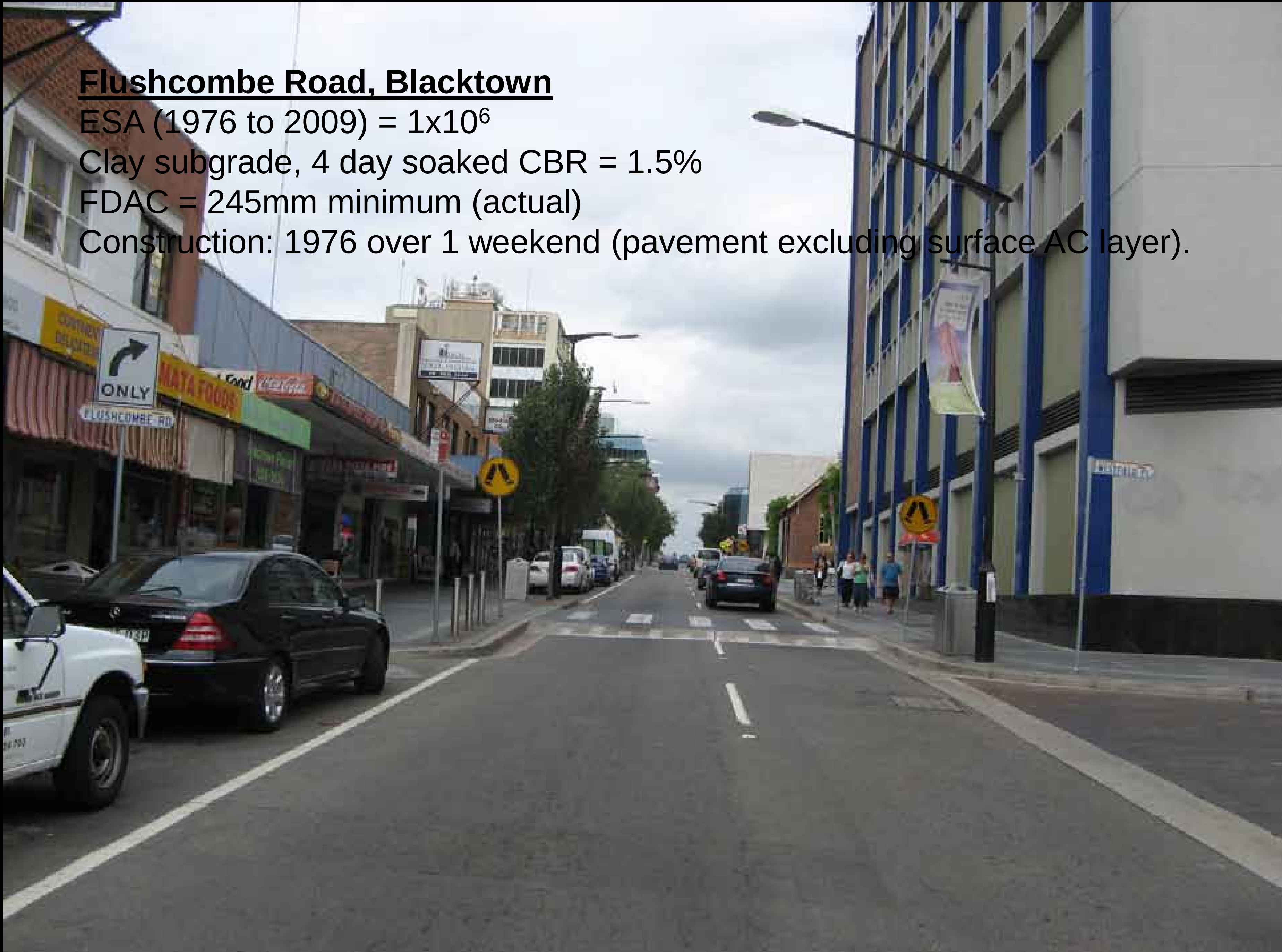
Flushcombe Road, Blacktown

ESA (1976 to 2009) = 1×10^6

Clay subgrade, 4 day soaked CBR = 1.5%

FDAC = 245mm minimum (actual)

Construction: 1976 over 1 weekend (pavement excluding surface AC layer).



