Utilization of Mega Weather Data for Preventive Maintenance of Asphalt Pavements: An Overview

Hanqi Liu, Ph.D., Sharjah Research Academy
Mufid Samarai, Ph.D., Sharjah Research Academy
Waleed Zeiada, Ph.D., University of Sharjah
Ghazi G. Al-Khateeb, Ph.D., University of Sharjah
Rulla Saad, Sharjah Research Academy

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Outline

- Introduction to Preventive Maintenance
- Selection of Appropriate Preventive Maintenance Treatment
- Determination of Right Maintenance Time
- Conclusions

Pavement Maintenance

- **Pavement maintenance is used to prolong the pavement service life**

Rutting (High Temperature)

Fatigue Cracking (Intermediate Temperature)

Thermal Cracking (Low Temperature)

Pavement Maintenance

- **Pavement maintenance is used to prolong the pavement service life**
- **Three types of pavement maintenance**
  - **Preventive maintenance**
  - **Corrective maintenance**
  - **Emergency maintenance**

Pavement Maintenance

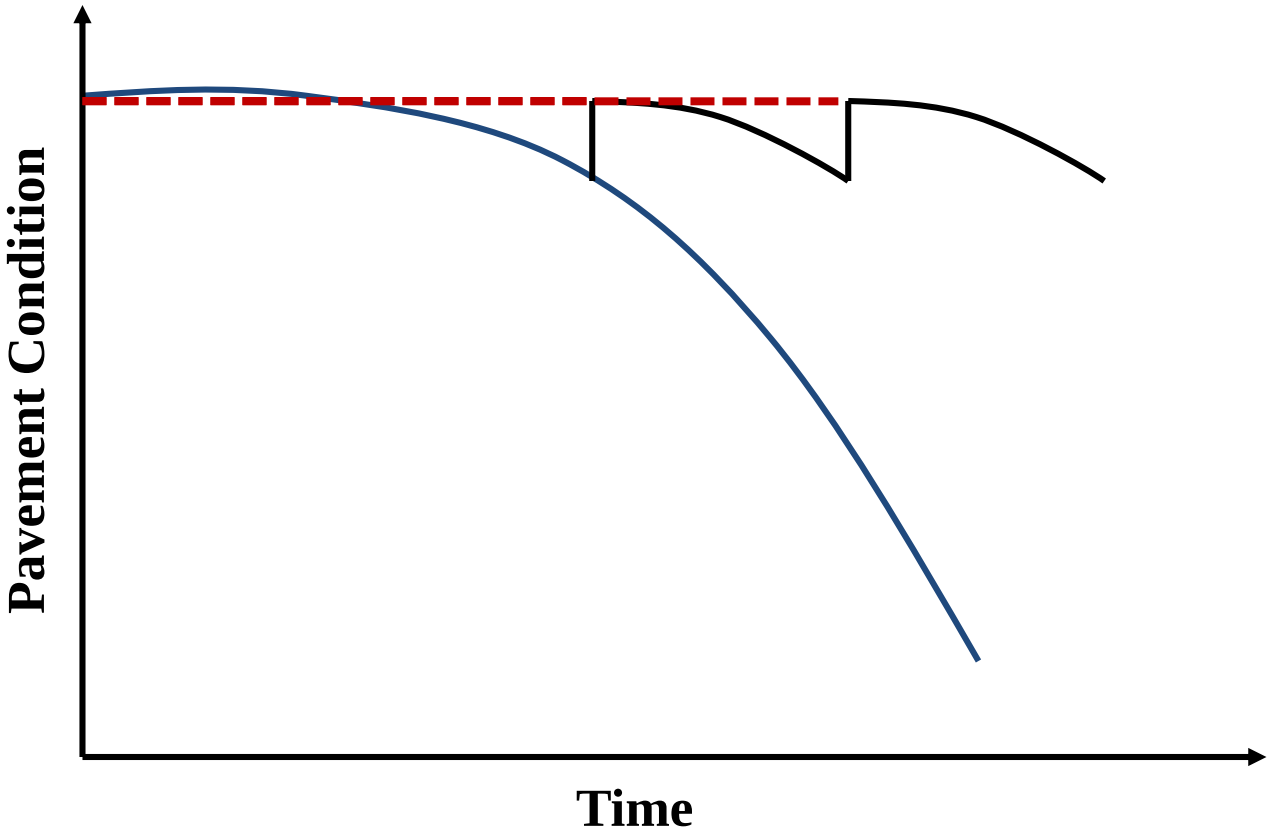
- **Pavement maintenance is used to prolong the pavement service life**
- **Three types of pavement maintenance**

