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Recognising the problem

Understanding ground conditions is so important when setting up lifting equipment

This is the 10th year that Cranes & Access has highlighted the importance of using outrigger mats, cribbing and other forms of ground protection in order to reduce the likelihood of equipment overturning or sinking, especially when working on soft ground, over hidden voids such as drains, sceptic tanks or cellars and above poor load bearing layers.

Over the years we have stressed the importance of understanding the ground conditions when setting up lifting equipment, and how even taking the most basic steps to spread the load and properly set outriggers, could more than halve crane accidents overnight.

Thanks to the efforts of a number of people and associations - and perhaps due, in part to the regular reporting of cranes and work platforms overturning on www.vertikal.net - significant progress has been made. The use of purpose designed mats and temporary tracks are increasingly prevalent, as more companies pay serious attention to this aspect of the job. Awareness has also been raised by an increasing number of industry associations including the launch of global campaigns, such as IPAF's Spread the Load'. Regulatory and safety authorities have also helped with new rules coming on line and safety inspectors increasingly aware of what to look out for when on site or tragically when investigating accidents. However there are still way too many operators, site managers and other lifting equipment users that do not take this subject seriously enough, or are just ignorant of the requirements and responsibilities they face.

A new most comprehensive guide

The latest effort to improve the knowledge in this area sees the launch later this month of the Ground Conditions Good Practice Guide - a sizeable 73 page document developed by the UK Strategic Forum for Construction, in co-operation with national associations such as the Health and Safety Executive, the CPA and CITB. For those not wishing to wade through the hefty full length version, a more manageable four-page summary is also due to be published. We have reviewed the draft publication, which covers not only the ground below a machine's outrigger jack, tracks or wheels, but also highlights the challenges of getting a heavy crane or truck mounted lift across uncertain ground to the working area.

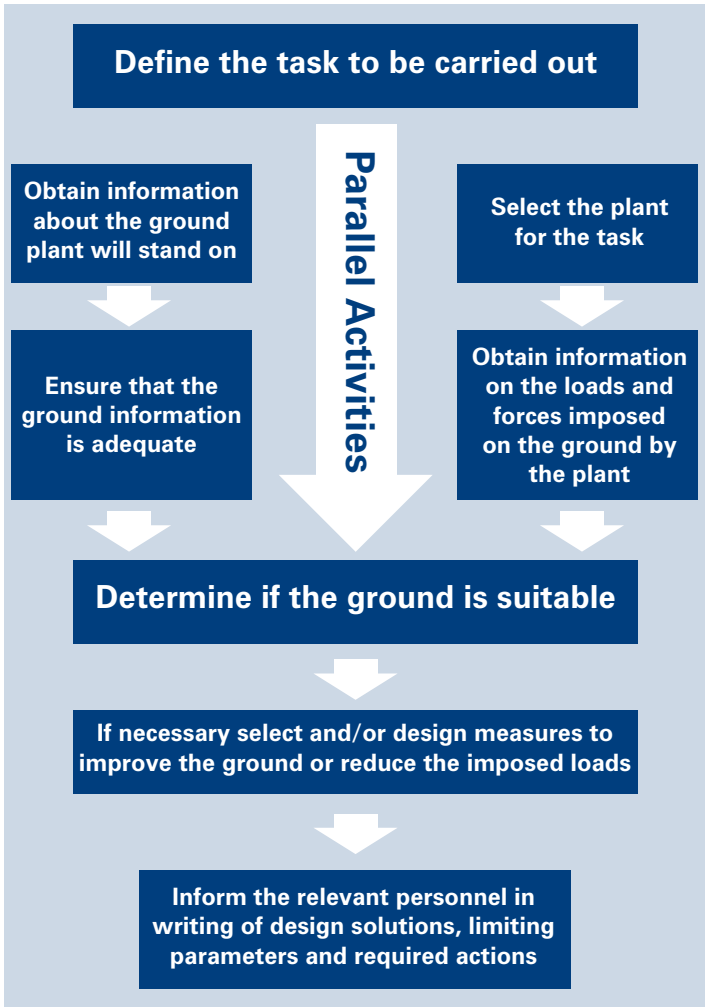
The guide is based around a flow chart which goes through each process, such as defining the task, obtaining information on the type of ground, selecting the equipment and the load forces it imposes, to determine the suitability of the ground and the measures to be taken. Each of these steps is dealt with in separate sections within the guide.

