Diamond Grinding or Grooving a Concrete Pavement? Achieving the 4S’s in the 21st Century. A Contractor’s Experience in Australia

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ABSTRACT

Diamond grinding / grooving (DGAG) of concrete pavement is undertaken for a number of different purposes include improve ride (smoothness), increase skid resistance, quieter pavements (silent) and for concrete road revival (sustainability). This technique was first used in 1965 on a 19 year of section of I-10 in Southern California to eliminate excessive faulting. Since then, diamond grinding has become a major element of concrete pavement restoration project in the USA. DGAG was introduced in Australia in the early 21st century. The Company has undertaken diamond grinding / grooving assignments in Australia for the past four years. These assignments were undertaken on new concrete pavements, existing concrete pavements and existing concrete pavement with asphalt overlay removed in New South Wales, Australia. The outcomes of these years of experience shows that the DGAG process is a cost effective process in achieving 4S’s. This paper presents a brief description of some of the DGAG assignment conducted and a summary of the findings.

KEYWORDS: diamond grinding, grooving, concrete, pavement, ride count.

INTRODUCTION

Over the past six years, an Australian Contractor has undertaken DGAG on various types of new and timeworn concrete pavements on the eastern seaboard of Australia. These concrete pavements include plain concrete pavement (PCP), asphalt overlay plain concrete pavements (AOPCP), continuously reinforced concrete pavement (CRCP) and steel fibre reinforced concrete pavement (SFCP). This paper gives an overview of DGAG from a contractor view’s point.
Existing concrete pavements have suffered from a bad brand image due to the fact they are very mature, are providing a reduced level of service and have been designed to other criteria than today’s specifications and have been built using old techniques and construction methods.

DGAG is a concrete pavement restoration technique (CPR). The primary purposes for this technique can be correct out of tolerance pavement surface levels, improve ride quality, improve pavement surface texture and reduce pavement noise. These purposes are mutually exclusives.
Typically, DGAG involves removing a thin layer (0-8mm) off the top of the hardened Portland Cement Concrete (PCC) pavement using an assembly of circular diamond encrusted blades separated at regular and comparatively minor gaps and thereby leaving a longitudinal textured surface with a very slender fins or projection between the saw-cut grooves (see Figs. 4, 5 and 6). The result is a smooth level pavement surface with longitudinal texture with desirable friction and quiet pavement characteristic.

**Figure 4. Blade configuration.**

**Figure 5. Cutting Depth.**
Diamond grinding can be sub-divided into three sub sets:

1. Maintenance diamond grinding (MDG) of existing pavements;
2. New diamond grinding (NDG) of new pavements; and
3. New diamond grinding and grooving of new pavements (NGCS).

![Figure 6. New Generation Concrete Surface.](image)

**SMOOTHNESS**

MDG is used to achieve corrections to ride characteristics and reestablish of surface coarseness and friction. MDG is usually executed after other CPR procedures. These procedures include full-depth repairs, load transfer restoration, slab stabilization or mud jacking. CPR procedures that occur after grinding are repair joint and crack spalling and resealing joints.

DG provides a smooth riding surface that is often as good as or better than new pavement. DGAG equipment is capable of corrective (bump) grinding or continuous grinding depending on the job requirements.

![Figure 7. Holiday after grinding.](image)
QUIETNESS

Conventional DG reduces the thumping noises from concrete slab faulting. Various noise studies show a reduction in road noises after DG.

This innovative grinding technique, NGCS, was used on a section of the Hunter Expressway, NSW. It is a two stage technique of grinding and grooving which provides a consistent profile absent of positive or upward texture, resulting in a uniform land profile design with a predominantly negative textures. Studies by the RMS shows road noises quieter than stone mastic asphalt.

Figure 8. Edge Grinding under Patent by Australian Contractor.

SPECIFICATIONS

Road Authorities are placing greater emphasis on tire/pavement noise, smoothness and constructions delays. This has resulted in the ongoing development of tighter smoothness, new noise specifications and development of low noise surface treatments and equipments. The Road and Maritime Services, NSW, use two key measures of pavement durability (extent of cracking visible) and ride quality (a measure of smoothness).

RIDE QUALITY AND SURFACE IMPROVEMENT

Ride quality measures the undulations in the road and therefore provides an indication of ride comfort experienced by the driver and passenger. Smoother roads also tend to reduce the wear and tear on vehicles and hence minimize road user costs. The ride quality, or longitudinal profile of the road surface, is measured using vehicle mounted laser technology and is measured as IRI and NAASRA.

