The Cost of Abandoning the ARFC Overlays on our PCCP Highways

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PCCP and ARFC

Asphalt Rubber Friction Course (ARFC)

Portland Cement Concrete Pavement (PCCP)

- Approximately ¾”
- 10-year life cycle
- Reduce reflective cracking
- Maintain smooth ride
- Noise reduction

Note: I-17 NB & SB 16th Street-Buckeyed RD bid together with Phase IX Project
Note: I-17 NB & SB Thomas Rd - Peoria was overlayed with 1" AR-ACFC in 2000 . At that time it was not called Quiet Pavement
Note: US 60 EB and WB from I-10 - Val Vista was overlayed with 1" AR-ACFC in 2002-2003 . At that time it was not called Quiet Pavement

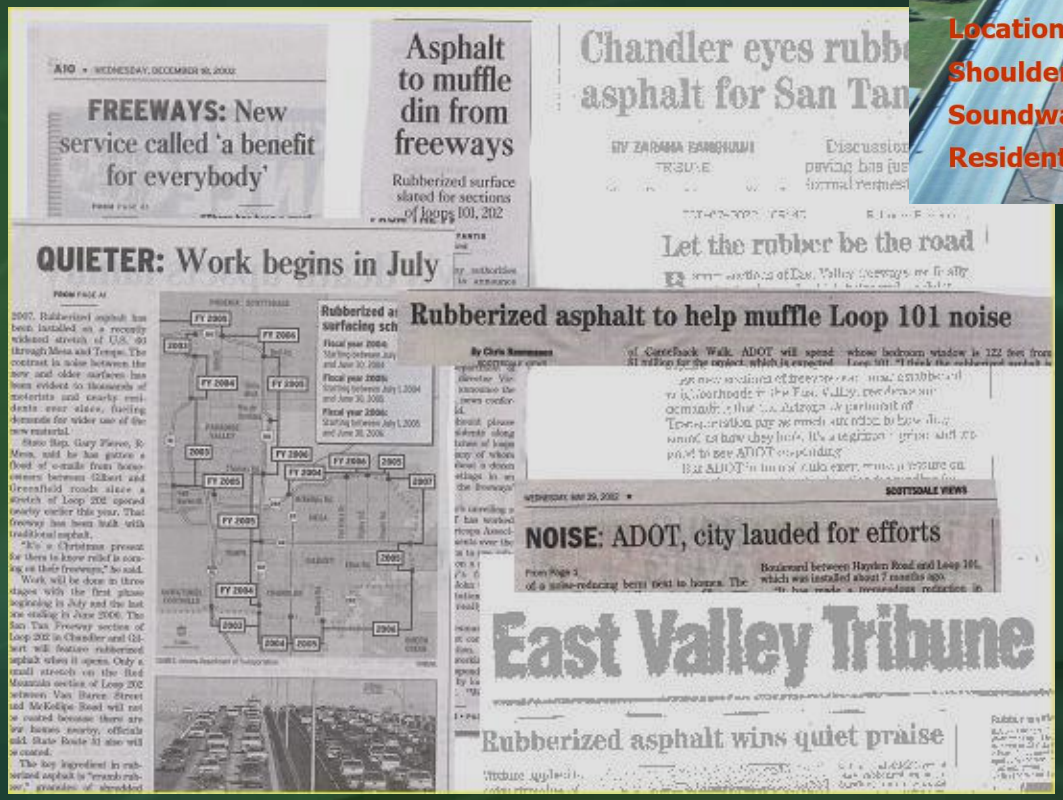
I-10 Wearing Course Experiment

- Arizona DOT Pavement Preservation Experiment – 1999
- Mile Post 186.2 to 195.3 East Bound
- Annual Daily Traffic (ADT) ~ 60,000 with 25% trucks
- Total Equivalent Single Axle Loads (ESALs) ~ 26 Million
- Five (5) Asphalt Concrete Friction Courses as Test Sections
- 32 Replicate Test Cells

