PROBLEMS AND FAILURE OF ASPHALTIC CONCRETE WEARING SURFACE CAUSED BY TRANSVERSE SAW CUT JOINTS

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This paper recommends construction technique for asphaltic concrete wearing surface without using transverse saw cut sealed joints. It points out that the transverse saw cut joints are the problems and causes for the observed failure of asphalt wearing surfaces seen in present day US highways. The paper presents the first observed failure of this type of joints on a 17-km long concrete bridge expressway in Bangkok, Thailand, 40 years ago. Since that lesson learnt, no saw cuts have ever been used on the pavement construction in Thailand with positive results. Presently in the US and elsewhere, saw cut seal joints are still used by some sectors of engineers, despite the observed failure of the asphalt wearing surface all over the country wherever the transverse saw cuts are used. This paper demonstrates the pictures of typical failure seen on actual structures. Pictures of good pavements without using transverse saw cuts are also shown for comparison. Brief discussions of the adverse effects caused by the saw cuts are given.

Keywords: Bridge, Crack, Deck, Highway, Maintenance, Repair, Serviceability.

1 INTRODUCTION

This paper is a construction technique paper addressing the means and methods of construction of asphaltic wearing surface or overlay on concrete bridge deck and concrete pavement. Particularly, it describes the problems and failure of the saw cut sealed joints, observed 40 years ago on a 17-km first stage expressway in Bangkok, Thailand. In comparison, the asphalt wearing surfaces designed and constructed properly without using any saw cuts have been seen to be in good conditions without transverse cracks. Pictures of cases in Thailand and in USA are shown. Fundamental reasons why the saw cuts are the causes of failure are given.

2 ASPHALTIC SURFACE LAYER, ASSUMPTIONS, AND METHODOLOGY

2.1 Asphalitic Concrete Surface Layer

Asphaltic surface layer, commonly called pavement black top refers to the asphalt surface course (overlay) that is paved as the finished layer over concrete road pavement or concrete bridge deck, and as the surface course over the asphaltic base course of flexible road pavement. The average thickness of the layer is between 50 mm to 75 mm depending on the design. It acts as the wearing surface protecting the base underneath, and provides smooth riding surface.
2.2 Assumptions
The road pavement and bridge deck discussed in this paper refer to those that are properly designed and constructed by professional engineers. Hence, the cause of the problems and different behavior of pavements are confined to one factor, the transverse saw cut joints.

2.3 Transverse Saw Cut Sealed Joint (Saw Cut Joint)
The transverse saw cut sealed joint, briefly called saw cut joint, refers to the transverse saw cut at the top face of the asphalt layer across the full width of roadway or bridge deck. Figure 1(a) shows typical saw cut joint over the buried expansion joint of bridge deck. Figure 1(b) shows typical saw cut over the joint of concrete pavement (reflective joint).

![Figure 1. Saw cut over buried joint in (a) bridge deck and (b) concrete pavement.](image)

2.4 Free Versus Restrained Movement
Full depth expansion joints on bridge deck are free to move. Saw cut joints are not free to move.

2.4.1 Expansion joints and expansion bearings
Expansion joints are used on bridge deck to accommodate movement due to temperature change. The deck is supported on a series of fixed and expansion bearings. Hence, the deck is free to slide at the expansion bearings.

2.4.2 Saw cut joints on surface layer restrained at bottom face
Saw cut joints are not free to move as they are not a full layer depth cut, normally the depth of the saw cuts would be about 25 mm in a 75 mm-thick wearing course, or about one-third of the wearing course thickness. It is called by many names: pseudo joint, dummy joint, crack inducer. Also, the bottom of the surface layer is fully in contact with the concrete deck surface. The bonding and friction at the interface prevent the surface layer from sliding. The surface layer is restrained from movement. Hence, the saw cut joints are not free to move and of no use for temperature movement.

2.5 Problems with Saw Cut Joints – Causes of Failure
The notch and the sealant reservoir recess at the top of the asphaltic surface are stress raiser. Stresses at the saw cuts are higher than the stresses in un-cut sections due to stress concentration. The stress concentration contributes to the failure at the saw cut joints, as none of the pavement analysis and design has ever included truck tire loads and tire traction forces at the surface saw cuts into consideration (Myers 1999, Wang 2011).
Saw cutting the asphalt surface removes the confining pressure. It is known that removing confining pressure of adhesion-frictional materials causes reduction in shear strength of the materials. The stiffness of the surface layer at the saw cuts is less than that at the un-cut sections of the layer, due to the reduction of section’s effective depth.

2.6 Stresses at Top of Asphalitic Concrete Surface (Without Transverse Saw Cut Joints)

Myers (1999) measured contact stresses on asphaltic concrete surface for different truck tire types in the laboratory, using steel plate to represent asphaltic pavement. Figure 2 shows typical diagrammatic state of stresses with respect to Mohr-Coulomb shear strength failure envelope. For a safe design, the stress tensors are below the failure envelope for normal asphaltic concrete without transverse saw cuts. Hence, there is no failure of un-cut asphaltic layer.

![Figure 2. Mohr-Coulomb shear strength failure envelope in asphaltic surface without saw cuts.](image)

2.6.1 Effects of saw cut and stress concentration

Due to stress concentration at the saw cut, the stress tensors due to heavy wheel loads in Figure 2 would be raised to exceed the shear strength envelope of the asphaltic concrete, leading to failure.