Newton Road, Blacktown

ESA (1980 to 2009) = 3×10^6

Clay subgrade, 4 day soaked CBR = 1.5%

FDAC = minimum 250mm (actual)

Construction: 1980 over 1 weekend (pavement excluding surface AC layer)

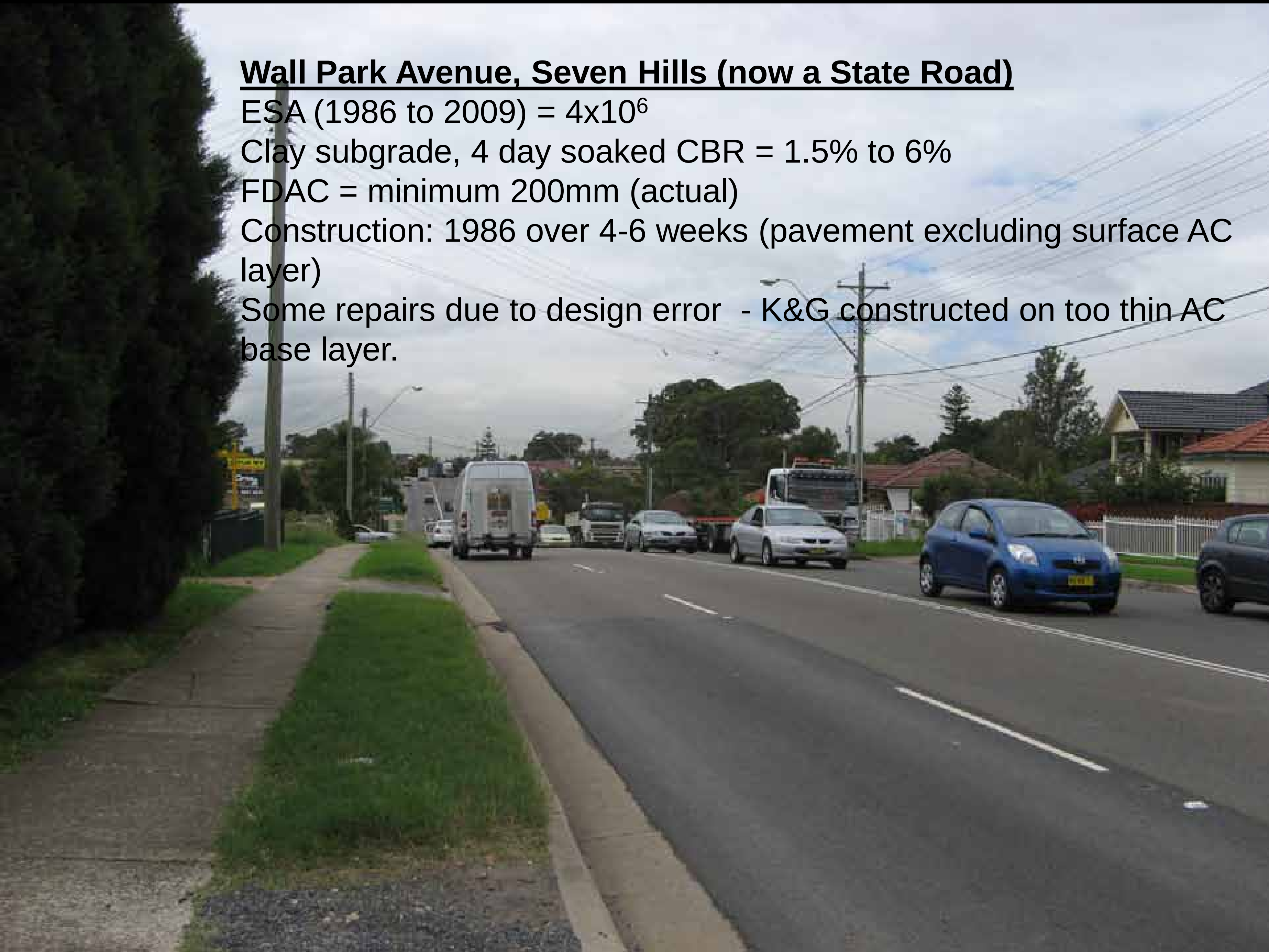
Prospect Highway, Seven Hills (now a State Road)

