Spread the word spread the load

Every year since 2006 we have focused on the importance of spreading outrigger or wheel point loads by using good quality outrigger mats or tracking and setting outriggers correctly for the work to be done. That first feature came a year after we began reporting crane and aerial lift accidents on Vertikal.net. During that time, it became apparent that the vast majority of incidents resulting in serious injuries or fatalities were related to overturning, mostly due to a failure to spread outrigger loads with proper mats or cribbing, along with poor outrigger set up. Most companies now appreciate the importance of setting up properly, and mat usage is commonplace, but overturns remain a major problem.

Short rigging outriggers can be disastrous if forgotten

A more positive attitude

Today most companies that run cranes or aerial lifts, along with their operators, and the contractors they work for, understand the importance of establishing the ground bearing ability of a site and checking for underground voids before any lifting equipment is allowed to set up. However, there are still plenty of idiots out there who seem to be oblivious to what should be second nature.

Mike Ponsonby has been investigating lifting related accidents since 2007 and has compiled a database of his findings. Even today, outrigger and ground related incidents make up half of all serious accidents *(see page 46)*.

So why is overturning still happening so frequently? Short rigging outriggers on one side and forgetting is a classic cause, with cranes tipping rearwards when the retracted boom is raised.

The introduction of outrigger, counterweight and slew position sensing, complete with lockouts, may eventually eliminate this issue while providing improved versatility and ease of setup.

Failure to check for voids can be costly

The failure to properly check for underground voids remains a major cause of overturns. An experienced operator will tell you that simply looking at the ground and surrounding area can provide valuable clues as to what one can expect, which should lead to asking probing questions regarding what lies below ground. If in any doubt, then the operation should overcompensate with larger mats or low test lifts. Ideally, a full ground survey is the best course of action, especially for larger cranes, but this is not a practical reality for everyday taxi crane work. Thus the importance of an experienced operator with an eye for dodgy ground conditions, who is also prepared to ask tough questions and not take quick answers as gospel.

This truck crane overturned in Ft Lauderdale, Florida, earlier this month when two of its outriggers dropped into an underground septic tank. The crane operating company said: "The customer advised that there was NO septic tank, thus making it safe to park in the driveway but there was, in fact, a septic tank."

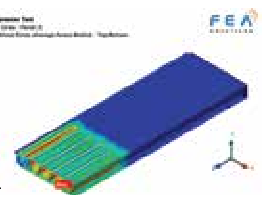
As more crane owners and contractors have come to understand the importance of good quality outrigger mats, demand for them has increased and the number of manufacturers and suppliers has grown. The smaller, more popular mat sizes have become something of a commodity, carrying the risk that buyers think they are all the same - they most definitely are not! The fact that there is no clear standard/certification for outrigger mats in most of Europe does not help.

Many leading suppliers have been extending their product ranges with new products and innovations, with a focus on improving performance and making mats lighter and easier to use. Some are also working with end users to find ways to improve the performance of larger, more specialised mats and mat systems, using sophisticated testing and analysis to better understand how mats react under heavy pressure on various surfaces. On the following page, we look at how Finite Element Analysis has helped US manufacturer Dica better understand the spreading performance of mats on harder surfaces, resulting in some very specific recommendations.

Poor outrigger set up affects smaller machines too

Testing to point of destruction

In the UK Brilliant Ideas has also been using Finite Element Analysis to test its Alimats interlocking aluminium mat system. Among the independent tests carried out is a simulated deformation test, involving a 463.94-tonne point load from a 450mm square pad. The test resulted in an internal rib failure in one of the mats, but indicated that fully interlocking mats in a multi mat set up behave like a single monolithic unit, enhancing bi-directional load spread.



Alimats FEA test

New products


Outrigger Pads new Incline Pad can be combined.


Power-Pads HD Lite mats

UK based supplier Outrigger Pads is to launch a Inclined Pad range of composite mats that combine with its regular mats to help set up on sloping ground. Its first Incline Pad is 405mm square, with a capacity of 15 tonnes and weighs 12.79kg.

