

MAIN ASPECTS THAT INFLUENCE THE RIGHT CHOICE OF CRANES

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Abstract

The article deals with the matter of the right project of construction cranes. Most designers use almost no calculations to solve this matter. They often use their previous experience with the buildings that they have already built. The designer should be able to explain the choice of certain crane type. The choice should be based on calculation only and not on groundless factors. For this reason the article shows basic possible ways how to substantiate the project of the construction crane and how to prevent the crane from being either undersized or oversized.

Key words: *Load, distance, costs, usage, time of construction*

INTRODUCTION

Recently the trend in construction has been to prefer the price to quality during construction works. It is a logical but a wrong procedure. Nevertheless, many companies accept this trend and do not realize the consequences of these wrong procedures and methods. Often, bankruptcy is a result of their actions. The highest prices in construction works budgets are often formed by the prices of the construction machines and that is why it is crucial to devote sufficient time and preparation to their design. There are many ways and methods that enable the design of the optimum mechanical assembly. Companies have insufficient information about their existence or find them useless. However, the opposite is true. Only in sporadic cases it happens that machines designed without previous calculations are suitable. This occurs only exceptionally. Mostly useless overdesign or undersize of machine sets appear. This causes lags and increases financial costs. Based on the above mentioned facts, this article outlines basic design methods that enable planners to design basic construction machines that are frequently used in construction.

CONTEMPORARY USED METHODS

In my opinion, basic methods that have been used for lifting mechanism design are relatively outdated. But these methods can be still applied. Their application is correct, nevertheless, the development of lifting mechanisms has accelerated so much that these methods have become only orientation and these methods cannot be relied upon. Such methods include for example:

2.1 Method that uses the indicator of the number of workers

The number of necessary cranes is set according to the number of workers who need the crane for their work in the construction site. Authors of this method do not deal with the crane types and only exceptionally do they specify the relationship according to the type of the building construction. Usually from 10 to 20 workers are assigned to the construction site for one crane in action.

2.2 Method that uses the indicator of the enclosure in a unit of time

This method relies on the number of cubic metres of the enclosure that can be built while supplied by one crane in a certain unit of time, for example one month. This method also does not consider the crane type. One thousand cubic metres of the enclosure per month can be built while supplied by one crane.

2.3 Method that uses the indicator of weight of the transferred material in a unit of time

In this method it is crucial how many kilonewtons of material it is possible to transfer with the help of one crane in a unit of time, for example in a month. This method does not deal with the crane type. One crane can carry 3000 – 6600 kilonewtons of material per month.

2.4 Method that uses the indicator of volume or weight of material carried in a unit of time

The design in this case uses volume or weight of materials carried in a unit of time. It is for example a cubic metre of concrete, square metre of casing and so on.

2.5 Method of crane design according to the time norms of crane operated processes

Priority in this method is to find out the time norms of crane operated processes because the duration of all operations can be then determined. This duration is then divided by the required construction time and the result is the final number of cranes. Rounding up of final number to integer is necessary. The final number has to be corrected with the so called coefficient of idle time of a machine. This coefficient can rise up to 48 %.

2.6 Method of estimate of time that is necessary for crane operation

This method assumes that 80 % of construction material in the construction site will be carried by the crane. That is why it is first necessary to determine the density of the building construction. This is determined on the basis of the enclosure [m^3] and relative weight [t/m^3]. Another precondition of this method is that the crane carries at the end of the crane jib 1 ton in one cycle of 6 minutes. Based on these facts it is then possible to determine the time that is necessary for the material transfer. However, coefficients of real possibilities have to be applied.

2.7 Method Using the Theory of Multiple Handling

This method is based on an accurate modeling of movements of certain lifting mechanisms in three basic groups. The first group includes activities that require a full-time capacity of the crane. The second group consists of activities that do not require a full-time capacity of the crane. And activities that have atypical requirements for lifting mechanisms belong to the third group.