ARFC Performance Evaluation

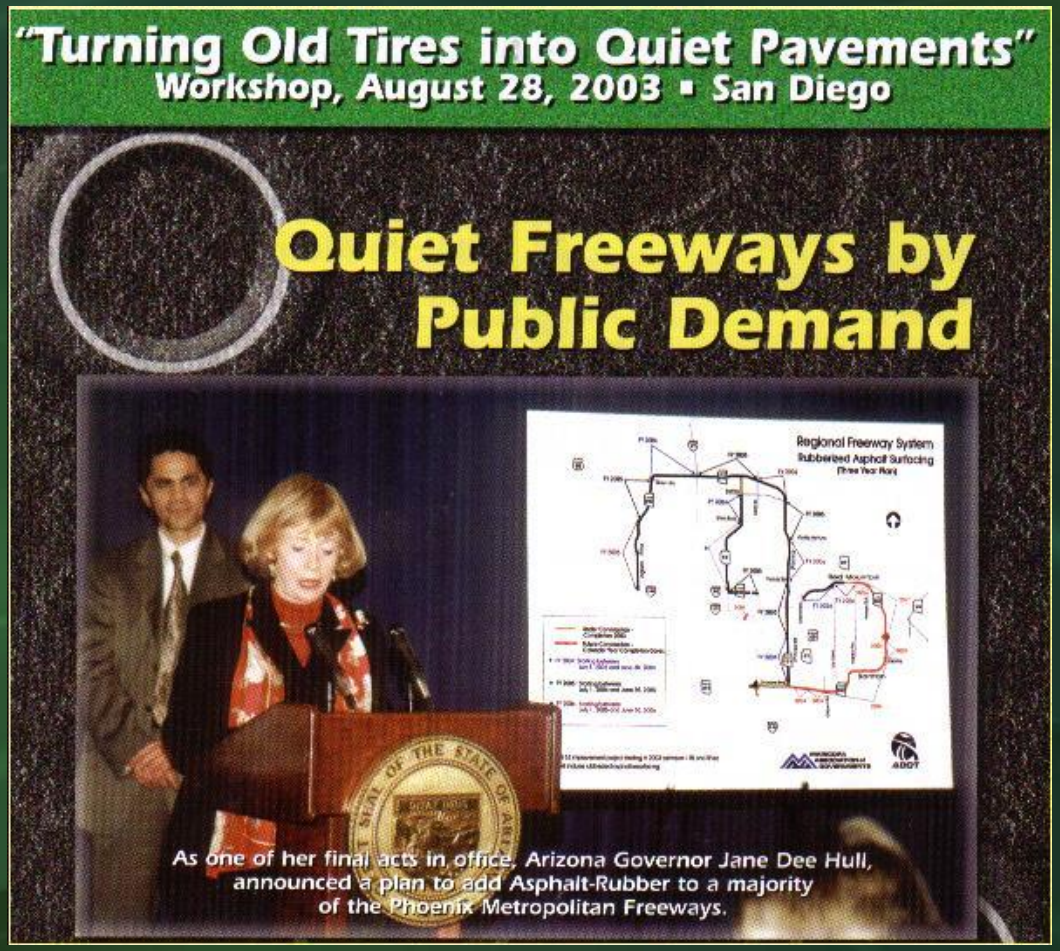
Adjacent Conventional ACFC

ARFC Early Applications

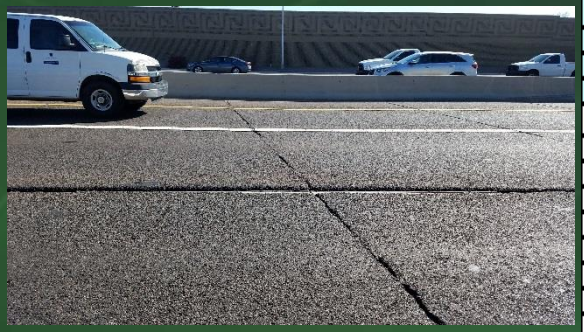


Quiet Pavements Program [Early 2000's]

Driven by the public's call for quieter roads, the Maricopa Association of Governments (MAG) through the Arizona Department of Transportation (ADOT) initiated the Quiet Pavements Program in the early 2000's



Today many of the ARFC overlays are 13 to 16 years old



2019

ADOT Quiet Pavement Projects

Phase	Tracs No.	Route	Direction	Milepost	Roadway segment	Year	HMA	AR	Tires
I	H637101C	Loop 101	EB	15.64-23.08	Union Hills-31st Ave	2003			
		Loop 101	WB	15.64-23.09	Union Hills-31st Ave	2003			
		Loop 101	EB	23.54-31.67	21st Ave. - Tatum Blvd	2003			
		Loop 101	WB	23.54-31.68	21st Ave. - Tatum Blvd	2003			
		Loop 101	NB	37.83-41.73	RainTree - Mt. View	2003			
		Loop 101	SB	37.83-41.74	RainTree - Mt. View	2003			
		SR 51	NB	9.35-13.39	N. of Shea - Bell Rd	2003			
		SR 51	SB	9.35-13.40	N. of Shea - Bell Rd	2003			
							77,000	7,500	308,000
II	H637102C	I 10	EB	143.70 - 148.01	19th Av - Van Buren St	2003			
		I 10	WB	143.70 - 148.02	19th Av - Van Buren St	2003			
		Loop 101	NB	42.32 - 51.03	90th St - McKellips Rd	2003			
		Loop 101	SB	42.32 - 51.04	90th St - McKellips Rd	2003			
		Loop 101	NB	54.95 - 61.00	US 60 - Chandler Blvd	2003			
		Loop 101	SB	54.95 - 61.00	US 60 - Chandler Blvd	2003			
		Loop 202	EB	11.54 -15.97 & 18.73-20.76	Alma School - Higley	2004			
		Loop 202	WB	11.54 -15.98 & 18.73-20.76	Alma School - Higley	2004			
							100,000	9,500	400,000
IIA	H646301C	Loop 202	EB	16.5 -19.0	Gilber Rd - Val Vista	2004			
		Loop 202	WB	16.5 -19.0	Gilber Rd - Val Vista	2004			
							8,000	750	32,000
III	H637103C	I 10	EB & WB	137.42 - 142.82	67th Av-27th Av	2004			
		I 10	EB & WB	155.44 - 159.69	Baseline -Rd	2004			
		I 17	NB & SB	211.16 - 214.45	T-Bird - Utopia	2004			
		Loop 101	NB & SB	34.24 - 37.83	Scottsdale Rd - Frank Llo	2004			
		Loop 101	NB & SB	51.53 -54.56	8th St. - US 60	2004			
		SR 143	NB & SB	2.69 - 3.38	Belleview St. - Van Bure	2004			
		Loop 202	EB & WB	0.00 - 4.19	20th St - Van Buren	2004			
							116,000	10,500	464,000
IV	H648201C	Loop 101	NB & SB	1.90 - 15.65	I-10 - Union Hills	2005			
		I-17	NB & SB	198.80- 201.80	Buckeye - Thomas	2005			
							50,000	5,000	200,000
V	H648801C	Loop 101	NB & SB	31.67 - 34.24	Tatum - Scottsdale Rd	2005			
		Loop 101	NB & SB	50.46 - 51.52	McKellips - 8th St	2005			
		Loop 101	NB & SB	22.99 - 23.46	21St Ave - 31st Ave.	2005			
							14,200	1,400	56,800
VI	H65001C	Loop 202	EB & WB	4.42 - 11.23	Van Buren - Alma chool	2006	37,000	3,500	148,000
VII	H694501C	I-10	EB&WB	129.67-137.46	67th Ave-Dysard Rd	2006	38000	3800	152,000
VIII	H695601C	I-10	EB&WB	148.01-155.44	Van Buren-Baseline Rd	2006	45200	4520	180,800
IX	708101C	I-10	EB&WB	142.83-143.68	19th Ave-27th Ave	Under	42000	4200	168,000
		Loop202	EB&WB	54.15-56.08	48th St-Kyrene Rd	Under construction			

