TECHNICAL NOTE 016

Heavy Lifting Operation – Lifting Plan & Firm Ground Testing

Keywords
Crawler-mounted Crane, Truck-mounted Crane, Lifting Plan, Applied Bearing Pressure, Ground Bearing Capacity, Firm Ground Tester

Synopsis
Heavy lifting is a high risk operation that must be planned and executed properly. This technical note aims at preventing lifting failures caused by supporting ground not being firm enough, highlighting the importance of having a proper lifting plan and a correct estimate of the applied bearing pressure induced by different types of crane. A method is proposed to ascertain the ground bearing capacity / firmness using a Firm Ground Tester.

1.0 Introduction

Incidents of lifting operation failure are not uncommon. A lot of crane tipping incidents were caused by the supporting ground not being firm enough to resist the applied bearing pressure. An incident is shown in the link below in that a truck-mounted crane went over on a river bank as the ground started to give way and the outrigger pads sank.
(https://www.youtube.com/watch?v=xz71eVreMDc)

Truck-mounted crane tipping caused by unfirmed ground [Source: Internet]

Crawler-mounted crane tipping caused by unfirmed ground [Source: Internet]

To enhance the safety of lifting operations with a particular focus on ground firmness, the routine below shall be followed:

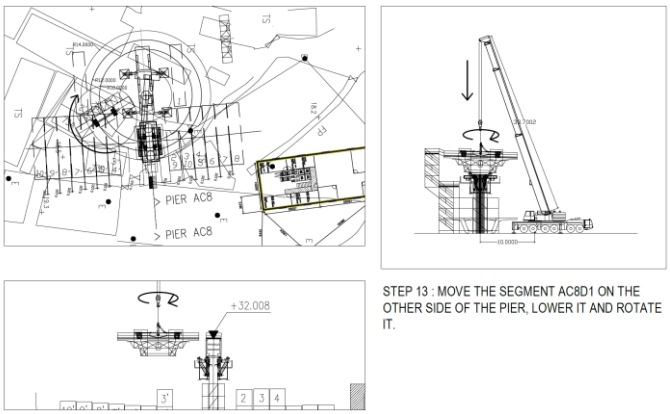
i) Preparation of a lifting plan;
ii) Determination of applied bearing pressure;
iii) Verification of ground bearing capacity.

An RAT meeting should be held to go through the entire lifting process.

2.0 Lifting Plan

A lifting plan (see examples below) shall be prepared by the responsible operation team prior to any lifting. The plan shall include at least the following information:

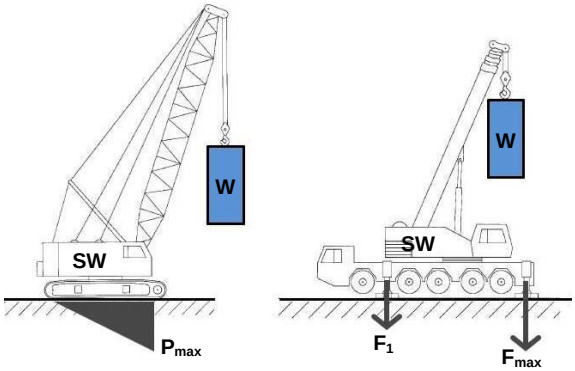
i) Size, weight and positions (initial & final) of the object to be lifted;
ii) Crane(s) to be used and its lifting capacity;
iii) Setting out of the crane(s) relative to the existing reference;
iv) Boom length(s), lifting radii and swing angle(s);
v) The necessary step(s) to lift the object from its initial to final positions.

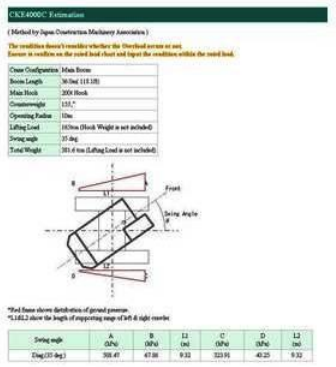


STEP 13 : MOVE THE SEGMENT AC8D1 ON THE OTHER SIDE OF THE PIER, LOWER IT AND ROTATE IT.