Preventive Maintenance	• Implemented when the asphalt pavement stays in relatively good condition
Corrective Maintenance	• Performed while the pavement needs to be repaired
Emergency Maintenance	• Performed during an emergency situation

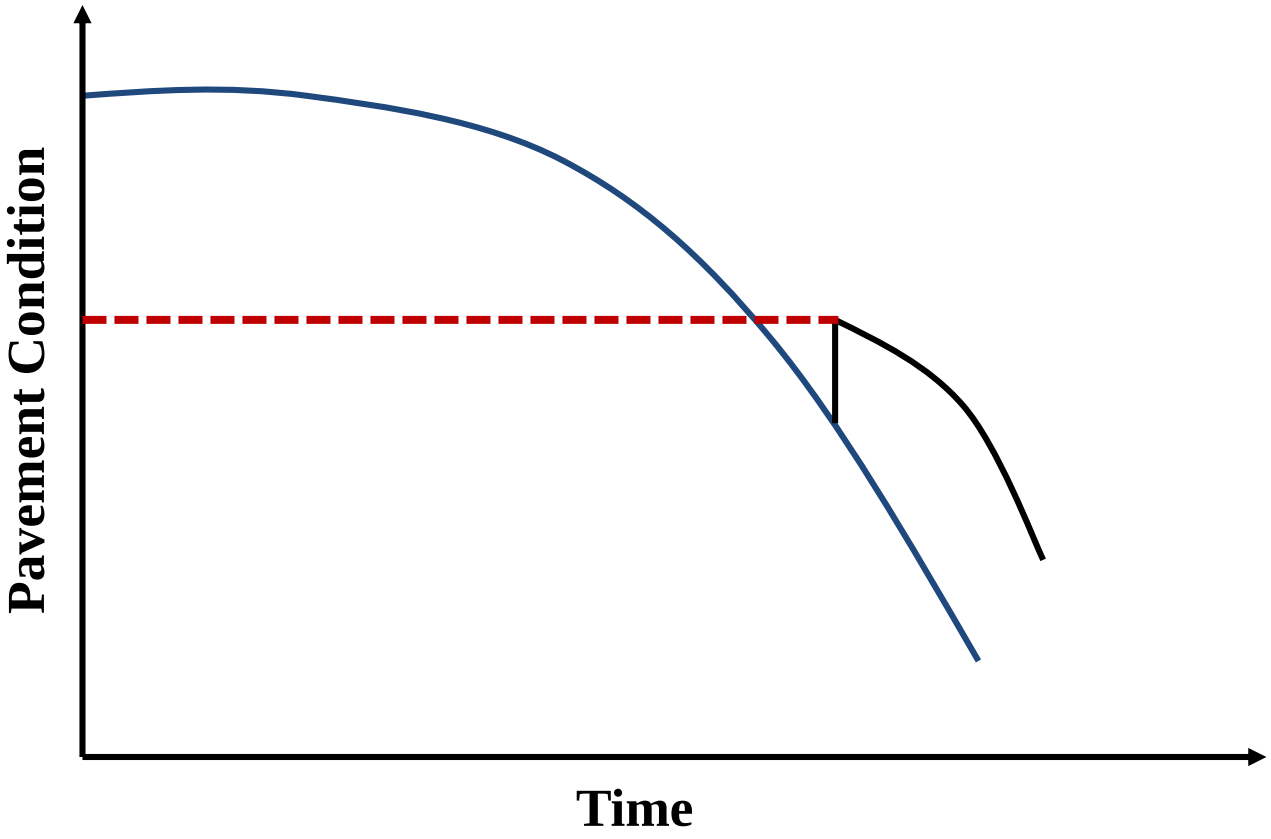
Preventive Maintenance: Definition

A planned strategy of cost-effective treatments to an existing roadway system and its appurtenances that preserves the system, retards future deterioration, and maintains or improves the functional condition of the system (without significantly increasing structural capacity)