Over the past six years, a one pass of diamond grinding give ride quality improvement of greater than 39%. Two passes greater than 50%. Figure 2 gives an example of ride quality improvement.
Figure 9. Liverpool Road, Ashfield. Improved road condition is indicated by lower results.

TRAINING / STAFF

The selection of the appropriate DGAG technique / treatment is dependent on a number of factors.

It is the Company’s view that a competent qualified workforce makes a fundamental contribution to achieving high quality durable DGAG. This is achieved by using training, “457” work visa, knowledge transfer and develop of training regimes.

SUSTAINABILITY

Carbon management is becoming an increasingly important issue for client bodies and highway maintaining authorities are increasingly expected to demonstrate carbon savings on contracts. To illustrate the potential carbon savings from using grinding and grooving further research is needed.

Modern long life pavements are characterized by low environmental impact, low life-cycle cost and durable high-quality surfaces. Light colored surfaces and rigid structures contribute to tackling of global warming through the positive aspects of albedo and reduced fuel consumption. These turn concrete roads into invaluable assets in terms of sustainability and a benefit for society. Further research is needed in the benefits of “cool” concrete pavement.
DIAMOND BLADES

Figure 10. Typical grinding machine layout.

Figure 11. Sintered metal-bonded diamond blades, diameter varies between 300 mm to 500 mm.

A diamond blade grinds, rather than cuts, through material. Blades typically have rectangular teeth (segments) which contain diamond crystals embedded throughout the segment for grinding through concrete.

The bond is a term used for the softness or hardness of the powder metal being used to form the segments. The powdered metals hold the diamonds in place. The bond controls the rate at which the diamond segments wear down allowing new diamonds to become exposed at the surface to continue grinding with a "sharp" edge. An important step in choosing a blade is to match the bond to the specific material to be cut. Additional factors to consider are the type and power of the equipment to be used and the availability of water. Harder materials need a softer bonded segment to allow for continuous diamond exposure. Softer materials like asphalt or freshly poured concrete can use a harder segment to resist the increased wear that softer, abrasive materials create. In addition, the diamonds’ grit (size), toughness, and concentration should also match the nature of the material to be sawed. For example, when hard materials are cut, the diamonds should be smaller.

Approximately 100-150 litres of water is used per minute to cool the blades. This water is recycled and the fines are removed from the recycled water.
QUALITY ASSURANCE

As a grinding/grooving Contractor generally operate to first party quality assurance schemes. However the intention is to embody grinding/grooving and become registered to ISO 9001.

COST CONSIDERATIONS

DGAG used to be an expensive operation; however, new, high production equipment as well as improved synthetic diamonds for blades made DGAG, knowledge transfer and improved training has made a more cost competitive option for PCC pavement rehabilitation. Contract prices will be provided by contractors based on an indication of the likely size of the client’s programme. Significant reductions in the size of the indicated programme will increase the contractor’s overhead costs—and thus the price per square metre of work undertaken - and where appropriate, contracts should make provision for compensating contractors under these circumstances.

Engineering and economic analysis carried out by RMS has confirmed that surface restoration of concrete roads by diamond grinding will achieve a maintenance costs of up to 26 per cent over 30 years when compared to traditional alternative of restoration by milling and resheeting.

BENEFITS OF DIAMOND GRINDING

Increasing Road Authorities Specifiers are specifying diamond saw cut surfaces to reduce roughness, reduce noise and increase the friction of their pavements, bridges and runways. In certain situations is it economical, long-lasting, effective and environmentally friendly.

Costs are less than a hot asphalt overlay or a thin lift asphaltic concrete treatment. DG ground PCC pavements can provide better fuel economy. Increases and restores surface friction and reduces hydroplaning.

It is a challenging time for the Pavement Engineer. Motorists are increasingly demanding safe, smooth, quiet and delay free roadways while funding necessary to meet these demands remains elusive.

Diamond saw-cut textures (grooving and grinding) is an additional technique for Pavement Engineers. It is a time proven, cost effective means of providing consistently smooth, quiet and safe textures at a less cost of asphalt overlays.

REFERENCES

RMS, Specification Guide NR93 Guide to Diamond Grinding of Concrete Pavement
RMS, R93, March 2014.