ESA (1982 to 2009) = 4.7×10^6

Clay subgrade, 4 day soaked CBR = 1.5%

FDAC = minimum 310mm (actual)

Construction: 1982 over 1 week (pavement excluding surface AC layer)



Wall Park Avenue, Seven Hills (now a State Road)

ESA (1986 to 2009) = $4x10^6$

Clay subgrade, 4 day soaked CBR = 1.5% to 6%

FDAC = minimum 200mm (actual)

Construction: 1986 over 4-6 weeks (pavement excluding surface AC layer)

Some repairs due to design error - K&G constructed on too thin AC base layer.

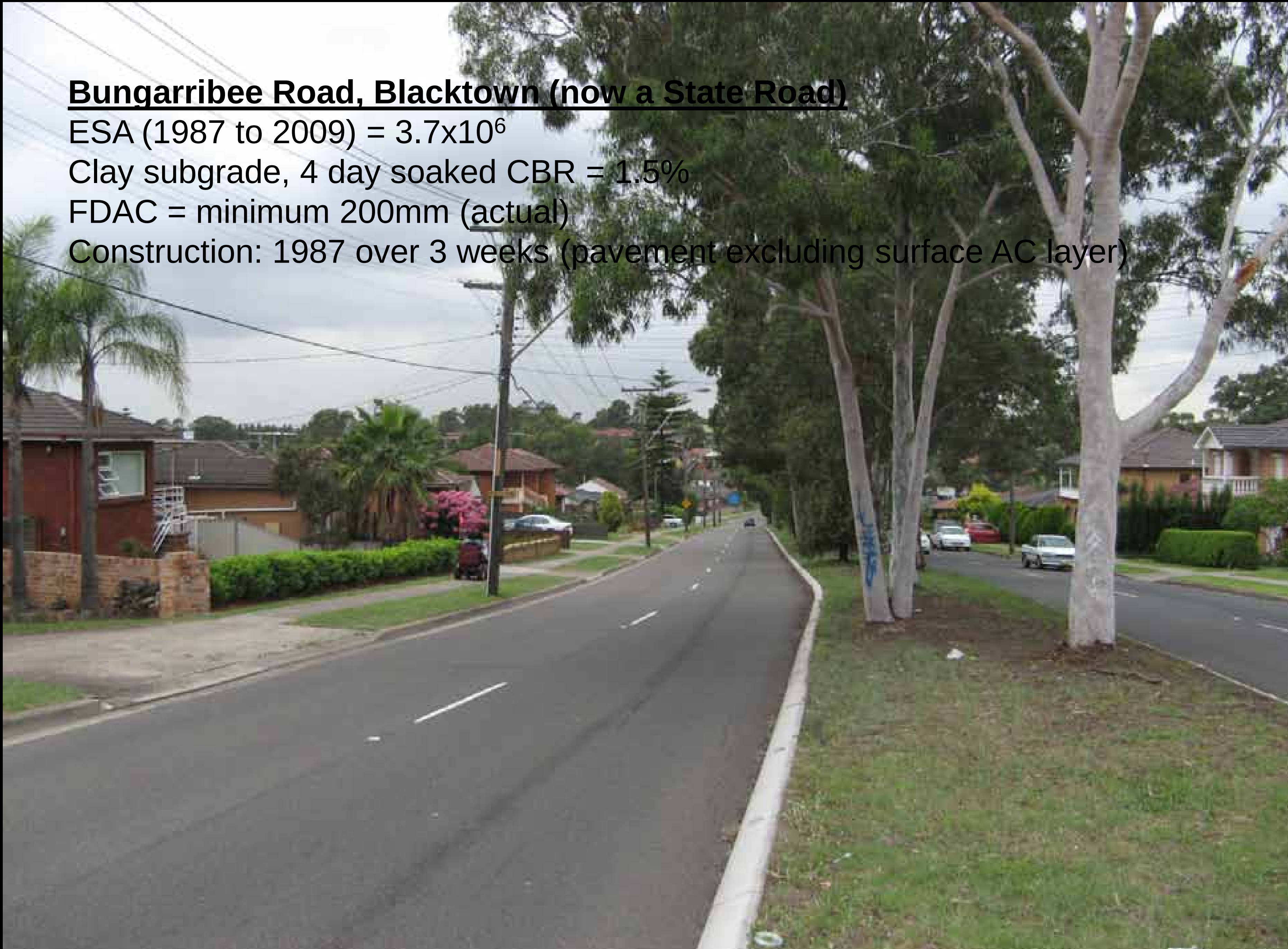
Bungarribee Road, Blacktown (now a State Road)