Preventive Maintenance: Effect

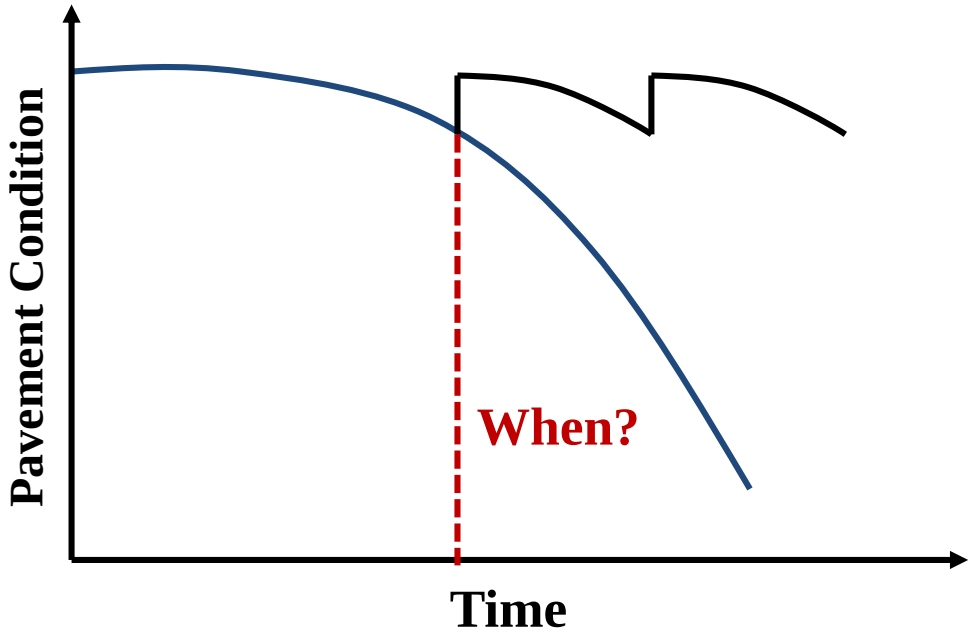


Corrective Maintenance: Effect



Preventive Maintenance: Concerns

- Determination of right maintenance time



- Selection of appropriate preventive maintenance treatment

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Preventative Maintenance Treatment Methods

Highway Asphalt Pavements in Guangdong Province, China

Involved Pavement Thickness (mm)	Maintenance Level	Treatment Methods
0–15	Low	Fog Seal, Micro-surfacing, Chip Seal
10–30	Medium	Ultra-thin Friction Course
20–40	High	Thin Hot Mix Asphalt Overlay
20–50	Very High	Mill and Overlay, Hot In-place Recycling, Central Plant Hot Recycling

Note: Crack seal and crack filling are used before preventive maintenance as pre-repair of an old pavement

Specific Pavement Study (SPS)–3 Experiment

- **Four maintenance treatment methods were investigated in the experiment design**
  - **Crack seal**
  - **Chip seal**
  - **Slurry seal**
  - **Thin hot mix asphalt (HMA) overlay**

Specific Pavement Study (SPS)–3 Experiment

- **Four maintenance treatment methods were investigated in the experiment design**

Crack Seal	• Place specialized materials into working cracks (greater than about 2 mm) to prevent entry of water or other incompressible substance
Chip Seal	• Spray a pavement surface with asphalt (generally emulsified) and immediately cover the surface with aggregate and then roll
Slurry Seal	• Use a mixture consisting of water, slow setting emulsified asphalt, well-graded fine aggregate and mineral filler to fill cracks and seal areas
Thin HMA Overlay	• Place plant-mixed asphalt mixtures, which can be dense-graded, open-graded or gap-graded, in depths of 2–4 cm over asphalt pavements

Specific Pavement Study (SPS)–3 Experiment

- **Four maintenance treatment methods were investigated in the experiment design**
- **Five design factors were considered**
  - **Moisture**
  - **Temperature**
  - **Subgrade type**
  - **Traffic loading**
  - **Existing pavement condition**

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- **Five design factors were considered**
  - **Moisture**
  - **Temperature**
  - **Subgrade type**
  - **Traffic loading**
  - **Existing pavement condition**
- **Performance of pavement sections using preventive maintenance treatments was compared with that of the control sections with no treatment**