Expected ARFC Benefits!

- Better service life compared to conventional ACFC layers
- Enhanced skid resistance
- Reduced splash and spray
- Smooth ride
- Recycling Arizona's tires to beneficial uses

Did they meet expectations?

AR Performance

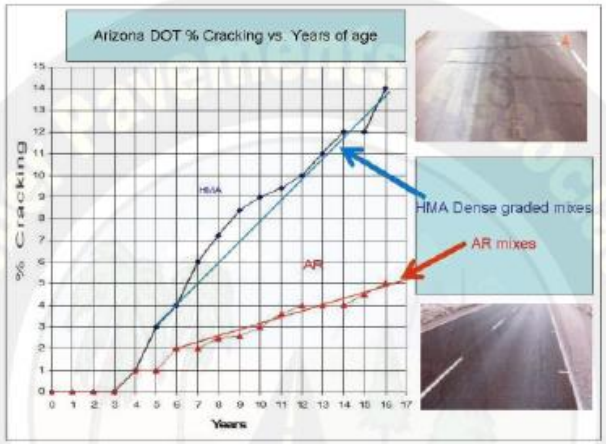


Figure 60 – *Statewide cracking performance with and without asphalt-rubber*

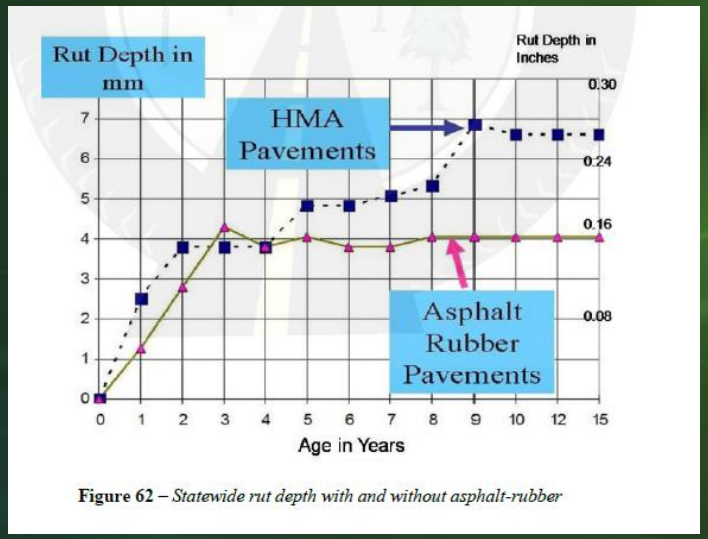


Figure 62 – *Statewide rut depth with and without asphalt-rubber*

ASU Studies: Very good performance!

Kamil Elias Kaloush*. "Asphalt Rubber: Performance Tests and Pavement Design Issues". Journal of Construction and Building Materials, 67 (2014) 258–264, Elsevier publications, March 2014.

Alexander Zborowski and Kamil E. Kaloush*, "A Fracture Energy Approach to Model the Thermal Cracking Performance of Asphalt Rubber Mixtures". *Road Materials and Pavements Design Journal*, Volume 12 Issue 2, pp 377-395, Lavoisier, 2011. (+)

Maria Carolina Rodezno and Kamil E. Kaloush*, "Implementation of Asphalt-Rubber Mixes into the Mechanistic Empirical Pavement Design Guide". *Road Materials and Pavements Design Journal*, Volume 12 Issue 2/2011, pp 423-439, Lavoisier, 2011. (+)

ARFC Friction

LANE	Average Friction Value	
	PCCP	AR-ACFC
I010EHOV	0.54	0.66
I010ELN1	0.60	0.61
I010ELN2	0.49	0.61
I010ELN3	0.47	0.60
I010ELN4	0.47	0.54
I010WHOV	0.51	0.58
I010WLN1	0.64	0.57
I010WLN2	0.50	0.59
I010WLN3	0.44	0.59
I010WLN4	0.42	0.58

