MEMO

To: Peter Galvin

Cc; Gary Holt

From: Ivan Mihaljevic

Date : September 01, 2011

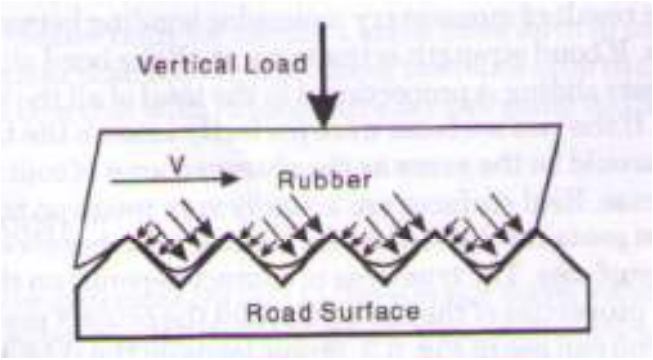
Re: Go Kart Tracks and Asphalt

Peter - you have asked that I provide a simple explanation on the fundamentals in using asphalt on go-kart tracks (or motor racing tracks) in relation to ravelling distress. I list these in point form as follows:

i. Bitumen performance – shear forces that are applied by race cars around corners are more severe that than those applied by passenger vehicles and even trucks. Shear forces are required to turn the race car around corners. The force is generally applied through the action of friction from the tyre to the pavements surface. There are three components to friction – adhesion, deformation and tearing forces. These are explained as follows:

   a. Adhesion is thought to be by far the largest active component of friction in dry weather. Adhesion is applied between the tyre and asphalt surface in a similar way to which adhesive tape sticks to paper. Adhesive forces increase with an increase in contact area and load. However when the pavement is wet the adhesive friction component tends to zero as moisture is trapped between the tyre and the pavements surface. Traditionally race tyres are very soft and very sticky and therefore the tyres chemical compound will also influence the friction levels attributed to adhesion.

   b. Deformation also known as mechanical keying is the process where the rubber takes the shape of the macro texture of the pavements surface. Macro texture can be defined as the interstitial void space of the asphalt surfacing measuring up to 0.1mm in depth. The energy required to move the rubber within valleys of the surface texture is made up of the differential pressure between the peaks of the surface (see illustration below). The angle of the aggregate surface peaks is proportional to the level of deformation friction. An asphalt material containing more angular aggregate will provide higher friction than a rounded aggregate derived say from a river gravel source. It is this mechanical keying that provides friction between the road and tyre surfaces on a wet circuit. Deformation friction is diminished as the use of the pavement increases. The aggregate surfaces are “polished” by the action of passing traffic which reduces the angle of aggregate peaks and therefore also the magnitude of friction delivered by deformation.



c. The third and final component of friction is generated from rubber deformation which results in tearing. When the tyre slides at high speeds across the pavements surface, the local stress at the point of contact can exceed the tensile strength and elastic recovery of the rubber and the rubber will commence to tear. Initially the torn rubber may not dislodge from the tyre however with repeated contact and stress the rubber can tear further dislodging from the tyre which may stick to the pavements surface or become airborne.

From these three friction elements it can be seen that the pavement surface is very highly stressed underneath a race tyre, particularly when soft compound rubbers are used. To counteract these frictional and tearing forces it is important to have a tough and resilient bitumen binder in the asphalt material. Typically polymers are added to the bitumen in order to increase the toughness and tensile strength of the bitumen mastic in the asphalt. A lot of work has been done to select the right polymers as not every polymer is suited for race tracks.

If polymer modifiers are not added to bitumen binder used in asphalt on racing tracks, then the binder film around the aggregate will fail as a result of high fractional forces and the aggregate will tend to pull out from the surface initiating surface ravelling failure.

Surface ravelling can also be caused by inadequate compaction of the asphalt surfacing during construction. This can occur as a result of cold asphalt, poor compaction methods or inadequate compaction equipment. Other issues may also arise which can contribute to poor compaction. The photo below shows ravelling failure of poorly compacted asphalt on a motor racing track.

ii. Asphalt Curing Time – this term is inaccurate as asphalt does not cure, rather the bitumen binder component of the asphalt oxidises. Oxidation is the process where the bitumen binder hardens. There are a number of methods of bitumen oxidation. The first is by the action of ultra violet radiation (sunlight) and water. Like most materials, oxidation of bitumen will occur when it comes into contact with water and sunlight. This leads to the bitumen material becoming harder and increasing in tensile strength which aids to resist the damaging frictional forces of the tyres as mentioned above. The asphalt typically hardens from the surface down. It may take many years for asphalt to harden at deeper levels. When asphalt is compacted adequately, ingress of water and sunlight is restricted.

Bitumen also oxidises as a result of oil leaching. Bitumen contains hydrocarbon chains of many lengths and some of these are light fractions referred to as oils. Most of these oils will evaporate quickly after construction with some taking time to dissipate. The source of the crude and the polymer modification process will determine the volume of oils in the bitumen. The initial evaporation of these oils needs to take place so that the bitumen can gain initial hardness to resist the frictional forces. It is therefore important that the asphalt not be trafficked with high shear loading soon after construction. The time for evaporation will vary with ambient temperature conditions and also bitumen chemistry.