2.8 Method Using a Mathematical Model

This method has not been used recently as it is not in a final version. The main idea of this method is the identification of critical activities in construction that will require high demands on the lifting mechanism. These activities will then be assigned the highest priority, allowing that their handling will always take precedence over the remaining activities.

THE CHOICE BETWEEN THE TOWER AND MOBILE CRANES

Lifting mechanisms in construction belong to the most expensive machinery and therefore, great emphasis is placed on reducing the costs of these machines. This means their maximum utilization is necessary as well as the need to avoid hiring of oversized types of these machines. That is why most preparers decide when to use the mobile and when to use the tower cranes. There are several views on

how to proceed but the most widely used criterion in the design of the machine is the time the machine will have to be present at the construction site. The basic factors that have to be considered are the price of transport and daily rental of the machine. Given current prices for rentals of these machines, it is obvious that it is appropriate to choose tower cranes only for long time constructions and on the other hand mobile cranes should be chosen for less time consuming constructions. It is not easy to define the limits between the short term and long term construction because every construction is an original and requires different machine type. Therefore, it is necessary to trace basic prices for the rental and transport of the mobile cranes and rental price, price for transport, assembly and disassembly of the tower cranes and these prices have to be compared.

To exemplify this, a balance sheet is provided below. The balance sheet shows that the usage of the tower crane is advantageous in cases where the usage of this machine will be longer than 7 working days.

Machine Type	Mobile Crane	Tower Crane
Price for machine rental per hour [CZK]	730	500
Number of working hours per day	8	8
Transport costs per kilometre [CZK]	40	80
Kilometres per day	30	-
Tower crane assembly [CZK]	-	7000
Tower crane revision [CZK]	-	3000
Tower crane disassembly [CZK]	-	7000
Rental price of mobile crane for the tower crane assembly, transport included [CZK]	-	1930
Total one-off costs [CZK]	-	21330
Total costs of one working day [CZK]	7040	4000

Tab. 1 Input prices

	Total costs for mobile crane per [thousands CZK]	Total costs for tower crane per day [thousands CZK]
0.day – Total one-off costs [Kč]	-	21330
Day 1	7040	25330
Day 2	14080	29330
Day 3	21120	33330
Day 4	28160	37330
Day 5	35200	41330
Day 6	42240	45330
Day 7	49280	49330
Day 8	56320	53330

Tab. 2 Financial costs development

THE MOST WIDELY USED METHOD FOR THE DESIGN OF CRANES

Although it might seem that the basic method for selecting a suitable lifting mechanism based on factors of weight and distance of the load may be outdated and inaccurate, the opposite is true. It is the most widely used technique in the design of lifting mechanisms. The main advantage of this method is the small time consumption and little knowledge requirements. Unlike other methods, this method is very fast and requires only a basic knowledge of construction methods. Moreover, this process is from the above mentioned methods, the initial method. The lifting mechanism is therefore proposed on the basis of load diagrams, in which only objects with the highest demands on the machine are plotted. Identification of these loads is very simple. It is sufficient for us to have the elements extract and a basic ground plan in which there will be indicated the placement of these elements and the position of the lifting mechanism. From these input data we will choose 3 loads that require a transfer with the help of the lifting mechanism. For selected loads it is always necessary to know the distance from the axis of the lifting mechanism to the place of their placement. In case of the element montage from the stockpile the correct distance will be always the less favourable one.

First the heaviest load will be drawn into the load diagram, then the furthest and finally the closest load. In many cases the most important load is often the one with the biggest weight. Nevertheless, this is not proved in every case and that is why we plot all the three variants.

Every load that is plotted in the load diagram must be within the zone of lifting capacity of the selected machine type. In order for the selected machine to be designed effectively and not to be oversized, the plotted loads must be as close as possible to the curve of the maximum load.