Lighter large mats

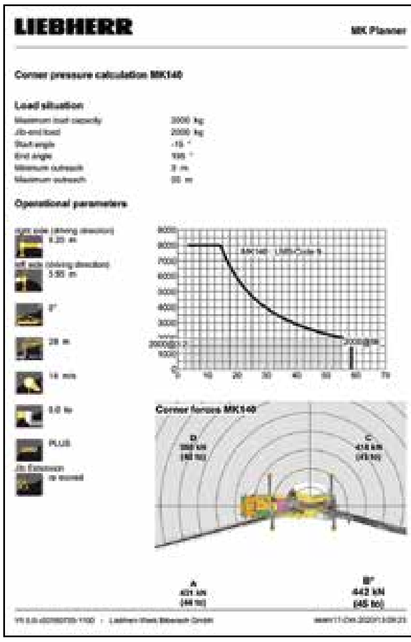
TMC Lifting Supplies added the new HD Lite aluminium outrigger support mats to its Power-Pad range this summer. Manufactured from high-grade aluminium, the HD Lite pads have a depth of 100mm with a 50mm base layer of Etha foam ground protection, providing capacities from 60 to 125 tonnes. Weighing 68kg per square metre, it is feasible to carry four mats measuring 2.5 by 1.8 metres, on board a crane, or on a 3.5 tonne truck or two axle trailer. Available in a variety of sizes, features include integrated corner mounted lifting eyes or inset lifting points which allow multiple mats to be placed side by side and positioned in a modular format if required.

Variable outriggers pay off

Outrigger position sensing and variable set up can not only improve safety and ease of set up, but also be financially rewarding. Cork Crane Hire recently posted the following report.

"Nice little six week hire for one of our Liebherr MK140's started this week on VarioBase. Unfortunately, couldn't send the Spierings AT6 as it can't be operated with half riggers on one side and full on the other, despite another supplier telling the customer that it can. Well done to the customer for seeing through him, keeping it legal and not putting safety and people's lives at risk.

I am sure Spierings are working on this and it will only be a matter of time before its sorted, but until then the MK140 is going to be the winner on a variable outrigger set up. Must say, two tonnes at a 55 metre radius is a decent lift for a mobile self-erecting crane."



The Lift Planner highlighted every aspect of a short rigged lift.

Setting up on hard ground

As more contractors, and the site managers they employ, understand the ground conditions on their sites and grasp the importance of spreading outrigger and extreme tyre point loadings, more thought and planning is being carried out prior to a lift. This in turn is leading to more stringent requirements being placed on crane suppliers or operators. North American based outrigger mat manufacturer Dica discusses the challenges of getting the most out of outrigger mats on hard ground and avoiding peak loads.

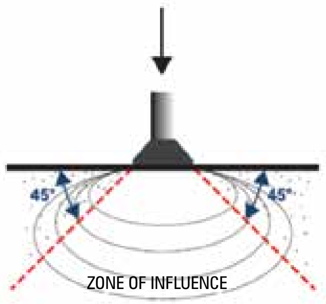
Many of our customers are facing ever more stringent requirements for reduced ground bearing pressures. This may be due to greater regulatory attention on equipment setup, or site owners who are more risk averse to unknown ground conditions, or a lack of understanding of how crane mats distribute loads. When working on very hard ground with strict load reduction requirements, using an intermediate layer as a buffer can help get optimum performance out of your outrigger pads or crane mats.

A common misconception regarding the load distribution of crane mats is that outrigger loads are evenly distributed across the entire mat area in all ground conditions, no matter the mat size or loads applied. These assumptions should not be made. To achieve even, equal, and predictable distribution over the area of the mat, an infinitely rigid material would be required. In the world we live and work in, there are no infinitely rigid materials—not even high strength steel. Therefore, there will always be some level of peak loading, and actual load distribution will be the result of how the load, ground and mats influence each other.

From the ground up

Some movement and compaction of the ground allows pads and mats to deflect. Managed deflection of pads and mats improves overall load distribution because it increases the contact area between the mat and the ground. Even with engineered and properly selected outrigger mats, some deflection is expected.

However, hard ground presents different challenges. As the ground conditions become harder or ground bearing capacities increase, mats become less effective in spreading the load. In very hard ground conditions such as a slab of concrete, load typically distributes at an angle of 45 to 60 degrees through the thickness of the mats. This results in higher peak pressures and higher overall



ground bearing pressures because of the reduced area of distribution. Often the interaction between the ground and mat is not recognised or understood, which results in higher ground bearing pressures than are intended.