2.7 Joint Performance on Actual Bridges and Highways (Actual VS Lab Assumptions)

Actual behavior of asphaltic pavement and bridge deck under sustained truck tire loadings cannot be accurately predicted or simulated in a laboratory or by any computer software. No University or research Institute in the world can build 17-km expressway in the laboratory for say 400,000 vehicles of different size and weight travelling on it every day for one or two years to investigate the behavior of real pavement. Note that the measured stresses reported by Myers (1999) used steel plate to represent asphaltic pavement. The stresses reported in the PhD dissertation by Wang (2011) were based on finite element model using assumed models and properties for pavement and for the truck tires. The investigation did not mention or include saw cut joints.

The following sections present the actual performance of the real structure under the sustained loadings from vehicle and truck tires for the cases with saw cut joints, and without saw cut joints.

3 OBSERVED SAW CUTOFF JOINT FAILURE 40 YEARS AGO

Under the administration of the Expressway Authority of Thailand (EXAT), the 9-km Din Daeng-Port section of the first stage expressway system (FES) in Bangkok was completed and opened to traffic in 1981. The second section, the 8-km Bang Na - Port was opened in 1983. These are elevated dual carriageway for 6 traffic lanes. A well-known engineering company from Europe...
was commissioned to lead the detailed design of the expressway. The design is described in the paper by the designer (Vavasour 1983). The typical viaduct cross section (Figure 3a) and the typical saw cut above buried deck joint (Figure 3b) are taken from the paper by Vavasour (1983).  

![Figure 3. a) Typical viaduct cross section, b) Typical saw cut at buried joint.](image)

The viaduct deck is concrete slab on concrete girders, paved with asphaltic wearing surface. Note that the typical girder span is 20 m long simply supported between piers. The saw cut sealed joints occur at very pier above and in line with the deck expansion joints (buried joints). Roughly, there are 850 joints on the southbound carriageway, and 850 joints on northbound carriageway over the 17-km FES expressway.

### 3.1 Asphaltic Surface Damages at All Saw Cut Joints – 100 % Failure Rate

It was well known to commuters using the FES, and as reconfirmed by EXAT’s head of maintenance department, that the saw cut joints on the FES started to crack within the first year of its operation in 1981. The cracks propagated and the areas, about 150 mm both sides of all saw cuts were severely damaged with cracks and deformed along the length of the transverse saw cuts within 2 years. Figure 4 shows pictures of the inspection of the damages at the joints.

![Figure 4. Damages at saw cut joints on the FES, pictures taken in 1983 (courtesy of EXAT).](image)

The pictures show the failure was in the intermediate stage, the cracks formed along the entire width of the deck from parapet to parapet. The initial width of the cracked area was about 300 mm, approximately equal to the tire contact length over the transverse joint. The cracked area depressed down as the saw cut propagated downward. The bumping effect as the tires went over the cracked and depressed joint area increased impact loads on damaged surfaces, escalating...
further failure. Ultimately, under repeated grinding of truck tires, the damaged area enlarged in width and depth exposing the buried expansion joints. The joint areas became wide hollow trenches along the joint lines and unsafe to drive on. All existing saw cut joints of the FES were replaced by asphaltic plug joints similar to that shown in Figure 5.

![Asphaltic plug joint diagram](image)

**Figure 5.** Asphaltic plug joint.

### 4 OBSERVED SAW CUT JOINT FAILURE AT PRESENT TIME

Figure 6 shows pictures of damaged and repaired areas at saw cut joints on US highways. The damages and failure patterns are similar to that seen on FES 40 years ago.

![Pictures of damaged saw cut joints](image)

(a) Route 9W, Brookline, MA  
(b) Route 9W, Kennebunk, Maine  
(c) Lowell St., Newtonville, MA  
(d) I-80W, Erie, PA  
(e) I-87N, Nyack, NY  
(f) I-87N, Nyack, NY

**Figure 6.** Pictures of damaged transverse saw cut joints on US highways (October 2021).

### 5 PERFECT ASPHALTIC SURFACE ROADS WITHOUT SAW CUTS
Figures 7 and 8 show the road and bridge deck with asphaltic surfacing that were designed and constructed properly without saw cut joints, are in good conditions within its design service life.

![Image of rural road eastern seaboard](image1)
![Image of Second Stage Expressway in Bangkok](image2)
![Image of road within UN-ESCAP](image3)

(a) Rural road eastern seaboard  (b) Second Stage Expressway in Bangkok  (c) Road within UN-ESCAP

Figure 7. Pictures of asphaltic surface roads without saw cut joints in Thailand.

![Image of Memorial Drive Cambridge, MA](image4)
![Image of Parker Ave., Newton, MA](image5)
![Image of I-95, Kennebunk, Maine](image6)

(a) Memorial Drive Cambridge, MA  (b) Parker Ave., Newton, MA  (c) I-95, Kennebunk, Maine

Figure 8. Pictures of asphaltic surface layer without saw cut joints in USA.

6 CONCLUSION

The paper recommends the no-saw cut approach for asphaltic pavement construction.

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References