Friction improved

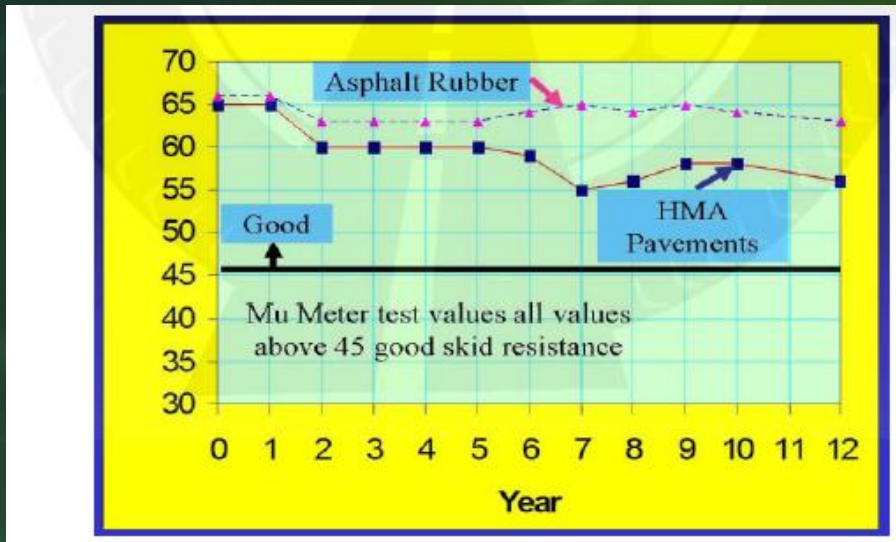
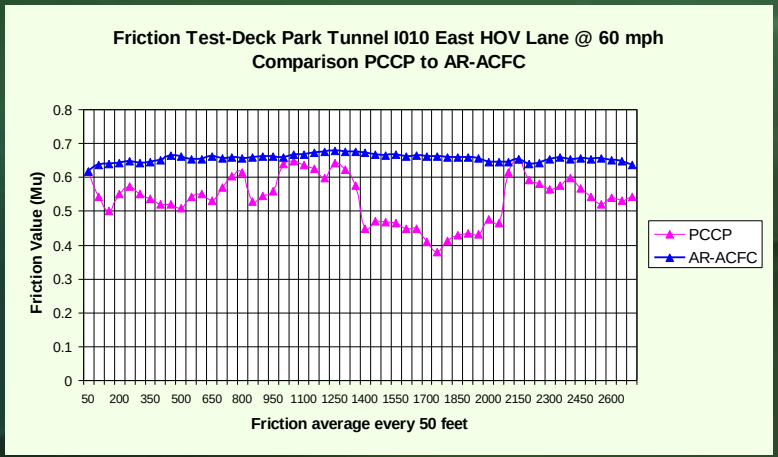


Figure 64 – *Statewide skid resistance performance with and without asphalt-rubber*



Asphalt-Rubber Standard Practice Guide, Prepared for the Rubber Pavements Association, October 2012, Second Edition. George B. Way., Kamil E. Kaloush., and Krishna P. Biligiri. (+)
http://www.rubberpavements.org/Library_Information/AR_Std_Practice_Guide_Second_Edition_20121001_Reduced1.pdf


ADOT 0421 I-17 NB CACTUS 209.96-2015/10/21 12:41:50


San Antonio I-35

ARFC Ride Quality

LANE	IRI (in/mi)	
	PCCP	AR-ACFC
I010EHOV	96.34	43.57
I010ELN1	123.20	59.03
I010ELN2	104.29	48.81
I010ELN3	111.87	47.80
I010ELN4	115.30	52.91
I010WHOV	85.44	32.51
I010WLN1	87.94	37.79
I010WLN2	85.40	46.92
I010WLN3	96.83	46.11
I010WLN4	97.75	36.81

Ride Quality improved

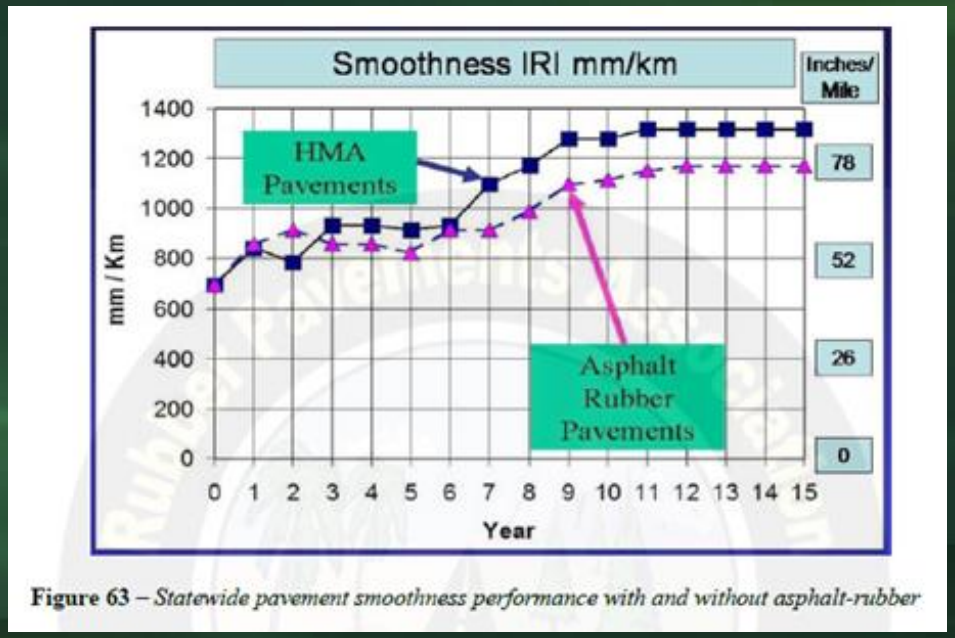


Figure 63 – *Statewide pavement smoothness performance with and without asphalt-rubber*

Asphalt-Rubber Standard Practice Guide, Prepared for the Rubber Pavements Association, October 2012, Second Edition. George B. Way., Kamil E. Kaloush., and Krishna P. Biligiri. (+)
http://www.rubberpavements.org/Library_Information/AR_Std_Practice_Guide_Second_Edition_20121001_Reduced1.pdf