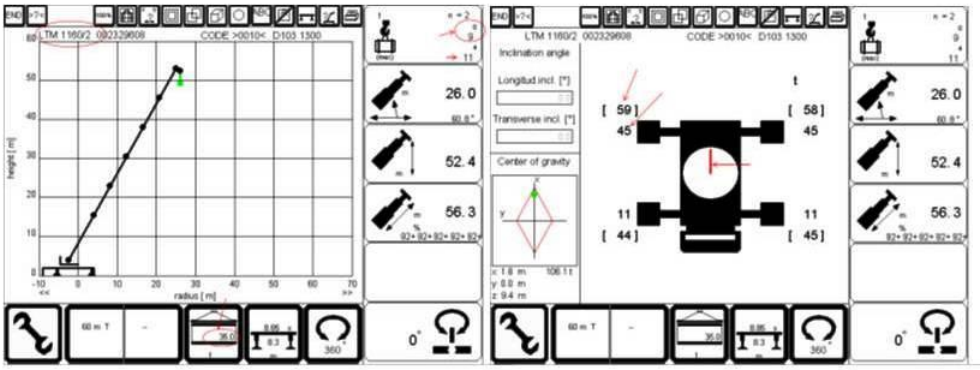
3.0 Determination of Applied Bearing Pressure

The applied bearing pressure on the supporting ground can be very different depending on the crane types.





Pressure distribution diagram for Crawler-mounted Cranes



Concentrated load distribution for Truck-mounted Cranes

For **crawler-mounted cranes**, the applied bearing pressure distribution under the tracks tends to be triangular and/or trapezoidal, whereas for **truck-mounted cranes**, the discrete outrigger floats exert concentrated load.

Based upon the lifting plan and the selected cranes, the applied bearing pressure can be determined using crane-specific software provided by the suppliers. Typical output is shown in the diagrams above.

NB –
In calculating the applied bearing pressure, it is **incorrect** to simply assume an average value equal to the total weight divided by the contact area because the maximum pressure is far in excess of this average value. The crane suppliers must be consulted to obtain the crane-specific pressure / load distribution diagrams as shown above.

4.0 Verification of Ground Bearing Capacity

Once the applied bearing pressure is known, the ground bearing capacity of the specific area (ie, the area where the crane sits) must be verified using a Firm Ground Tester. For detail, please refer to the document entitled '**Procedure of Firm Ground Tester**' issued by the Compliance Department.

4.1 Firm Ground Tester

Simply put, the Firm Ground Tester is a designated truck equipped with a set of hydraulic jack and measurement devices (for load and settlement). The hydraulic jack is fixed with a float having a plan size of 316mm×316mm, giving a contact area of 0.1m^2 approximately. The testing concept is similar to that of plate loading tests. The kentledge is provided by the self-weight of the truck and the concrete blocks it carries.

Once activated for testing, the load in the hydraulic jack can be read from the Force Indicator (unit in Ton). The specific ground bearing capacity is obtained using the following simple conversion:

Force Indicator (Ton)	Ground Bearing Capacity (kPa)
1.0	100
up to...	
6.5	650

On ground settlement, given that lifting is a temporary operation, the absolute magnitude of settlement at the specific area is not a prime concern. However, a dial gauge is proposed to measure the trend of settlement. As long as the ground does not settle further at the test load (ie, reaching a plateau in settlement), the ground is considered firm enough for the lifting operation.

Concrete blocks on truck

Force indicator (unit in Ton)

Hydraulic jack

Float & dial gauge for monitoring settlement

- End -

This technical note is for internal circulation only.
For enquiry, please contact

Gary Chou
KMS / GM (Technical)
Technical Department
Chun Wo Construction & Engineering Co Ltd
E gary.chou@chunwo.com
T 3758 8379
F 2744 6937

Firm Ground Tester –
A designated truck equipped with a set of hydraulic jack and measurement devices for load and settlement

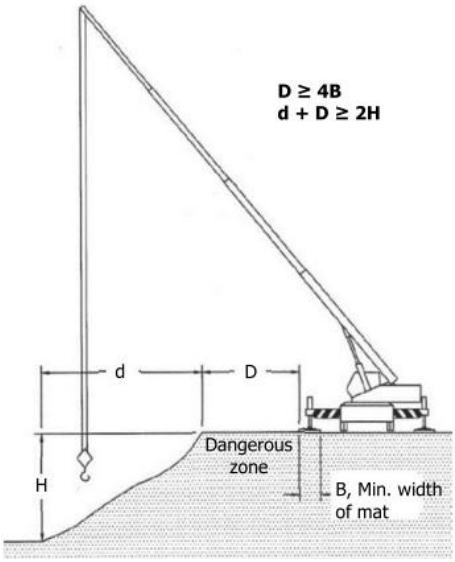
Appendix I – Special Considerations

A) Exceptionally Heavy Lifting

When lifting exceptionally heavy objects such as TBM, precast bridge segments, it is possible to induce an applied bearing pressure in excess of 500kPa by the cranes. In such circumstances, specific treatment should be considered. This may include having tailor-made shimming pads to spread the applied pressure; paving the area concerned by a reinforced concrete mat to enhance the ground bearing capacity.

