TIN 042 Selection of Tower Cranes - Anticipated Utilization

This Technical Information Note addresses the high utilization of top-slewing tower cranes, which may lead to structural issues. It emphasises the importance of tower crane users assessing, with the help of suppliers, the anticipated utilization of top-slewing tower cranes, before cranes are selected and installed on site.

Introduction

It is a common misconception that tower cranes can be used to lift heavy loads at high frequency with impunity. This is not the case, as intensive use, that is lifting loads approaching the rated capacity very frequently, may well use up the design life of the crane far more quickly than the designer intended. Reaching the end of the design life of a top-slewing tower crane does not mean that the crane structure will immediately fail. It does however mean that the likelihood of fatigue cracks developing is significantly increased and that such cracks will grow rapidly and if not found at an early stage may well lead to failure of the crane. It is therefore essential when planning the use of tower cranes that the mass of the loads to be lifted, the frequency of lifting and the duration of the crane on site are evaluated to ensure that a crane which is suitable for the application is selected. Further information is given in **Annex A**.

High Intensity Operations

In general, the use of tower cranes in building operations should not give rise to any problems, although high frequency, high load operations such as skipping concrete and using muck skips to move spoil should be treated with caution. On the other hand, the use of tower cranes on civil engineering sites such as bridges, shafts, tunnels and large excavations should always be treated with caution and may well require specification of a larger capacity crane to ensure that the tower crane's life does not get used up too quickly and lead to failure.

Indicators of the type of anticipated usage and crane configuration that may aggravate potential problems from high intensity operations include:-

- Usage in excess of 10 hours per day
- Planned lifts in excess of 6 lifts per hour
- Risk of shock loading (emptying muck skips for instance)
- Use largely within a restricted arc of operation
- Frequent use above 70% SWL
- Short mast (20m or less)
- Short jib (30m or less)
- Permanently sited tower cranes in ship repair facilities, factories and plant yards
- Use of radio controls with consequent loss of operator feedback

NOTE: *The application of shock loading to tower cranes should be avoided at all times (BS 7121-5:2006 Clause 15.2.1)*

NOTE: *Additional information on tower crane classification and the effect of a high load spectrum on tower crane life is given in* ***Annex C****.*

Maintenance, Inspection and Thorough Examination

When a crane is supplied for use in a high intensity application, the hirer and owner should ensure that the intervals between inspections, maintenance and thorough examinations are significantly reduced to ensure that any cracking or other structural deterioration is discovered well before structural failure occurs. It is also essential that before a tower crane is erected on site a detailed inspection is carried out in the supplier's depot to ensure that any defects are found and rectified. It is always much easier to repair a tower crane on the ground than when it is erected. Further information is given in **Annex B**.

Monitoring Tower Crane Components

Tower cranes are assembled from a number of components which may be of different ages with a variable usage history. Best practice suggests that all tower crane components should be individually identified so that the duration and intensity of their usage can be recorded and monitored.

NOTE: *Work is currently underway on developing an agreed approach to the monitoring of tower crane components*

Annex A - Evaluation of Potential Tower Crane Usage

When planning the use of tower cranes on a construction site it is essential that the mass of the loads to be lifted, the frequency of lifting and the duration of the crane on site are evaluated to ensure that a crane which is suitable for the application is selected. If necessary the user should seek the assistance of the supplier in carrying out this evaluation.

An example of such an exercise is shown in **Table A1.1** which shows the number of lifts anticipated, ranked by percentage of Rated Capacity at the intended lifting radius. From this it one can ascertain both the frequency of lifting and the load spectrum.   In the example, where the crane is used for skipping concrete, a large number of lifts (5760 out of a total of 8340 during the contract period) are at between 91% and 100% of the crane's rated capacity, indicating that the crane is being used at a far higher load spectrum factor than is normally anticipated (Q4 load Spectrum Class rather than Q2) which will drastically reduce the design life of the crane.

In such a case steps must be taken to reduce the load spectrum factor such as providing a crane of larger capacity where the 1.5 m^3 concrete skip and concrete will be a smaller percentage of the cranes rated capacity or reducing the mass of the load.

It is important to note that it is bad practice to plan lifts of over 90% of rated capacity and that the example in **Table A1.1** has been given to make a point. It should also be noted when lifting volumetric materials such as concrete that a weight margin should be allowed for variable material density and overfilling.