SPS–3 Experiment: Suggested Treatments

Distress	Suggested Treatment	Temperature		Precipitation		Subgrade		Traffic		Pavement Condition		
		Freeze	No Freeze	Dry	Wet	Fine	Coarse	Low	High	Good	Fair	Poor
Fatigue Cracking	First Choice	CH	CH	CH	CH	CH	CH	CH	CH	CH	None	TH
	Second Choice	TH	–	–	TH	–	TH	–	TH	–	–	CH
Rutting	First Choice	TH	TH	TH	TH	TH	TH	TH	TH	TH	TH	TH
	Second Choice	CH	–	CH	–	–	–	–	–	–	–	–
Roughness	First Choice	TH	None	None	None	TH	TH	None	TH	None	None	TH

- Chip seal and thin HMA overlay were generally superior when compared with slurry seal and crack seal
- In terms of fatigue cracking, chip seal was the only suggested treatment for pavements in no-freeze zones, dry climates, pavements with fine subgrade, low traffic conditions, and pavements initially in good condition

SPS–3 Experiment: Suggested Treatments

Distress	Suggested Treatment	Temperature		Precipitation		Subgrade		Traffic		Pavement Condition		
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	Second Choice	TH	–	–	TH	–	TH	–	TH	–	–	CH
Rutting	First Choice	TH	TH	TH	TH	TH	TH	TH	TH	TH	TH	TH
	Second Choice	CH	–	CH	–	–	–	–	–	–	–	–
Roughness	First Choice	TH	None	None	None	TH	TH	None	TH	None	None	TH

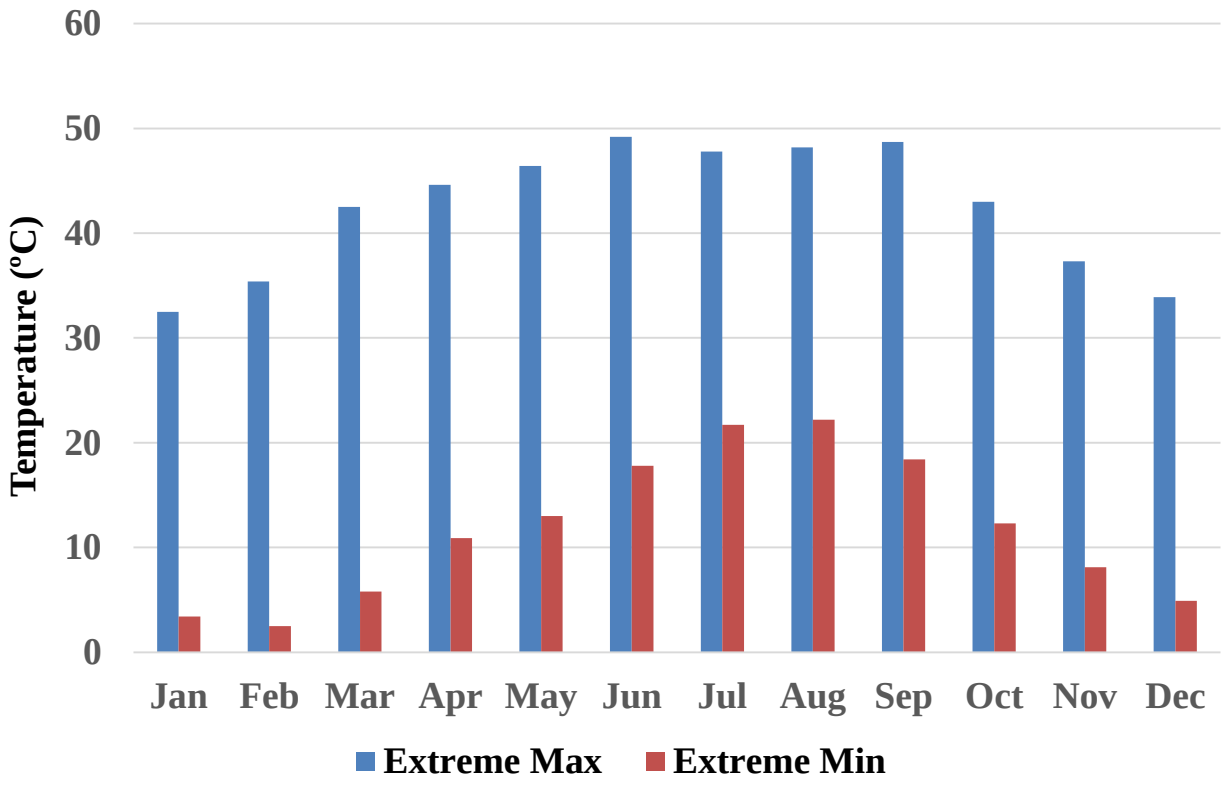
- As for rutting, thin HMA overlay was effective under any design circumstance and outperformed the other three treatments
- Thin HMA overlay was found to be the only treatment that was effective in delaying the progression of roughness, which can be used in freeze zones, pavements with high traffic conditions, and pavements initially in poor condition