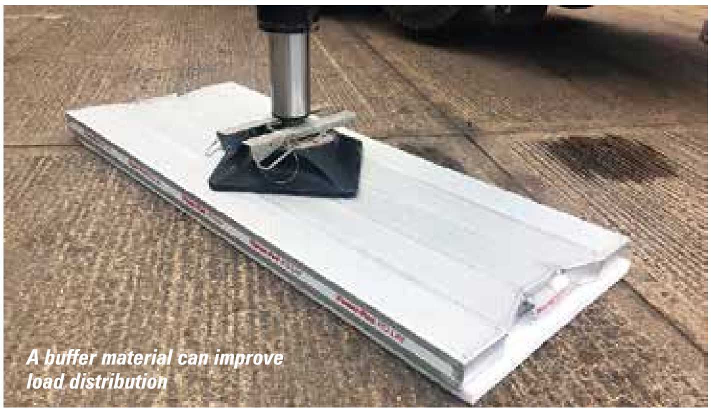
Simple solutions

To reduce ground bearing pressure in very hard ground conditions, consider introducing a softer buffer layer that allows for managed pad deflection to occur. The objective is to soften the ground to make the existing pad more effective as opposed to stiffening the pad to overcome the hard ground conditions. Softening the ground is a counterintuitive approach, however making pads stiffer can significantly increase costs and weight. Commonly used intermediate buffer materials include sand, or materials with high compaction strength, such as neoprene or rubber.

Regardless of the type and construction of the outrigger mat you are using, any of these intermediate buffers will help with improved load distribution and the achievement of lower ground bearing pressures.

Beyond softening the ground to enhance load distribution, an additional benefit of using an intermediate layer is to fill any inconsistencies or voids between the pad and the ground - think about a surface of brick pavers. Filling these inconsistencies helps to eliminate point loading on small areas of the ground, and it helps protect the ground surface under heavy loads.

Sand as an intermediate layer can be a great solution. However, subject to the loads and objectives,



A buffer material can improve load distribution

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a 50 to 150mm - two to six inch - thick layer of sand may be needed. A downside with using sand is that it is messy.

A cleaner option that Dica recommends is neoprene which is available in different sheet sizes and thicknesses. Using 20mm/0.75 inch in a single layer or multiple layers is a simple and effective solution. Because neoprene is a manufactured product, the material also has defined performance properties that users can count on. These consistent properties produce predictable and measurable results. We recommend using a 60-durometer neoprene for this application, which will squish under

Dica recommends using Neoprene to help spread the load

these high loads but not break down.

The proof

We use Finite Element Analysis (FEA) modelling to project actual results of different set ups. By using this technology for hard ground setups, we are able to demonstrate how significant reductions in peak and overall ground bearing pressures are achieved by adding an intermediate neoprene layer.

Figure 1 and Figure 2 FEA images reflect a quarter symmetry model. The section displayed is the upper left quadrant of a FiberMax Mega Duty Crane Pad. The grey area is the defined ground, and the purple grid pattern is the Mega Duty Pad. The upper left quadrant of the 600x600mm/24x24 inch outrigger mat is located in the lower right corner of each image.

In this case, the outrigger reaction force is 102 tonnes/225,000 lbs and the ground is solid concrete modelled as having a ground bearing capacity of 40,000psf/275N/sq.millimetre or if you prefer 195 tonnes per square metre, in other words extremely hard - with no expected movement. The colours shown indicate the pad to ground contact and associated, correlated pressures. The results indicate a reduction in the peak pressure of 35 percent and an improvement in overall pad to ground contact of 22 percent.

In Figure 1, the average ground bearing pressure is roughly 7,200psf/39 tonnes per square metre based on a mat to ground contact area of 78 percent of the mat. Figure 2 shows how the improved mat to ground contact - now 100 percent - reduces the

average ground bearing pressure to 5,625psf/26.9 tonnes per square metre which is the objective.

While the specific prescription depends on many factors, Dica has generally found that neoprene mats that are 20 to 40mm - 0.75 to 1.5 inches - thick produce optimal results. At this thickness, the amount of deflection can be managed and the benefits of softening the ground are optimised.

Figure 1

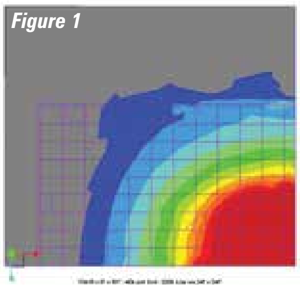
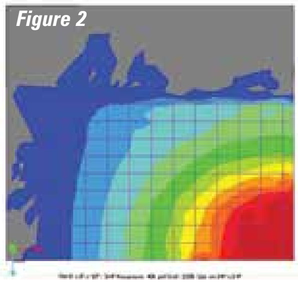


Figure 2



A legal and cost point of view

Mike Ponsonby's principal expertise is the law. However, he has also been monitoring crane accidents since 2007. Over the years, Ponsonby has created a database of crane incidents and their causes. Shockingly, more than half the accidents logged were caused by poor outrigger practice - often due to the lack of adequate mats or cribbing for the ground conditions.