Bonus Benefits Toward Sustainability and Quality of Life Goals

- Reduced tire wear emissions
  - Contributes to better air quality
  - Long term health of citizens
- Reduce Urban Heat Island impacts
- Exceeding design life with NO maintenance.
- Thermal blanket leading to a longer PCCP life
  - No PCCP surface distress

Many of the ARFC overlays are 13 to 16 years old

Tire Wear Emission Rates

May 2004 and
June 2005

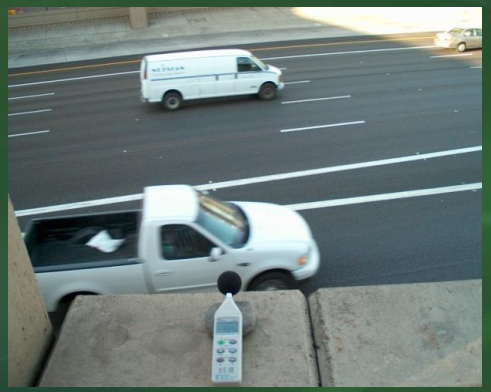
Emission rates calculated per kilometer driven (μg/km)

Tire wear emission rate based on	Experiment 1 (PCC road surface)	Experiment 2 (AR-ACFC road surface)
Compound # 3	354 ± 71	177 ± 35
Compound # 4	172 ± 34	120 ± 24

Olga Alexandrova (X), Kamil E. Kaloush*, and Jonathan O. Allen, "Impact of Asphalt Rubber Friction Course Overlays on Tire Wear Emissions and Air Quality Models for Phoenix, Arizona Airshed". *Journal of the Transportation Research Board*, No. 2011, pp 98-106. Washington, D.C., 2007.

Highway Noise

Condition / Location	Before Overlay	After Overlay
Inside Tunnel	96.3	85.4
At Exit	86.3	77.6
Inside Vehicle	71.3	67.1



Highway Noise and Health

http://www.bbc.com/news/health-38506735[1/6/2017 9:17:24 AM]

Dementia rates 'higher near busy roads' - BBC News

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Health

Dementia rates 'higher near busy roads'

By James Gallagher
Health and science reporter, BBC News website

5 January 2017 | Health | 445 Share

People who live near major roads have higher rates of dementia, research published in the Lancet suggests.

As many as 11% of dementia cases in people living within 50m of a major road could be down to traffic, the study suggests.

The researchers, who followed nearly 2m people in Canada over 11 years, say air pollution or noisy traffic could be contributing to the brain's decline.

UK dementia experts said the findings needed probing but were "plausible".

Nearly **50 million people** around the world have dementia.

However, the causes of the disease, that robs people of their memories and brain power, are not understood.

Dementia rates 'higher near busy roads' - BBC News

Compared with those living 300m away from a major road the ri

- 7% higher within 50m
- 4% higher between 50-100m
- 2% higher between 101-200m

The analysis suggests 7-11% of dementia cases within 50m of a major road could be caused by traffic.

The researchers adjusted the data to account for other risk factors like poverty, obesity, education levels and smoking so these are unlikely to explain the link.

Pollution particles 'get into brain'

Dr Hong Chen, from Public Health Ontario and one of the report authors, said: "Increasing population growth and urbanisation have placed many people close to heavy traffic, and with widespread exposure to traffic and growing rates of dementia, even a modest effect from near-road exposure could pose a large public health burden.

Living near heavy traffic increases risk of dementia, say scientists

Study tracking 6.6 million people estimates one in 10 cases of Alzheimer's among those living by busy roads could be linked to air and noise pollution

Hannah Devlin *Science correspondent*

@hannahdev

Thu 5 Jan 2017 02.25 EST

Epidemiology
Research

PDF

Are noise and air pollution related to the incidence of dementia? A cohort study in London, England

Iain M Carey[1], H Ross Anderson[1, 2], Richard W Atkinson[1], Sean D Beevers[2], Derek G Cook[1], David P Strachan[1], David Dajnak[2], John Gulliver[3], Frank J Kelly[2, 4]

Author affiliations +

Abstract

Objective To investigate whether the incidence of dementia is related to residential levels of air and noise pollution in London.