Historical weather data of Sharjah International Airport from 1977 to 2004

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperature (°C)												
Mean daily max.	24.4	25.7	29.0	34.2	39.1	41.3	42.4	42.2	40.1	36.3	31.1	26.5
Mean daily min.	12.1	13.0	15.5	18.4	22.2	25.0	27.9	27.8	24.6	21.0	16.9	13.8
Extreme max.	32.5	35.4	42.5	44.6	46.4	49.2	47.8	48.2	48.7	43.0	37.3	33.9
Extreme min.	3.4	2.5	5.8	10.9	13.0	17.8	21.7	22.2	18.4	12.3	8.1	4.9
Relative humidity (%)												
Mean daily max.	90	90	88	82	76	82	80	80	87	89	87	90
Mean daily min.	41	38	33	25	21	23	26	27	26	28	33	40
Rainfall (mm)												
Monthly mean	17.9	31.9	38.0	7.9	1.0	0.0	3.5	0.0	0.4	2.6	4.9	21.0
Monthly extreme	97.8	142.9	156.4	43.7	20.6	TR	53.1	0.6	9.2	63.4	41.6	146.5
Highest 24 hr. max.	62.7	115.5	76.7	36.6	14.4	TR	35.2	0.6	5.5	62.6	41.6	60.7
Mean No. of rain days	6.0	5.9	8.1	2.5	0.4	0.1	0.7	0.4	0.1	0.2	1.3	4.6

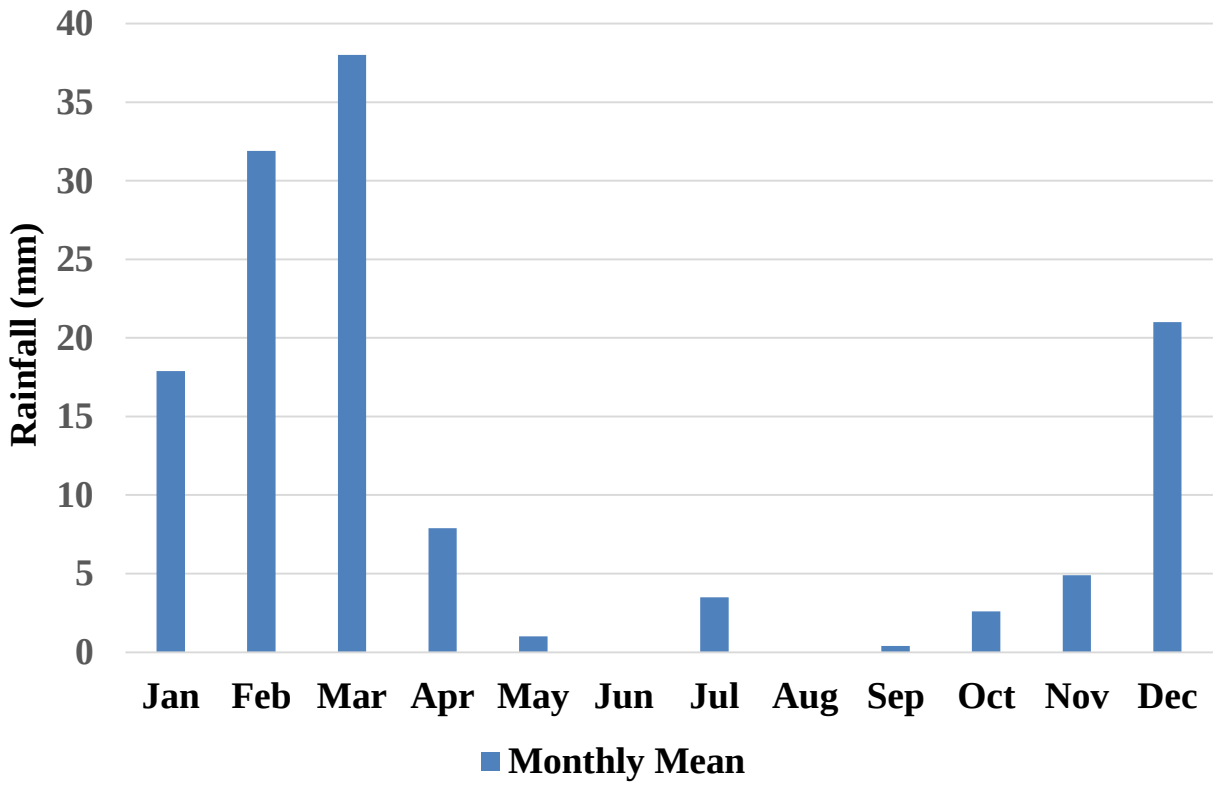
Note: TR means rainfall was less than 1 mm.