In recent years, Ponsonby has been presenting his findings at numerous seminars and is increasingly getting 'buy-in' from contractors. He has often been disparaged for his efforts but he's passionate about crane safety and hasn't been put off by internet trolls or naysayers. A recent overturn that he investigated prompted him to submit the following article.

Mike Ponsonby

Crane stability is the pre-requisite for a safe lift. In an increasingly litigious society, it is now highly cost-effective to select outriggers and mats to ensure maximum stability first time round, and every time. To look at it another way, it's cost prohibitive to ignore safety or to take a chance.

Outrigger mat sizes are almost infinitely variable, as are ground conditions and the bearing pressure it can support. What is a good procedure for calculating the correct mat size for a specific job?

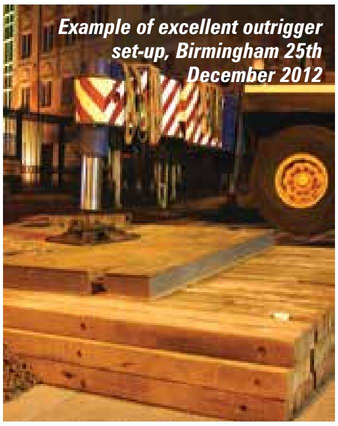
1. Site temporary works engineer must advise the Appointed Person of the maximum-permitted ground bearing pressures for the site and highlight any potential voids so that a lift plan can be drawn up.
2. The lift plan is produced taking into consideration the total loads to be lifted including rigging etc.
3. The lift planner then calculates the boom/jib lengths, radii and counterweight required and the outrigger configurations possible.
4. The maximum outrigger loadings can then be calculated and therefore the mat size required. A good method is to divide the total weight imposed by the crane with and without load at a minimum and maximum radius and divide this by three - rather than four - to build in an additional 25 percent of margin.
5. Once the force imposed on the ground in tonnes per square metre for each outrigger is calculated. The mat size can be selected to meet the maximum ground bearing pressures permitted for the site. The result should always be rounded up to the next whole number to achieve an additional safety margin per mat.

Example of poor outrigger set-up, Rotterdam 8th August 2018

Serious crane incident database 2007 – September 2020

Crane type involved	Totals	Mobile	Crawler	Tower	AWP	Other
Totals by Crane type		314	129	118	90	149
Total fatalities	617	39%	16%	15%	12%	18%
Total serious lifting incidents	802					

An avoidable incident in New Zealand



Example of excellent outrigger set-up, Birmingham 25th December 2012

While this procedure ensures a respectable margin of safety, temporary works engineers also tend to build in substantial safety margins, which can lead to ridiculously large mats being specified. However, that's better than underestimating because, in the event of an overturn, the engineer and his employer will have no hesitation ensuring that the crane supplier is in the frame legally and for all direct and contingent costs.

An example of what can happen if a lift plan is not sufficiently detailed can be seen in an overturn that happened in New Zealand on Thursday 24 September. The material facts are displayed in the safety bulletin. The crane was rigged with 5.2 tonnes of counterweight, while the load was a mere 150kg. The crane capacity was 1.3 tonnes with a full 50 metre boom at the maximum radius of 30 metres. It is possible that the radius was exceeded but it was the soft ground that caused the overturn.

The contractor told investigators that the crane had been set up on a 'non-approved work platform/base'. The site had a rule that required a permit for all lifts where outriggers were used, which included a ground stability check in advance of setting up. The situation was exacerbated by the size of the outrigger mats used. Had larger mats been selected, the crane may well have maintained stability.

This scenario is not at all unusual. I have been monitoring crane accidents since May 2007. In the 13 years since I have recorded 421 such incidents in my database of more than 800 serious crane incidents worldwide that I have personally researched. It's highly cost-effective to train, instruct and supervise all personnel involved in lifting operations because Force, mass and gravity are ever present factors that can never be completely excluded from crane and lifting operations, no matter how routine they might appear.