ESA (1987 to 2009) = $3.7x10^6$

Clay subgrade, 4 day soaked CBR = 1.5%

FDAC = minimum 200mm (actual)

Construction: 1987 over 3 weeks (pavement excluding surface AC layer)



HISTORY - B

Some interesting insights:

- Flushcombe Rd Project
  - During construction, at 2.00am Sunday morning, 50 m^2 of very poor subgrade encountered.
  - Excavated a further 150-200mm
  - AC 28 pushed into hole
  - Compacted with tracked excavator
  - Later deflection testing could not locate problem area.
- Corner Flushcombe Rd/Alpha St
  - A water main burst within the FDAC pavement in about 1984
  - Created 150mm dia hole and raised a section of FDAC about 15mm above the lip of gutter.
  - Deflection testing found the pavement was sound
  - Hole repaired and raised area milled and 25mm AC10 laid.
  - No problems since.

TESTING METHODS – For Subgrade and Asphalt

- **Subgrade**
  - Classification
  - In situ moisture
  - Plasticity Index (PI)
  - 4 day soaked CBR
  - 10 day soaked CBR
  - In situ CBR via Dynamic Cone Penetrometer during coring.
- **Asphalt**
  - Layer depth for different stone sizes
  - Nominal aggregate size
  - Density in base layer
  - Bitumen content in base layer
  - Type of bitumen in base layer (Penetration)

TESTING METHODS – Deflection and Remaining Life

- By Falling Weight Deflectometer (FWD) with 40Kn load.
- Carried out at 50m centres in each lane.
- 95th percentile deflection and mean curvature calculated
- ESA loadings calculated for following periods:-
  - Construction date to 2009
  - 2009 to 2019
  - 2009 to 2029
  - 2009 to 2059
- Remaining life in years calculated using the ELMOD program

TEST RESULTS – Subgrade and Asphalt

- **<u>Subgrade (17 cores)</u>**
  - All silty brown, red, & grey clay of high plasticity
  - Field moisture = 11% to 27.6%
  - PI = 15 to 60 with 14 of the 16 results being >25
  - 4 day soaked CBR = 1% to 6% with 14 of the 17 results being < 3.1%
  - 10 day soaked CBR = 0.5% to 4.5% with 13 of the 17 results being < 2.5%
  - In situ CBR via DCP = 2.5% to 29% with 11 of the 17 results being <15%

  The DCP results seem very high – normally would expect <9% and mostly approx 5% to 7%.
- **<u>Asphalt (23 cores)</u>**
  - Photographs exist of all cores
  - Base AC layers – 115mm to 260mm
  - Base AC stone size – one @ 40mm (Alpha St), rest @ 28mm
  - Bitumen content = 2.6% to 4.9%
  - Penetration at 25^0C = 6 to 32, most > 12
  - Density = 2.35 to 2.52 t/m^2