Historical weather data of Sharjah International Airport from 1977 to 2004: Temperature



No Freeze

Historical weather data of Sharjah International Airport from 1977 to 2004: Rainfall



Dry

Suggested Treatments: Sharjah

Distress	Suggested Treatment	Temperature		Precipitation		Subgrade		Traffic		Pavement Condition		
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Fatigue cracking	First Choice	CH	CH	CH	CH	CH	CH	CH	CH	CH	None	TH
	Second Choice	TH	–	–	TH	–	TH	–	TH	–	–	CH
Rutting	First Choice	TH	TH	TH	TH	TH	TH	TH	TH	TH	TH	TH
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Roughness	First Choice	TH	None	None	None	TH	TH	None	TH	None	None	TH

- The suggested preventive maintenance for fatigue cracking should be chip seal
- The suggested preventive maintenance for rutting should be thin HMA overlay
- None of the four treatment methods are effective in delaying the progression of roughness in Sharjah

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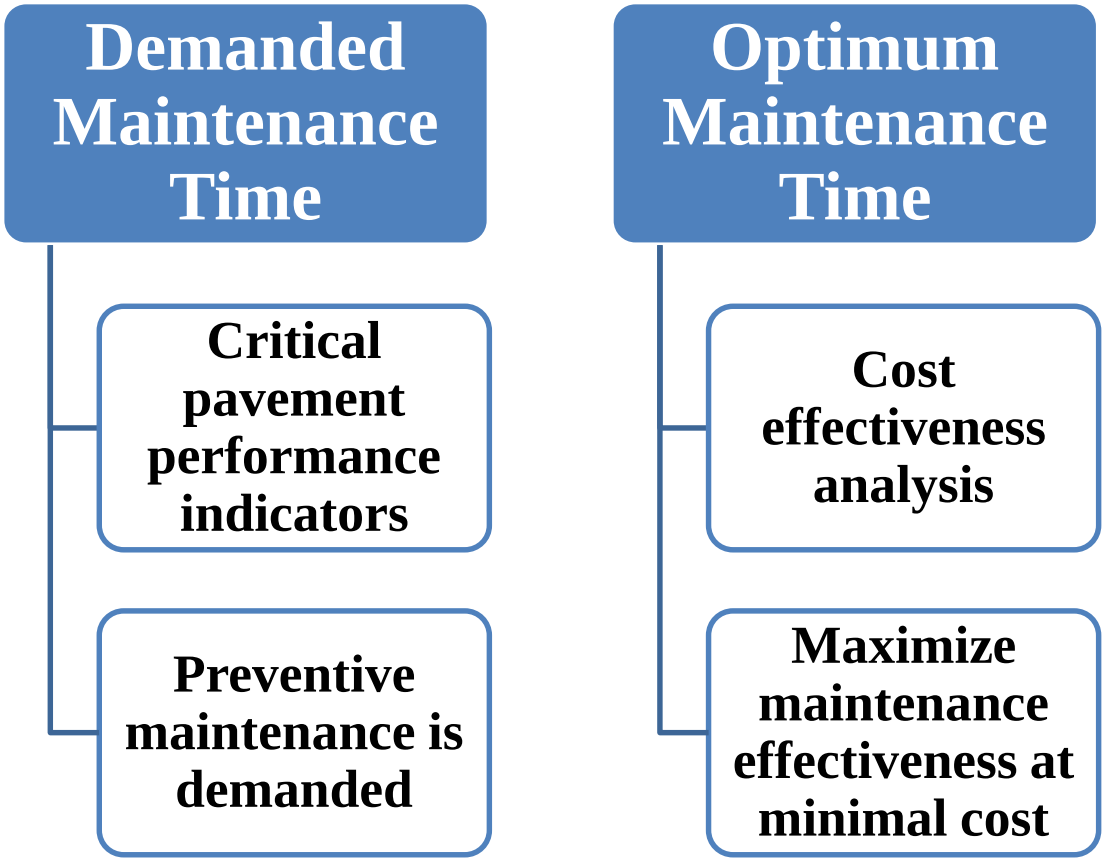
Determination of Right Maintenance Time