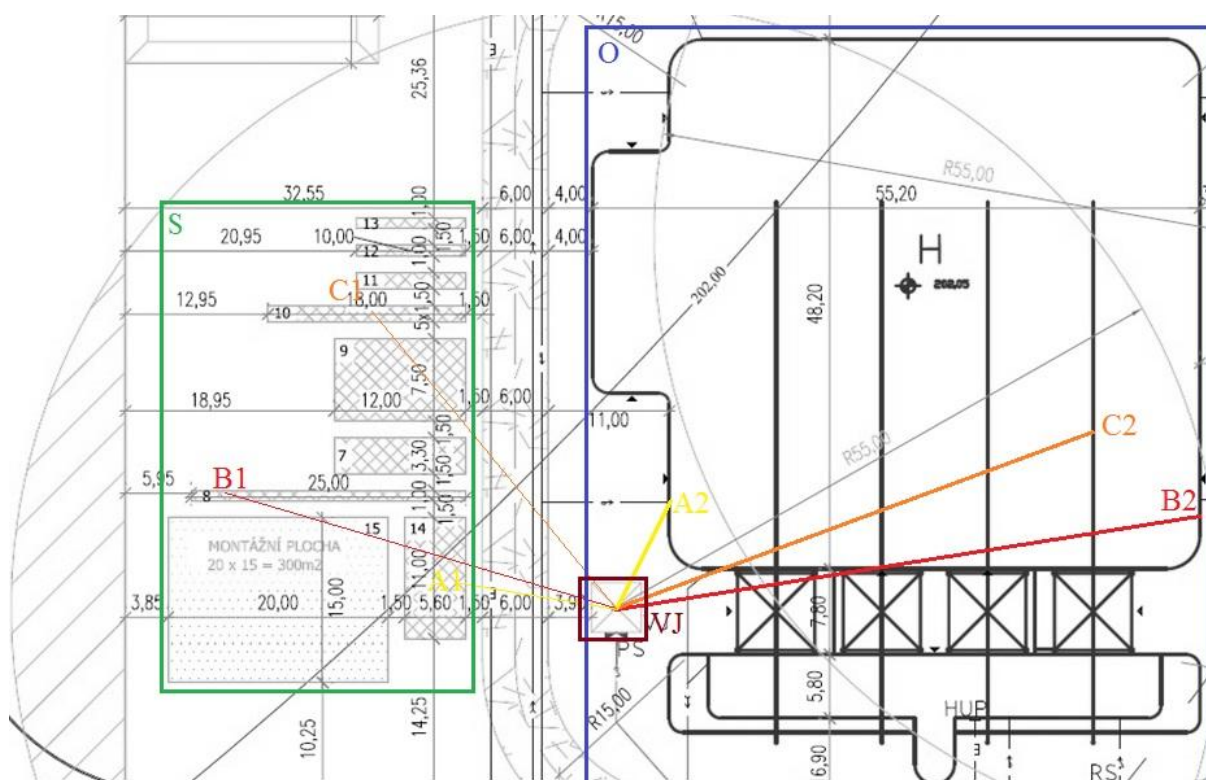


Fig. 1 Construction drawing with the plotted crucial loads

Fig. 1 shows the example of possible schematic construction drawing that is completed with the loads. Loads are marked in the picture as follows:

A1, A2 – the closest load (1 – stockpile, 2 – constructed object)

B1, B2 – the furthest load (1 – stockpile, 2 – constructed object)

C1, C2 – the heaviest load (1 – stockpile, 2 – constructed object)