NOTE: *Additional information on tower crane classification and the effect of a high load spectrum on tower crane life is given in* ***Annex C****.*

Projected Tower Crane Utilization

Project	Tall Towers, Battersea

Crane Specification

Make	Liebherr	***Model***	200 EC-H10 Fr.tronic	***Jib Length***	50m	***Height Under Hook***	40.3m	***Tower***	200HC	***Base***	Cast Anchors

Schedule of Lifts

Item	***Description***	***Weight kg***	***Lift Radius m***	***% Rated Capacity***	***Lifts/Day***	***Total Number of Days***	***Total Number of Lifts***
1.	1.5 m^3 Concrete skip + Concrete	3965	41	91	48	120	5760
2.	Bathroom Pods	2500	45	64	2	20	40
3.	Rebar	1000	45	26	10	30	300
4.	Formwork Profiles	1500	45	39	10	20	200
5.	Steel Columns	980	45	25	30	20	600
6.	Steel Beams	456	45	12	40	24	960
7.	Curtain Wall Units	1800	45	46	16	30	480
					Total	**264**	**8340**

Total Number of Lifts Ranked by Percentage of Rated Capacity

Item	***0 - 10%***	***11% - 20%***	***21% - 30%***	***31% - 40%***	***41% - 50%***	***51% - 60%***	***61% - 70%***	***71% - 80%***	***81% - 90%***	***91% - 100%***	***Total Number of Lifts***
1.										5760	
2.							40				
3.			300								
4.				200							
5.			600								
6.		960									
7.					480						
Total	0	960	900	200	480	0	40	0	0	5760	**8340**

Note: *In the event that more than 1000 lifts are planned in excess of 70% of the crane capacity, ensure a detailed lift plan is discussed with the crane supplier. Exceeding this limit may compromise the design assumptions of the crane manufacturer and in such situations a larger crane is recommended.*

Table A1.1 - Example of the Evaluation of Potential Tower Crane Usage

Annex B - Maintenance, Inspection and Thorough Examination

When a crane is supplied for use in a high intensity application, the hirer (user) and owner should ensure that the intervals between inspections, maintenance and thorough examinations are significantly reduced to ensure that any cracking or other structural deterioration is discovered well before structural failure occurs.

It is also essential that when the crane is dismantled and taken back to the owner's depot the crane components are inspected for deterioration, using appropriate NDT techniques as required. The crane manufacturer should be able to give advice on the areas of maximum stress to which particular attention should be paid.

Owners should also consider a rolling inspection programme for their stock of crane components to ensure that all components are examined for structural deterioration at specified intervals.

Advice on determining the intervals between inspections and thorough examinations of tower cranes is given in the manufacturer's manual for individual cranes and :-

- BS 7121-2-5:2012, *Code of practice for the safe use of cranes Part 2-5: Inspection, maintenance and thorough examination – Tower cranes*
- *Best Practice Guide on the Maintenance, Inspection and Thorough Examination of Tower Cranes,* Construction Plant-hire Association
- FEM 1.007, *Recommendations to Maintain Tower Cranes in Safe Conditions*

Annex C - Tower Crane Classification

1. Crane Service Life - Classification Criteria

All cranes are designed for a particular service life and load spectrum, as specified in crane design standards. Service life is the number of operating cycles the crane will carry out during its life, an operating cycle being defined as starting when a load is ready for hoisting and ending at the moment when the crane is ready to hoist the next load.

The load spectrum is the intensity of loading applied to the crane. In other words does it lift loads at or near its rated capacity most of the time or does it mainly lift light loads and very rarely lifts loads near to its rated capacity? Design standards for cranes classify cranes in groups, depending on the anticipated intensity of use and desired service life (See **Table 1**).

2. Tower Crane Service Life

The European Standard for tower cranes EN14439:2006+A2:2009 specifies that tower cranes meet FEM 1.001 Group A3, as a minimum. FEM 1.001 or DIN 15018 are the current European design standard for all tower cranes.

For a given group, the service life (class of utilization) will depend on the intensity of use (load spectrum class). **Figure 1** shows the reduction of service life with increased intensity of loading. The effect of this is that the more time that a tower crane spends lifting heavy loads, near to its rated capacity, the shorter will be the design life of the tower crane's structure.