Demanded Maintenance Time

- **Six pavement performance indicators are adopted to evaluate the need for preventive maintenance**
  - **Pavement structural strength index (PSSI)**
  - **Pavement condition index (PCI)**
  - **Sideway force coefficient (SFC)**
  - **International roughness index (IRI)**
  - **Rutting depth (RD)**
  - **Cracking rate (CR)**

Demanded Maintenance Time

- **Six pavement performance indicators are adopted to evaluate the need for preventive maintenance**
- **Other pavement maintenance technologies should be utilized instead of preventive maintenance when**
  - **Pavement structural strength index (PSSI) < 80**
  - **Pavement condition index (PCI) < 80**
  - **Sideway force coefficient (SFC) < 40**
  - **International roughness index (IRI) > 3.5 m/km**
  - **Rutting depth (RD) > 25 mm**
  - **Cracking rate (CR) > 50 m/1000m^2**

Demanded Maintenance Time

Pavement Performance Indicator	Critical Range	Need for Preventive Maintenance
SFC	>54	No need or low maintenance level
	48–54	Medium maintenance level
	40–48	High maintenance level
IRI (m/km)	<1.6	No need or low maintenance level
	1.6–2.3	Medium maintenance level
	2.3–3.5	High maintenance level
RD (mm)	<5	No need or low maintenance level
	5–15	Medium maintenance level
	15–25	High maintenance level
CR (m/1000m^2)	<5	Regular maintenance or low maintenance level
	5–20	Medium maintenance level
	20–50	High maintenance level

Optimum Maintenance Time

- **Life-cycle cost analysis (LCCA) is widely used to evaluate the cost-effectiveness of maintenance activities**
  - **Expected service life: Determined as the time at which a performance indicator reaches the threshold**
  - **Performance curve: Each performance indicator is plotted versus time**
  - **Effectiveness: Calculated as difference between the performance curve area without preventive maintenance and that after preventive maintenance**

Optimum Maintenance Time

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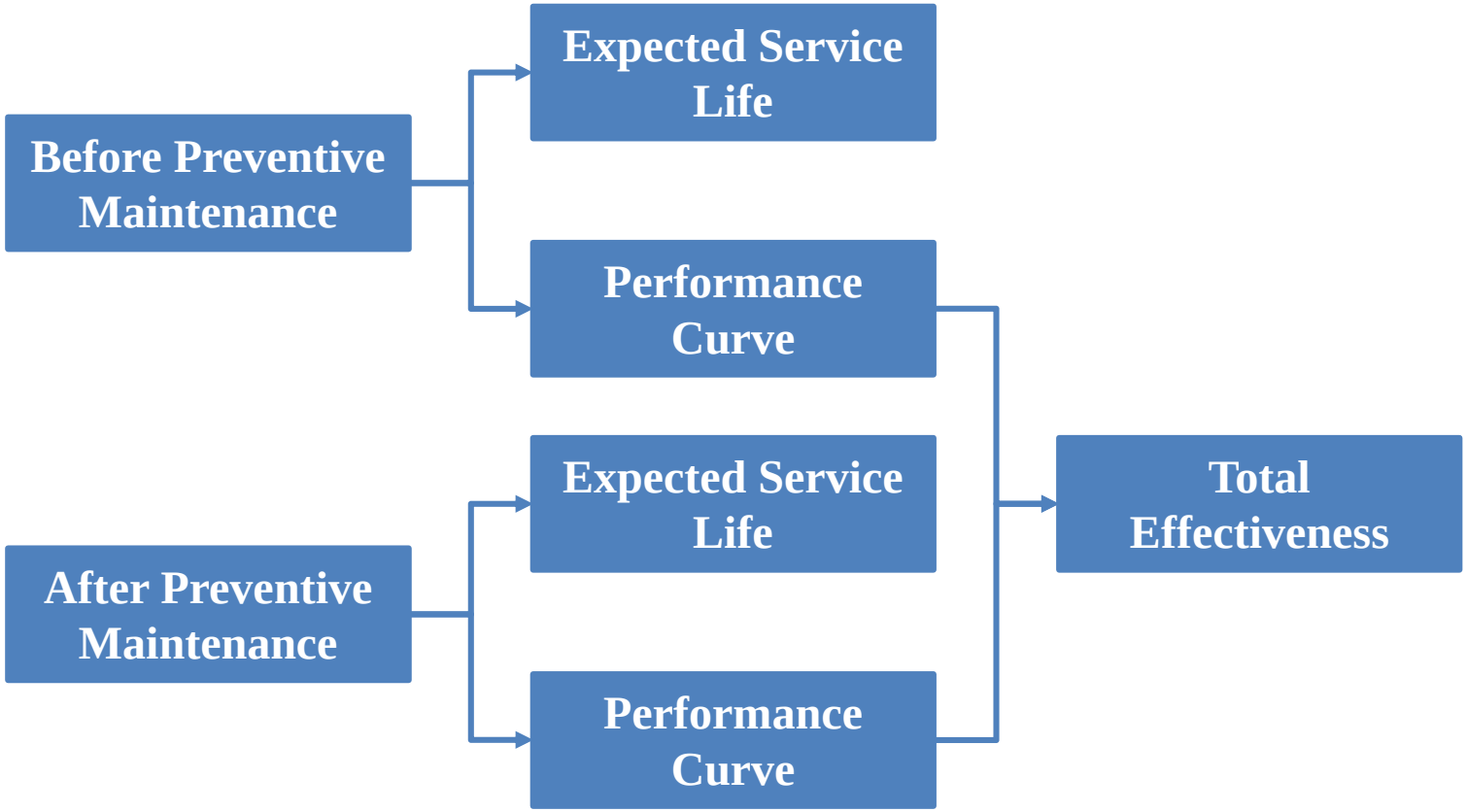