If the ground is suspect use a lighter machine or spread the load

If the ground is determined to be unsuitable for the loads that a machine applies, there are two solutions - reduce the loadings by using different equipment, or spread the load with mats or by building a concrete pad for example. This information is not new of course - it is pretty much what we and others have been saying for a long time now, but the main problem is that many customers/clients and contractors are still not fully aware that it ground conditions are ultimately their responsibility.

"The main purpose of the document is that it is not aimed at the experienced crane owner or operator, but it is for the end customer and the site management where the equipment is working, and it is they who should give the equipment operator much of the information specified in the new good practice guide, such as the maximum ground bearing pressures," says consultant engineer Tim Watson, who has

The simplified version of the flow chart



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Another problem is getting to the work position. Here a truck mounted platform and crawler crane find that the edge of the road was not as stable as initially thought

worked on this guide for more than three years. "This part is the easy bit, however the reason the guide has taken so long to produce is what to do about ground assessment. It is a very complex topic and very difficult to produce a simple document of practical use for people on site, without having to get a geotechnical engineer involved."

Of course there are situations where there is particular loading or types of ground where you have to consult an expert geotechnical engineer, however the document works and is kept simple if you accept the built-in high factors of safety.

The site owner, operator or main contractor is always responsible for ground conditions

In the UK and many other jurisdictions model rental conditions place the responsibility for the ground firmly with the client, be this the operator of a large chemical plant, or the main contractor on a construction site. Even when employing a crane under contract lift terms, where the crane supplier takes care of all aspects of the lift the responsibility for the ground remains firmly with the client. The new guide basically tells the client/site operator how to manage this and gives many examples showing the right and wrong ways of doing things.

"Generally the larger main contractors have their own temporary works co-ordinators and have the procedures in place," adds Watson. "This document is principally aimed at the middle and smaller contractors. For example, you can turn up for a lift on a housing estate, and the contractor is not the slightest bit interested in the ground, saying 'set the crane up over there and if you have pads use them' with little or no ground assessment etc... What we are trying to say to these companies is you have to assess the ground conditions and this is how you go about it."

On construction sites many contractors clearly do not understand ground condition information, with comments such as: "We had a 200 tonner with six metre pads on here last week so just do the same" and yet heavy rain, or a slightly different position, even when bringing in a much smaller 50 tonne crane, can change everything. We have reported on a number of incidents where a big crane has carried out a large number of lifts on a site without incident, and then it goes over while doing exactly the same job. In fact regularity and repetition can easily lead to complacency, and is a good demonstration of the importance of understanding what lies underneath you when operating heavy equipment.

Another related problem is getting to the lift position - will the grass, gravel or even hard standing support a crane with 16 tonnes axle loadings, or even 10 tonnes on a big truck mount? And while the crane might have all wheel drive and large single tyres, it does not mean that it will zip across a field as a Land Rover might. With the increase in the number of wind farms in wild, often marshy areas, internal access tracks between turbines can cause a major problem for the wide base of a large crawler crane. This has been exasperated in recent years as wind farm developers have cut back on the specification and standards of internal access tracks.

A further challenge can arise well before reaching the site, travelling down rural or mountainous roads to some of these often remote areas, with the crane or large truck mounted lift straying too close to the edge of a road that is barely wider than the vehicle. All too often this results in the machine overturning or even rolling down the side of a hill. Not only can this lead to the driver being seriously injured or worse, but the recovery from an inadequate road can be a nightmare.