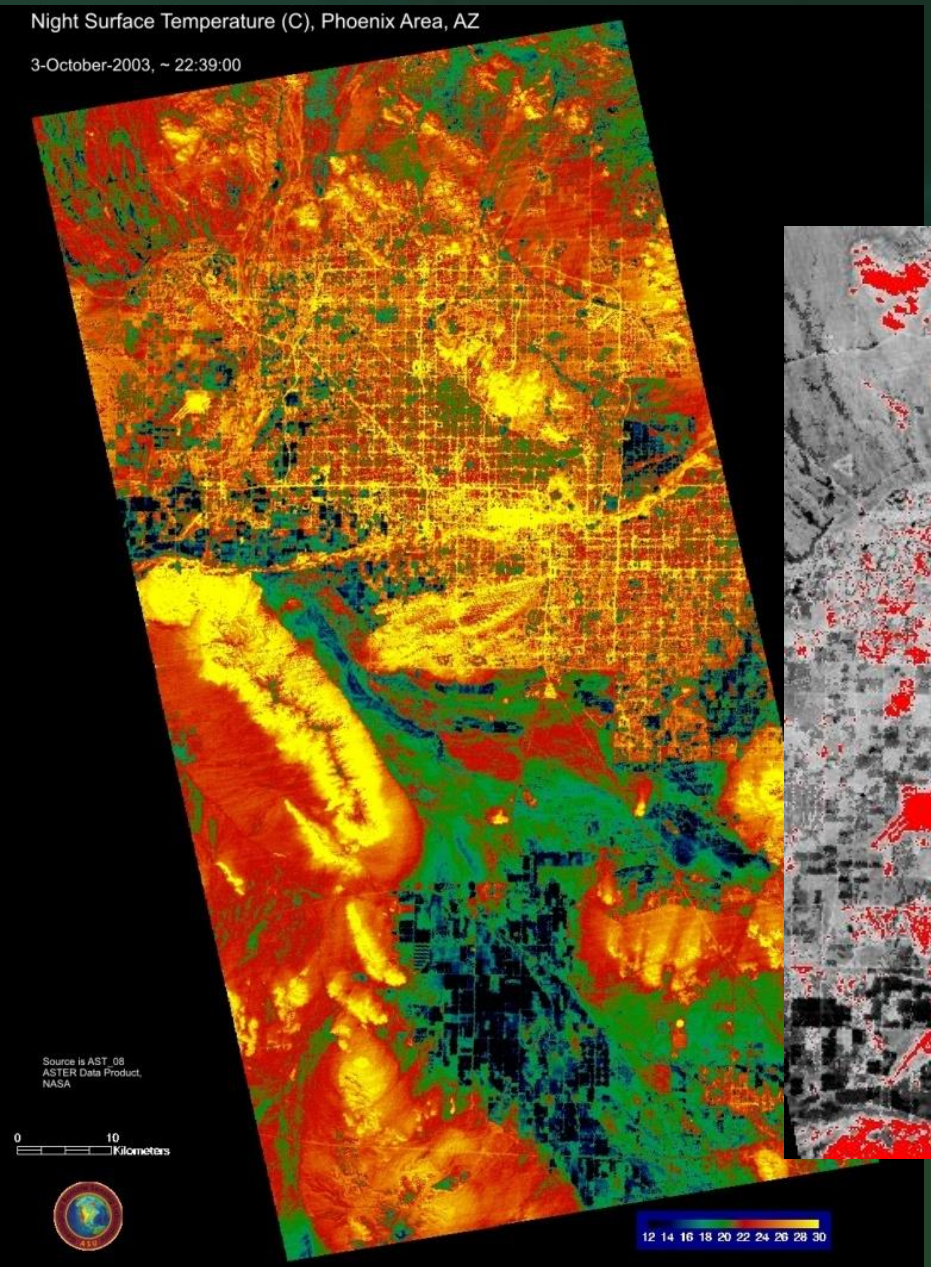
Design Retrospective cohort study using primary care data.

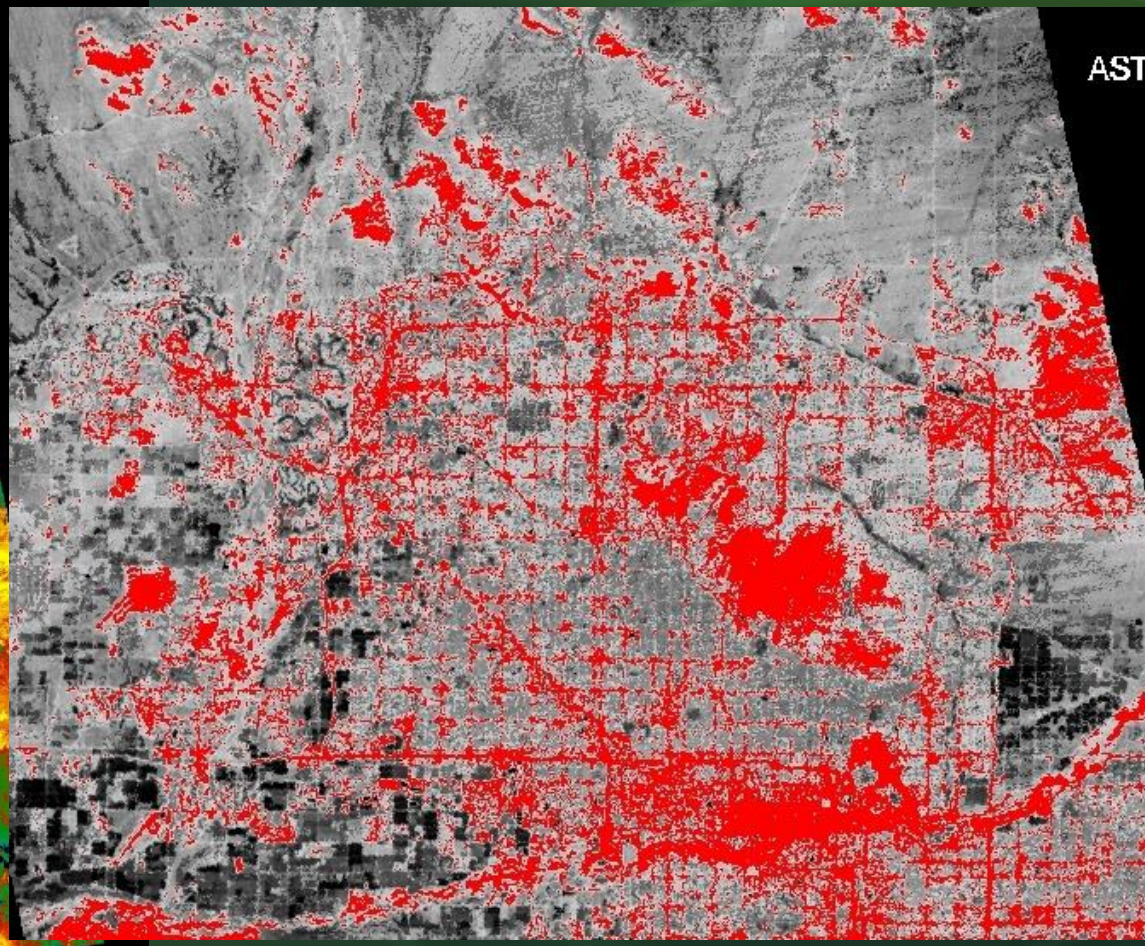
Setting 75 Greater London practices.