TEST RESULTS – Deflection, Curvature, & Remaining Life

Road Name	Age in Years	No of Tests	95th Percentile Deflect. - mm	Average Curvature - mm	ESA Loading to 2009	No of Years Remaining	Comments
Alpha St	36	16	0.59	0.06	$1.6x10^6$	15	Only 1 result is $<2x10^6$, so life is probably >40 years.
Flushcombe Rd	34	5	0.39	0.06	$1x10^6$	>50	
Newton Rd	30	30	0.65	0.09	$3x10^6$	1	Only 3 results are $<8x10^6$, so life is probably >50 years.
Prospect Highway (northbound carriageway)	28	12	0.30	0.03	$4.7x10^6$	>50	
Wall Park Ave	24	81	0.63	0.06	$4x10^6$	10	Only 7 results are $<1x10^7$, so life is probably >40 years.
Bungarribee Rd	23	52	0.68	0.08	$3.7x10^6$	3	Only 4 results are $<5x10^6$, so life is probably >20 years.

VISUAL CONDITION & WORK DONE SINCE CONSTRUCTION

Road Name	Overall Condition Rating – 1=failed, 10=excellent. Includes all defects including AC oxidisation	Work Done Since Construction	Comments
Alpha St	8	One AC surface mill & fill (30mm)	Nil structural defects
Flushcombe Rd	9	One AC surface mill & fill (30mm)	Nil structural defects and <1% minor rutting.
Newton Rd	8	1980 - AC surface mill & fill (30mm) 400m^2 rutting repair at signals, 60m^2 heavy patching (1%)	<1% structural defects and <5% medium rutting at signals.
Prospect Highway	8	One AC surface mill & fill (30mm) 100m^2 rutting repair at signals	Nil structural defects, with <1% minor rutting at signals
Wall Park Ave	7	One AC surface mill & fill (30mm) 1600m^2 heavy patching in last 10-20 years.	<1% structural cracking and <5% medium rutting at signals. The past heavy patching was a result of kerb and gutter failure causing kerbside lane failure due to a design error – insufficient AC under the kerb & gutter (50-90mm).
Bungarribee Rd	7	One AC surface mill & fill (30mm). 150m^2 heavy patching (2%)	4-5% structural cracking and <1% minor rutting

COMPARISON PAVEMENTS FOR SIMILAR SUBGRADES & ESA LOADING

- **Pavements Often Used by State Road Authorities & Some Eng. Consultants**
  - Based on AUSTROADS Pavement Design Manual – Chart EC13.
  - 150-300mm granular select or capping layer over the subgrade

    \+ Prime seal

    \+ 200mm cement bound road base – 2 to 5 Mpa

    \+ Prime seal

    \+ 100-175mm AC, with maximum 20mm stone and laid with an asphalt paver.

- **'Standard' Flexible Pavement**
  - Based on AUSTROADS Pavement Design Manual – Chart EC19.
  - 150-300mm granular select or capping layer over the subgrade

    \+ 260 - 275mm cement bound road base – 2 to 5 Mpa

    \+ 100mm 20mm unbound road base

    \+ 50-100mm AC, with maximum 20mm stone (usually 10-14mm) and laid with an asphalt paver.

COMPARISON OF CONSTRUCTION QA TECHNIQUES

Used	Method Details	
On the actual 6 FDAC road projects and mostly used by Local Govt	•Kerb & gutter constructed to line & level •Excavation depth checked by tape or marked rod •Visual check of subgrade by experienced engineer and deepened where considered appropriate (rare). DCP used on occasions. •No subgrade compaction, laboratory CBR, or PI testing carried out	•AC depth checked with a marked wire probe •Tonnage /area/depth relationship checked •AC temperature checked •Crown level checked by string line from kerbs and 'ups' painted on pavement •Compaction testing a few weeks after completion or via Nuclear densometer during construction •No work-as-executed levels taken on any layer.
On State Roads	•After excavation – laboratory 4 day soaked CBR's. Pavement deepened if results below design value. No pavement layers added until results received. •After excavation – laboratory PI ascertained. Pavement deepened if results >25. No pavement layers added until results received. •Visual inspection of subgrade and pavement deepened where necessary	•Leveling of subgrade by a Registered Surveyor •Compaction testing of the subgrade and every pavement layer. No overlaying until result for each layer is obtained. •Leveling of every pavement layer by a Registered Surveyor, including each AC layer.