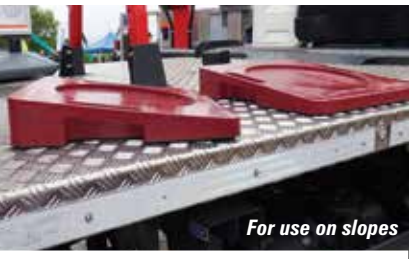
Equipment to spread loads

Moving on to some of the detail found within the report:

The guide contains a number of very useful annexes, for example Annex C runs through the various types of equipment currently available to spread loads and reduce ground bearing pressures, such as timber mats, trackway, proprietory systems, outrigger mats and bespoke spreader plates, giving a brief description, sizes and materials as well as pointers of what to look out for.

Be aware of hidden voids!

Various types of mats and pads


For use on slopes


Textured for extra grip


Outrigger located within the pad


Steel mat

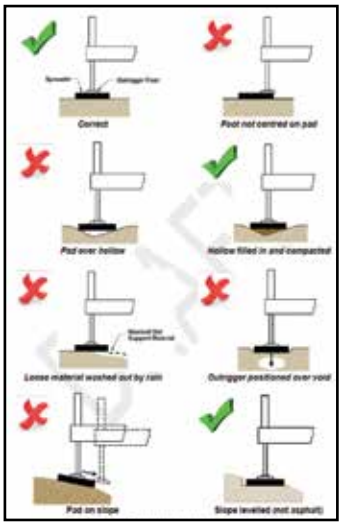

Timber mat


Pad with non-slip layer

For outrigger pads it offers the following:

"There are a number of proprietary outrigger pads available, made from plywood and various types of plastic such as nylon, polyethylene or polypropylene. They are supplied in a range of sizes from 800mm to 1,500mm in diameter and 400mm square to 1,200mm square in thicknesses up to 100mm. Pads carried on cranes, aerial work platforms and concrete pumps tend to be limited in area to sizes which can be manually handled."

"As these pads tend to have a smooth surface, care should be taken to ensure that outrigger feet do not slip off them in wet or icy conditions. Some pads are manufactured with a recess to locate the outrigger feet. Where pads are placed onto surfaces such as crushed concrete or other large granular material - a blinding layer may be needed to avoid point loading and pad damage.



Examples of good and bad practice.

The document also sets out graphically to demonstrate how to properly set up or use a mat and highlights the possible problems that can occur such as being off centre causing high point loadings on the edge or the mat.

Ideally the outrigger should be set centrally on the outrigger mat which should be rigid and not deform. This ensures the load is spread evenly, and by reducing deformation of the mat it increases its capacity. When the pad is too flexible and deforms, its effectiveness is reduced. In cases of excessive bending, the pads' benefits can be reduced to the point where they do little at all to help spread the load".

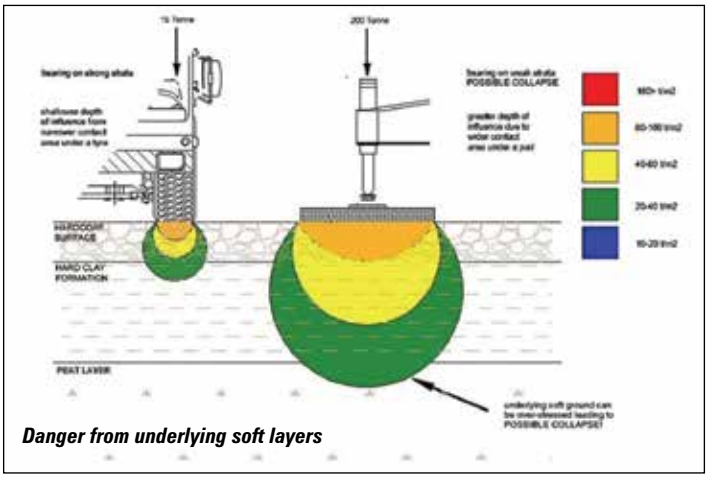
Bearing area

The Guide graphically shows the effect of a 50 tonne outrigger force applied directly onto the ground surface. The small outrigger pad area creates a high pressure leading to a very high point loading which can cause the outrigger to punch through the ground surface, resulting in the machine overturning. A larger mat will off course result in a lower ground pressure with the load safely distributed.