NOTE: *Tower cranes supplied before EN 14439 was published in 2006 were generally designed to FEM 1.001 or DIN 15018.*

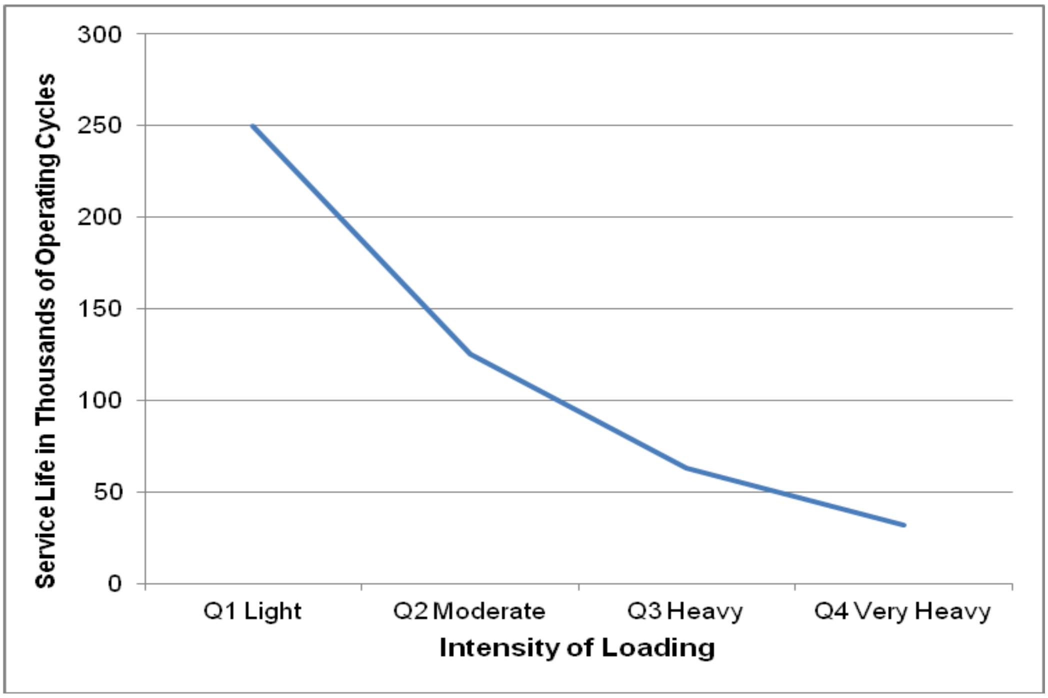

Figure 1 Variation of Service Life with Intensity of Loading for Group A3

If a tower crane reaches the end of its design life, it does not follow that its structure will immediately fail in a catastrophic fashion. It does however, indicate that the probability of fatigue cracks developing increases significantly and if these are not found at an early stage they may well grow to a point at which failure will occur.

This means that for such cranes an increased frequency of intermediate inspections and through examinations is required to ensure that any issues are identified and dealt with before they become dangerous.

Generally speaking, tower cranes on construction sites are used in the "light" or "moderate" load spectrums, with relatively low utilization. Consequently their towers and other parts of the structure should last for many years, whilst effective maintenance, inspection and thorough examination should pick up early indications of fatigue cracking. If however, a tower crane is used intensively, with the majority of loads lifted being in the "heavy or "very heavy" category, **Figure 1** shows that the service life can be quickly used up, with the consequence that fatigue cracks may initiate and grow to a size at which failure can occur, in the interval between inspections and through examinations. An example of such intensive use is where a tower crane is used over a period of many months for unloading heavy pre-cast tunnel lining segments from transport, placing them in a holding area and / or lifting them down a shaft for incorporation into the tunnel lining. There are a significant number of other examples, not necessarily limited to construction activities, where similar intensive use will be encountered.

	Class of Utilization	U0	U1	U2	U3	U4
	Total number of hoisting cycles	≤ 1.6 x 10^4	>1.6 x 10^4 to ≤ 3.2 x 10^4	> 3.2 x 10^4 to ≤ 6.3 x 10^4	> 6.3 x 10^4 to ≤ 1.25 x 10^5	> 1.25 x 10^5 to ≤ 2.5 x 10^5
Load Spectrum Class	Q1 (k_p = 0.125) **Light** Cranes which hoist the safe working load very rarely and, normally, light loads	A1	A1	A1	A2	A3
	Q2 k_p = 0.250 **Moderate** Cranes which hoist the safe working load fairly frequently and, normally, moderate loads	A1	A1	A2	A3	A4
	Q3 k_p = 0.500 **Heavy** Cranes which hoist the safe working load frequently and, normally, heavy loads	A1	A2	A3	A4	A5
	Q4 k_p = 1.00 **Very Heavy** Cranes which are regularly loaded close to the safe working load	A2	A3	A4	A5	A6

Table 1 - Crane Classification Groups from FEM 1.001 Table T.2.1.2.4