COMPARISON OF ESTIMATED COST & CONSTRUCTION TIME

- No kerb & gutter, stormwater drainage, and subsoil drainage are included.
- Costings are based on a Schedule of Rates Contract from a large Sydney urban Council.
- Costings are based on 2009 $.
- No wet weather delays.
- The State Road Authority Pavements include their QA procedure.
- The FDAC construction times exclude the final AC surface layer.
- Only for comparison purposes and not meant to be a budget estimate.

Road Name	Approx Area/ Length – m² /m	FDAC as Constructed		State Road Authority Pavement		'Std' Flexible Pavement	
		Est Cost - $	Construction Time	Est Cost - $	Est Construct Time	Est Cost - $	Est Construct Time
Alpha St	2,520/210	360,000	24 hrs over 3 nights	470,000	6 weeks	410,000	5 weeks
Flushcombe Rd	2,215/264	320,000	24 hrs over 3 nights	420,000	5 weeks	360,000	4 weeks
Newton Rd	5,000/407	750,000	48 hours over 4 nights	900,000	10 weeks	980,000	9 weeks
Prospect Highway	1,900/203	380,000	20 hrs over 3 nights or 4 days	390,000	5 weeks	400,000	4 weeks
Wall Park Ave	15,000/1,382	1,650,000	25 working days	2,220,000	25 weeks	2,200,000	22 weeks
Bungarribbee Rd	8,000/640	860,000	15 working days	1,330,000	15 weeks	1,340,000	13 weeks

OUTCOMES

- The 6 FDAC pavements are performing very well with a long low maintenance life to come.
- There is no segregation of the AC 28 and 40 at the interface with the clay subgrades, even with little or no subsoil drainage and grader laid AC.
- There is no detrimental effect due to the grader laid base AC layers and the subgrade is less stressed than if an asphalt paver was used (the trucks loading the paver are a particular problem).
- Despite the subgrade laboratory CBR results being very low and most of the PI results being >25, the pavements are performing very well, even with little or no subsoil drainage.
- The simple but effective QA construction procedure used for the FDAC pavements produced an excellent result.
- FDAC pavements can be constructed much more rapidly than other pavement types.
- FDAC pavements can be constructed at a lower cost than other pavement types mostly due to:
  - The lower haulage and disposal costs of the excavated spoil
  - The uniformity of the material used and subsequent lower testing of those layers.
- The results indicate that the term ‘perpetual pavement’ may very well be applicable to well designed FDAC pavements as even a minor increase of 25mm in FDAC pavement depth dramatically increases the pavement life, for a very minor cost increase.

CONCLUSIONS

- Why use a select or capping layer unless the subgrade is extremely poor (in situ CBR<3%) or the subgrade is beach sand?
- Why use a road base layer (bound or unbound) in FDAC pavements?
- Why not lay the base AC layers with a grader? Production of a 1,000t/shift is achievable.
- Why not use aggregate size >20mm in the base AC layers? This allows deeper AC lifts.
- Why utilise construction QA testing that delays construction and increases costs (it is accepted that different controls do need to apply to rural roads and motorways particularly in respect to level control)?
- Why not extend the life of waste disposal sites by using FDAC pavements and hence reducing excavation? This also reduces the cost of future projects as there is no doubt that disposal sites will be at longer distances in the near future.
- Why not use FDAC for all road construction and reconstruction on urban high trafficked roads, signalised intersections, and on roads where extensive construction time has a major impact on business', motorists, and pedestrians? Leads to lower cost, effect of wet weather (subgrade covered within 4 hours), extends the life of spoil disposal sites, and reduces risk of accidents (far less construction period).

  NB It is recognised that the application of FDAC to rural roads (all types), and motorways, is not so straight forward, eg these type of roads usually work on a balanced cut to fill.
- Why are we not using the most appropriate road construction technique to reduce the detrimental effect on business', residents, and motorists – OUR CUSTOMERS?
- YOUR DECISION!