Participants 130 978 adults aged 50–79 years registered with their general practices on 1 January 2005, with no recorded history of dementia or care home residence.

ARFC & Urban Heat Island

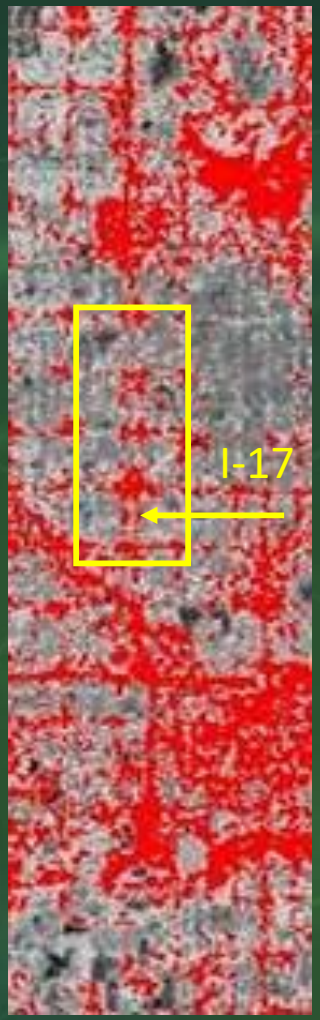
Paved surfaces are ~40% of the urbanized land cover in Phoenix





Phoenix Metropolitan Area (11pm at night)

Interstate 17
Phoenix, Arizona

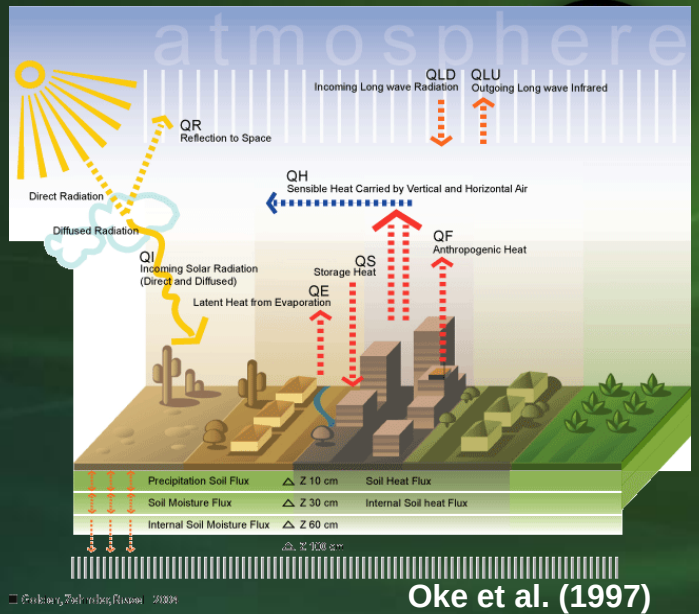


Golden, J.S.* and Kaloush, K.E., "Mesoscale and Microscale Evaluation of Surface Pavement Impacts on the Urban Heat Island Effects". *International Journal of Pavement Engineering*, Volume 7, No. 1, pp 37-52, Taylor & Francis, 2006. (+)

Golden, J.S.*, Guthrie, P.M., Kaloush, K.E., and Britter, R.B., "The Summertime Urban Heat Island Hysteresis Lag Complexity", Sustainable Engineering, *A Journal of the Royal Institute of Civil Engineers*, Volume 158, No. ES4, pp 197-210, 2005. (+)

UHI Driving Factors

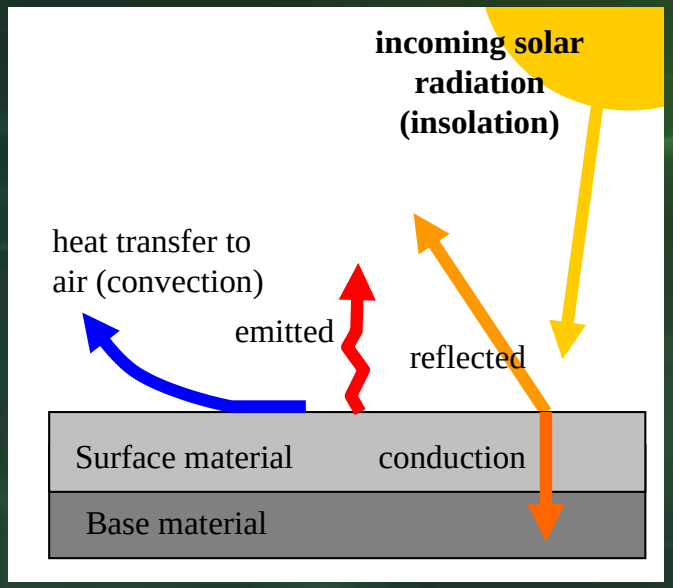
- *Canyon Geometry*
- *Thermal Properties*
- *Anthropogenic Heat*
- *The Urban Greenhouse Effect*
- *The Effective Reflectivity (Albedo)*
- *Reduction of Evaporating Surfaces*
- *Reduced Turbulent Transfer of Heat*