B) Heavy Lifting Close to Slope Crest

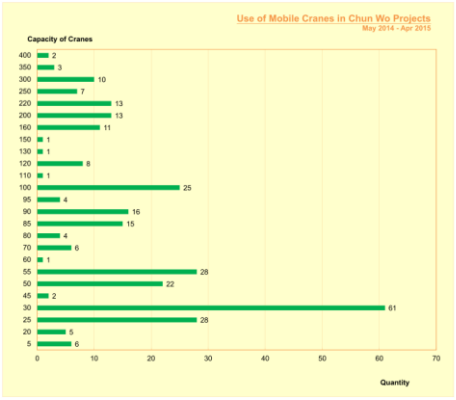
Another scenario that warrants attention is when heavy lifting is to be carried out close to a slope crest. When operating close to the edge of a soil slope or an unsupported soil excavation, a mobile crane may collapse as the load bearing capacity there is much lower than those away from the edge. As shown in the diagram below, a safety distance at least 4 times the width of the "foundation" (ie, the mat or timber blocking of the outrigger or the crawler) should be maintained between the foundation and the slope crest. The distance between the foundation and the toe of the slope of excavation should be at least 2 times the depth of the slope or excavation. Advice should be sought if in doubt.



Appendix II – Common Use of Mobile / Crawler Cranes

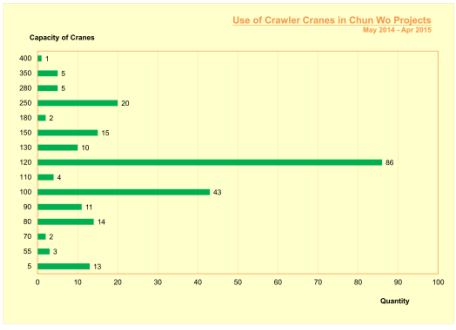
The use of cranes in Chun Wo in year 2014/15 has been reviewed. The charts below show the cranes (types and lifting capacities from 5 to 100t) and their frequency in use.

According to the statistics in the construction industry, crane tipping incidents are commonly associated with cranes having a lifting capacity of 100t or above. Given the scope of this technical note and the 'Procedure of Firm Ground Tester', approximately 32% of the lifting operations using truck-mounted cranes and 82% of those using crawler-mounted cranes will be covered in that the Firm Ground Tester will be used to verify the ground bearing capacity.



Mobile Crane			
Crane Capacity	Quantity	Proportional	Accumulated
5	6	2.0%	2.0%
20	5	1.7%	3.8%
25	28	9.6%	13.3%
30	61	20.8%	34.1%
45	2	0.7%	34.8%
50	22	7.5%	42.3%
55	28	9.6%	51.9%
60	1	0.3%	52.2%
70	6	2.0%	54.3%
80	4	1.4%	55.6%
85	15	5.1%	60.8%
90	16	5.5%	66.2%
95	4	1.4%	67.6%
100	25	8.5%	76.1%
110	1	0.3%	76.5%
120	8	2.7%	79.2%
130	1	0.3%	79.5%
150	1	0.3%	79.9%
160	11	3.8%	83.6%
200	13	4.4%	88.1%
220	13	4.4%	92.5%
250	7	2.4%	94.9%
300	10	3.4%	98.3%
350	3	1.0%	99.3%
400	2	0.7%	100.0%
Total	293		
Cranes with Lifting Capacity not less than 100T			
95	32%		

Mobile cranes used in May 2014 to Apr 2015



Crawler Crane			
Crane Size	Quantity	Proportional	Accumulated
5	13	5.6%	5.6%
55	3	1.3%	6.8%
70	2	0.9%	7.7%
80	14	6.0%	13.7%
90	11	4.7%	18.4%
100	43	18.4%	36.8%
110	4	1.7%	38.5%
120	86	36.8%	75.2%
130	10	4.3%	79.5%
150	15	6.4%	85.9%
180	2	0.9%	86.8%
250	20	8.5%	95.3%
280	5	2.1%	97.4%
350	5	2.1%	99.6%
400	1	0.4%	100.0%
Total	234		
Cranes with Lifting Capacity not less than 100T			
191	82%		

Crawler cranes used in May 2014 to Apr 2015