One area that the guide highlights is that when using a very large or oversized mat on weak ground, the forces can be transmitted deeper into the ground than when using a smaller mat. This may cause the forces - although smaller - to travel down into a very low load bearing strata such as peat which might just lead to an increased risk of the ground subsiding. This argument seems counterintuitive and seems to suggest that a larger mat is not always best. But the point is that when applying heaving loads increasing the mat size correspondingly will not always do the job – you really need to know the full make-up of the ground. This will of course almost always apply to larger loadings when it is usually advisable to involve engineering experts.

Assessing mat shape and size for ground conditions and loadings

The guide also includes a simplified method for calculating the ground capacity for certain ground and outrigger mats. A table shows the shape of the pad - round, square or

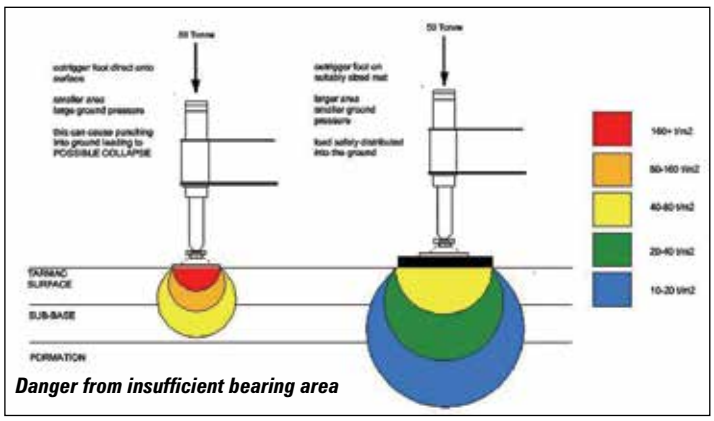


Danger from underlying soft layers


Pads should be rigid and not deform


Outriggers should be placed centrally


Beware setting up near manholes/drains!



Danger from insufficient bearing area

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Trackway can be used by all equipment on soft ground

rectangular - with its width/diameter and length, and then 10 different types of ground conditions from car parks/private roads to public highways, soft, firm and very stiff clay and loose, medium, dense and very dense sand/gravel, providing the safe working load for each type of ground with a given size of pad.

This is done by determining the type of ground you have by inspecting the surface and where possible carrying out a few simple tests - which are outlined in the document - or requesting the information from those likely to have the information. You then check the machine to find what the maximum outrigger load will be, and finally use the chart to select the size of mat that works with the loading and the ground conditions that are present. The chart incorporates a reasonable factor of safety as do most of the maximum outrigger or wheel loadings provided by most manufacturers.

While the guide aims to cover as many situations as possible, it cannot of course cover all eventualities and it states that a formal engineering assessment will be needed if:

- The single outrigger loads are greater than 25 tonnes
- The groundwater table is less than the width of the pad below the surface
- You have underlying soft layers, man-made structures or natural voids below the surface.
- The ground type is not listed in the chart
- You are working near a retaining wall/or top of an embankment
- Doubts exist about the ground type

There are of course other guides, devices and advice on dealing with some of these examples, but a great deal depends on the size of the equipment and the area the machine is working in. In general the larger the machine and the more confined the site the more critical the ground calculation becomes.

Useful examples

The guide has a number of useful examples to illustrate various points. Here is one which considers the use of a telehandler on site - it highlights the potential benefits but also warns that site engineers may have only tested certain areas for specific lifting work. If this is so, it highlights the importance of fully briefing the operator and other employees on this fact.

"Where materials need to be moved around site and lifted to height a telescopic handler can perform a variety of lifting operations and be fitted with a range of attachments and remove hazards involved in repetitious manual handling and dropped material". However it adds: "The telehandler may be restricted to travelling on specified routes that have been assessed for bearing capacity and lifting only while on designated areas. Operators should be provided with information that makes clear which operations are allowed in which areas. This may need to involve briefing documents (including a plan) and reminder signage set out in working areas".

The guide also gives some real life examples of what can go wrong if an operator is not fully briefed on the limitations of a ground surface, such as the following:

"A large crawler crane was being used for the erection of wind turbines on a wind farm. Once the erection of a wind turbine was completed the crane was travelled fully rigged to the site of the next turbine to be erected. This involved a journey of three-quarters of a mile along site roads. During the journey the edge of the road collapsed causing the crane to overturn. The crane operator had not been briefed on the importance of keeping the crane in the centre of the road and the road cross slope (camber) at the edge was greater than permitted, increasing the pressure under the track on that side".