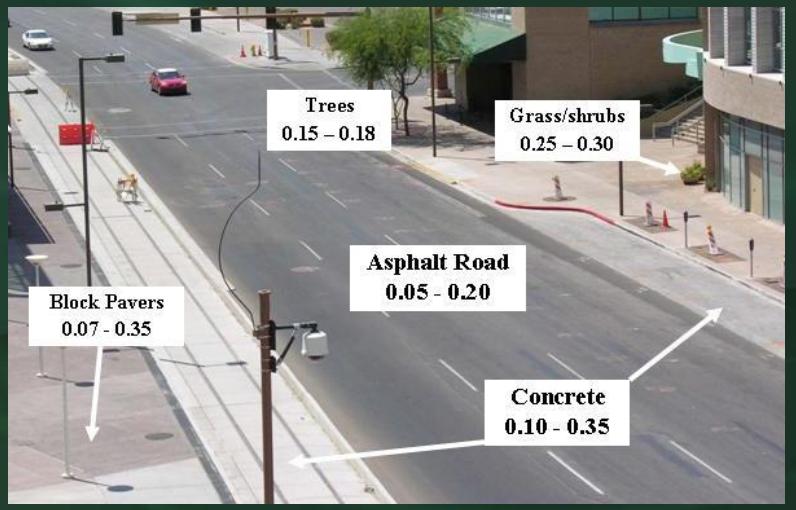


Oke et al. (1997)

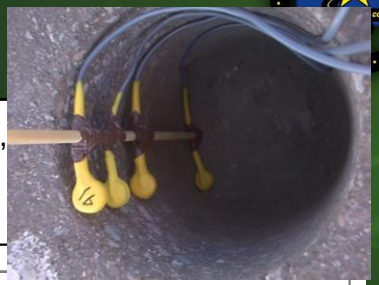
Fundamental Properties

- Albedo, α
- Emissivity, ε
- Convection Coefficient, h
- Thermal Conductivity, *k*
- Specific Heat, C
- Density, *ρ*
- Thermal Diffusivity, α,κ

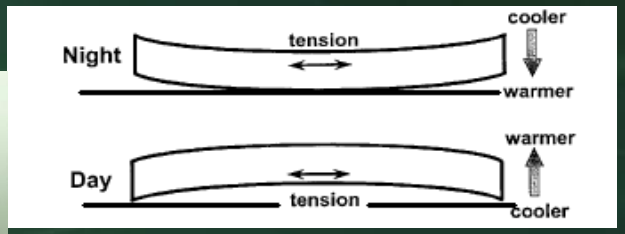


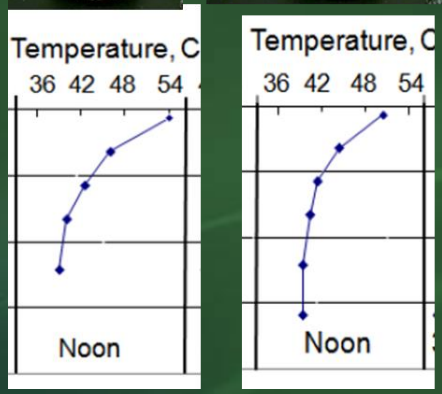


Temperature



Thermal Blanket Effect of ARFC reduces PCC Curling Stresses (8-25%)



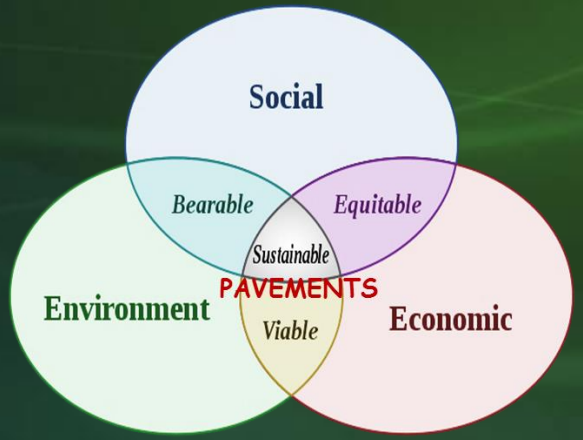


AR Friction Courses Unintended Benefits

Belshe, M., Mamlouk, M.S.*, Kaloush, K.E., and Rodezno, M., "Temperature Gradient and Curling Stresses in Concrete Pavement with and without Open Graded Friction Course," Vol. 137, No. 10, , pp 723-729, *ASCE Journal of Transportation Engineering*, 2011.

ARFC meets many sustainability goals!

- Performance / Durability
- Safety
- Ride Quality
- Quality of Life Issues
  - Highway Noise
  - Air Quality
  - Urban Heat Island
  - Human Health
- Extended PCCP Life



Concluding Remarks

- ARFC overlays have been highly successful at many levels
- Even if we match pavement/tire noise levels by special PCCP surface preparation techniques, we would:
  - Loose Urban Heat Island benefits
  - Increase vehicle tire wear
  - Have higher tire wear emissions pollution
  - Have long term impact on human health
  - Risk safety issues related to skid and splash
  - Loose long-term preservation of the PCCP pavement structure
- Industry impacts?


MINOR CRASH
MOVE VEHICLES
FROM TRAVEL LANES