Technology's place in pavement construction

Abstract

As technology accessible to the consumer in all facets of life advances at a startling rate, naturally, the technology available for use during all aspects of pavement construction is too. As a project manager, the decision to use equipment such as machine control technology is made not on the merits of the equipment itself, but on the balance of efficiencies and costs of using said equipment. I often find myself in the interesting position of weighing up potential increased productivity vs downtime and setup costs vs cost saving which both incorporate many variables. These decisions influence pricing, programme, methodology and personnel development among other sectors of my projects

Introduction

For those unfamiliar with the term 'machine control' – it refers to the survey based technology that is implemented in construction plant such as graders, excavators, pavers, profilers/ mills and bulldozers. In a nutshell – machine control gives the ability for the operator to toggle the level control function of the machine between manual, auto and various combinations of both. On auto, the machine will automatically track relative to a design. There are a magnitude of different functions that machine control can preform

As with any new technology, there is always a period of unfamiliarity during the introduction and implementation phase of said technology into practise. Because of the complexity of construction plant machine control technology and the rate at which the technology is being developed, this period of unknown is almost permanent.

Because of the staunch views of many within in the civil construction industry around methodology, one of the biggest challenges faced by companies developing the technology is persuasion of stubborn minds that machine control technology is in-fact beneficial, more efficient and the 'way forward'. Because of this, a number of developer driven and independent studies have been completed, eg (A∂alsteinsson 2008). Ultimately, the net result of these studies conclusively agree that on the balance of all considerations machine control technology is beneficial. This is fairly undisputable and is a point that I strongly agree with.

With these facts settled, the question is; what degree of survey/machine control technology implementation is required and at what stage in the project it shall be implemented to the greatest effect. Because of the dynamic environment that project management decisions are made in, and the numerous machine control options available, a significant amount of experience is required to make the most profitable decision in terms of quality, commercial and practical outcomes.

Discussion

Decisions around the implementation of machine control require a very dynamic assessment of the specific constraints, limitations and details of each individual task. These range from operator development to availability of resource to financial margins. Some of the points that are to be considered include (but are not limited to);

Financial – Very seldom do faster, more efficient and more accurate methodologies come along without a cost. Such is the case with Machine control technology. These additional costs are often offset by the increased productivities. Conversely, there are cases where the incurrence of the additional cost for greater output is not financially viable.

What stage to implement technology – Cunning integration of machine control technology at the right stage of a pavement construction project will increase the effect of the use of that technology on the construction. For example, using machine control at the milling stage to milling *X* depth below a pavement design surface so that a nominal depth of material can be placed by a paver is far more efficient than milling a nominal depth and paver laying to machine control.

Problems – With the implementation of all new technology there are problems with understanding and training to use. There are few scholars amongst construction crews and the equipment often requires a significant level of understanding to use which, understandably, can cause issues.

Further Advancements – Advancements are being made to machine control technology continuously. A recent example of this is the ability for multiple total stations to track a single piece of plant that is operating of machine control. This gives the ability for the operator to select the closest total station (which therefore has a lower chance of a factor of error being an issue) to control the machine.

Benefits of older methods - There are also benefits of traditional methods such as paving a 'nominal thickness' and grader laying material 'by eye'. Such benefits are; ease of use, speed, low cost, often suited to certain construction situations.

Constructability – 'tricky builds' - Pavements with multiple changes in horizontal and vertical geometry are typically high risk constructions for traditional methods. With the use of machine control technology the risk is significantly reduced because essentially there is a computer doing the work. Another example where machine control technology excels is in the high risk situation of pavement stabilisation with bitumen/cement/lime. During stabilising, 'primary compaction' needs to be achieved approximately 2 – 4 hours after stabilising depending on the treatment used. This is often a high pressure environment for the grader operator. Stress levels can be significantly reduced through the use of machine control because the 'shape' can be graded far faster than using traditional methods. Also, this gives less experienced operators the chance to complete stabilising operations.

Quality – NZTA requires tolerances of -5mm / +15mm in pavement surface layers. Realistically, this is very difficult to achieve using traditional methods. Machine Control Technology allows tolerances of +/-1mm to be achieved. These figures have been achieved using machine control technology by our construction teams in Canterbury. An example of this is the 9600m2 concrete slab base course prep at the Moffatts factory in Rolleston. The average variation in level between the actual prep surface

vs design was 0.83 mm. This resulted in 8m3 of additional concrete being poured over the 80m x 120m slab (8m3 / 1440m3) – something that the concrete pour manager had never seen in his 30 year career.

Because the desired accuracy can be achieved faster using machine control, there is less need for multiple 'cuts' while grading unbound material. Grading material causes segregation so a reduction in the number of 'cuts' made while shaping a material also improves material properties through less material segregation.

Survey requirements – There is a significant level of survey support required to operate machine control on any construction plant. This understanding includes;

- Knowledge of degree of accuracy of control points used,
- How data/design is read by machine,
- How to manipulate designs for machine control requirements
- Experience in the design and use of TIN design surfaces,
- An efficient data collation and register system

Productivity – In all cases, productivities are increased through the use of machine control. One of the few flaws of machine control is the potential 'down time' while teething problems are encountered. Down time can be reduced if the operators and engineers/surveyors are experienced enough to troubleshoot issues as they arise.

Safety - The use of machine control removes the need to manual level/height checks to be made. This reduces the number of staff working around plant on foot. Less staff on foot on site decreases the inherent risk.

Conclusion

Greater experience with the use of machine control technology will bring clarity to the nuances of debate around its use. Currently, the use of machine control is considered an abnormality by many aging practical staff; I expect this mind-set to be altered as the balance of tech savvy Y & Z generation minds in the civil construction workforce increases.

The importance of a higher level understanding of machine control is significant. A diverse and balanced level of experience in surveying, pavement construction and plant operation is required to fully understand the potential benefits, applications and constraints of machine control.

In ten years' time, I expect machine control technology to be a requirement on many pavement construction projects. There will be a higher level of acceptance by practical staff and ease of use is guaranteed to have improved. Functions within the technology will have developed and productivities through the use of machine control will have advanced even further.

In conclusion, machine control technology is hugely powerful & beneficial tool. The differentiating factor that determines the success of use is in the planning and understanding of machine control. Accurate implementation will increase productivity, safety, quality and financial margins.