Philip White the UK's chief inspector of construction added: "This guide will help construction personnel carrying out ground assessment to be aware of their own limitations - ground engineering can be a complex topic. It will help with planning simple operations and help site staff to work more effectively with experts. It is essential that all involved in planning equipment operations know when to stop and seek advice from a structural or geotechnical engineer."

In summary

This looks as though it will be an excellent tool to help increase awareness of how to deal professionally with ground conditions in most eventualities. While it has been written for the UK its advice and information will of course be useful in most parts of the world. So far it is the best guide we have seen in terms of being practical, without skimming too lightly over the heavier theory. We do though look forward to seeing the four page summary as this is will have the widest appeal for most routine lifts. We will update readers with how and where to obtain a copy in the next issue of the magazine.

Safe working loads for differing ground conditions and mat sizes.

Pad Shape	width/ diameter B (m)	Length L (m)	Safe Working Loads (tonnes)									
			car parks & private roads	public highways	soft clay	firm clay	stiff clay	very stiff clay	loose sand/gravel	medium dense sand/gravel	dense sand/gravel	very dense sand/gravel
circle	0.3	-	2.1	4.0	0.6	1.2	2.4	3.9	0.1	0.1	0.3	0.7
	0.45	-	4.0	6.4	1.4	2.7	5.3	8.9	0.2	0.5	1.1	2.3
	0.6	-	6.4	9.5	2.5	4.7	9.4	15.7	0.5	1.1	2.6	5.4
	0.75	-	9.5	13.1	3.9	7.4	14.8	24.6	1.0	2.1	5.2	10.6
	0.9	-	13.1	17.3	5.7	10.6	21.2	*25.0*	1.7	3.7	8.9	18.3
	1.2	-	22.2	*25.0*	10.1	18.9	*25.0*	*25.0*	4.1	8.7	21.2	*25.0*
	1.5	-	*25.0*	*25.0*	15.7	*25.0*	*25.0*	*25.0*	7.9	17.0	*25.0*	*25.0*
square	0.3	0.3	2.7	5.1	0.8	1.5	3.0	5.0	0.1	0.2	0.6	1.2
	0.45	0.45	5.1	8.2	1.8	3.4	6.8	11.3	0.4	0.8	1.9	3.9
	0.6	0.6	8.2	12.1	3.2	6.0	12.0	20.0	0.9	1.8	4.5	9.2
	0.75	0.75	12.1	16.7	5.0	9.4	18.8	*25.0*	1.7	3.6	8.8	18.0
	0.9	0.9	16.7	22.1	7.2	13.5	*25.0*	*25.0*	2.9	6.2	15.2	*25.0*
	1.2	1.2	*25.0*	*25.0*	12.8	24.1	*25.0*	*25.0*	6.9	14.7	*25.0*	*25.0*
	1.5	1.5	*25.0*	*25.0*	20.0	*25.0*	*25.0*	*25.0*	13.5	*25.0*	*25.0*	*25.0*
rectangle	1.2	0.6	12.9	17.4	5.4	10.2	20.4	*25.0*	3.5	7.4	18.0	*25.0*
	2.4	1.2	*25.0*	*25.0*	21.7	*25.0*	*25.0*	*25.0*	*25.0*	*25.0*	*25.0*	*25.0*

NOTES:-
1. *An overall factor of safety of 3 has been applied throughout*
2. *Values in italics have been restricted to the nominal maximum of 25T*
3. *Generally in accordance with BS8004 with bearing capacities calculated using Brinch-Hanson as per Tomlinson*
4. *For public roads the table the formation is assumed to be "firm clay" and loads are taken to be dispersed at 2v:1h through a total 250mm surfacing + sub-base*
5. *For car parks and private roads the formation is assumed to be "firm clay" and loads are taken to be dispersed at 2v:1h through a total 100mm surfacing + sub-base*