Optimum Maintenance Time

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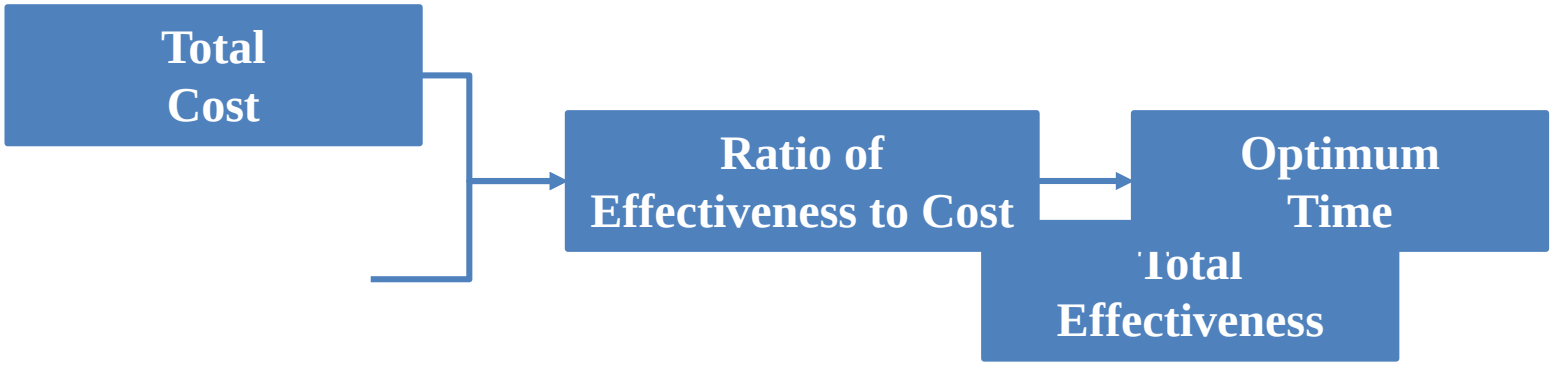

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Conclusions

- **Preventive maintenance is considered as the most cost-effective way to extend the pavement service life**
- **The suggested preventive maintenance for fatigue cracking should be chip seal and that for rutting should be thin HMA overlay in Sharjah**
- **As for demanded maintenance time, four pavement performance indicators, including SFC, IRI, RD and CR, are employed to determine the exact maintenance level.**
- **The optimum maintenance time can be determined based on life-cycle cost analysis**

Thank you for your attention!