O – constructed object

S – storage place

VJ – tower crane

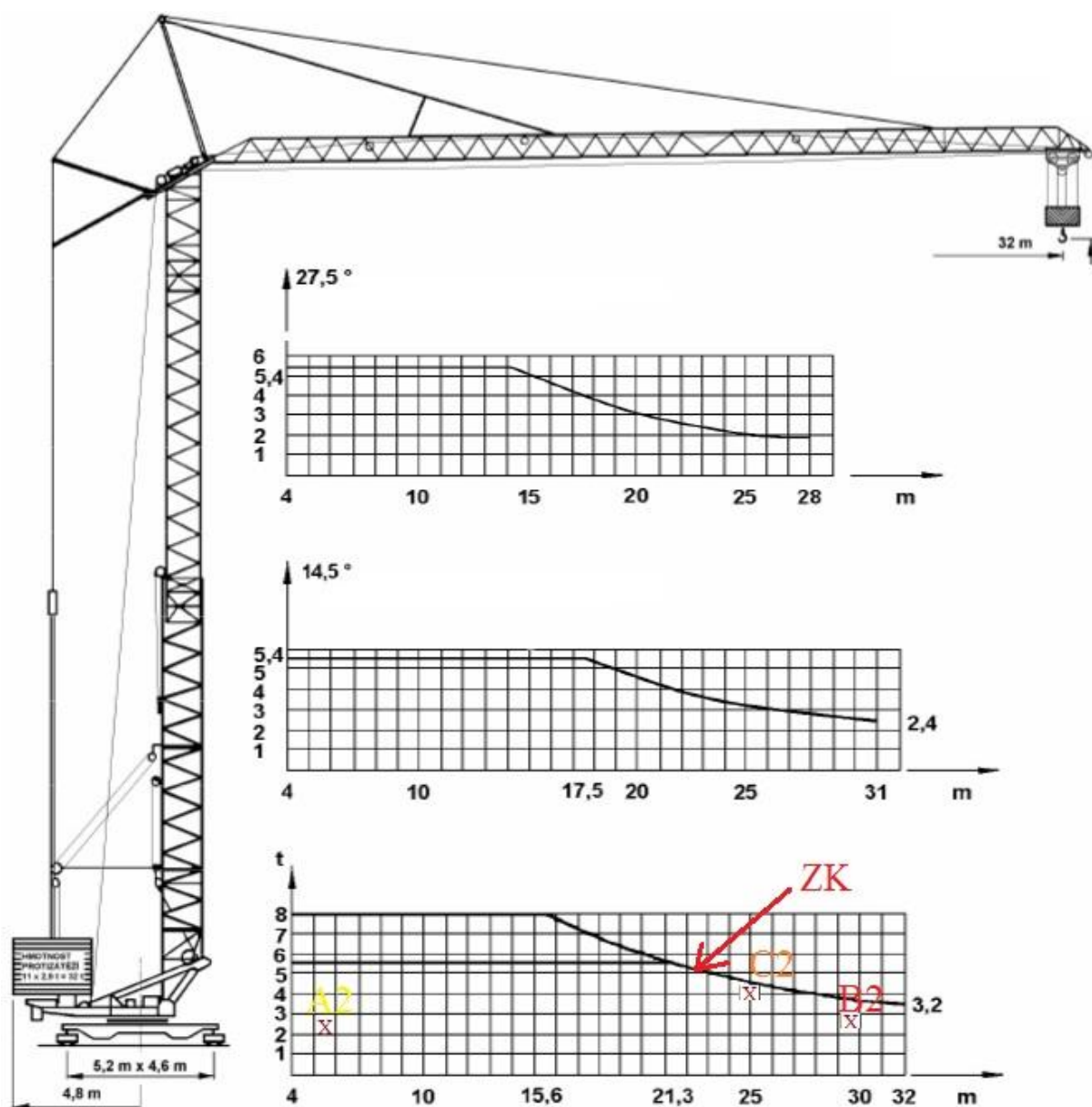


Fig. 2 Load diagram of the tower crane with the plotted loads

Fig. 2 shows load diagram of the tower crane that is completed with chosen loads. Only important loads according to their distance from the crane are plotted in the picture:

A2 – the closest load

B2 – the furthest load

C2 – the heaviest load

ZK – load curve

In order to compare the difference between the load diagram of the tower and mobile crane, the second diagram type is included.

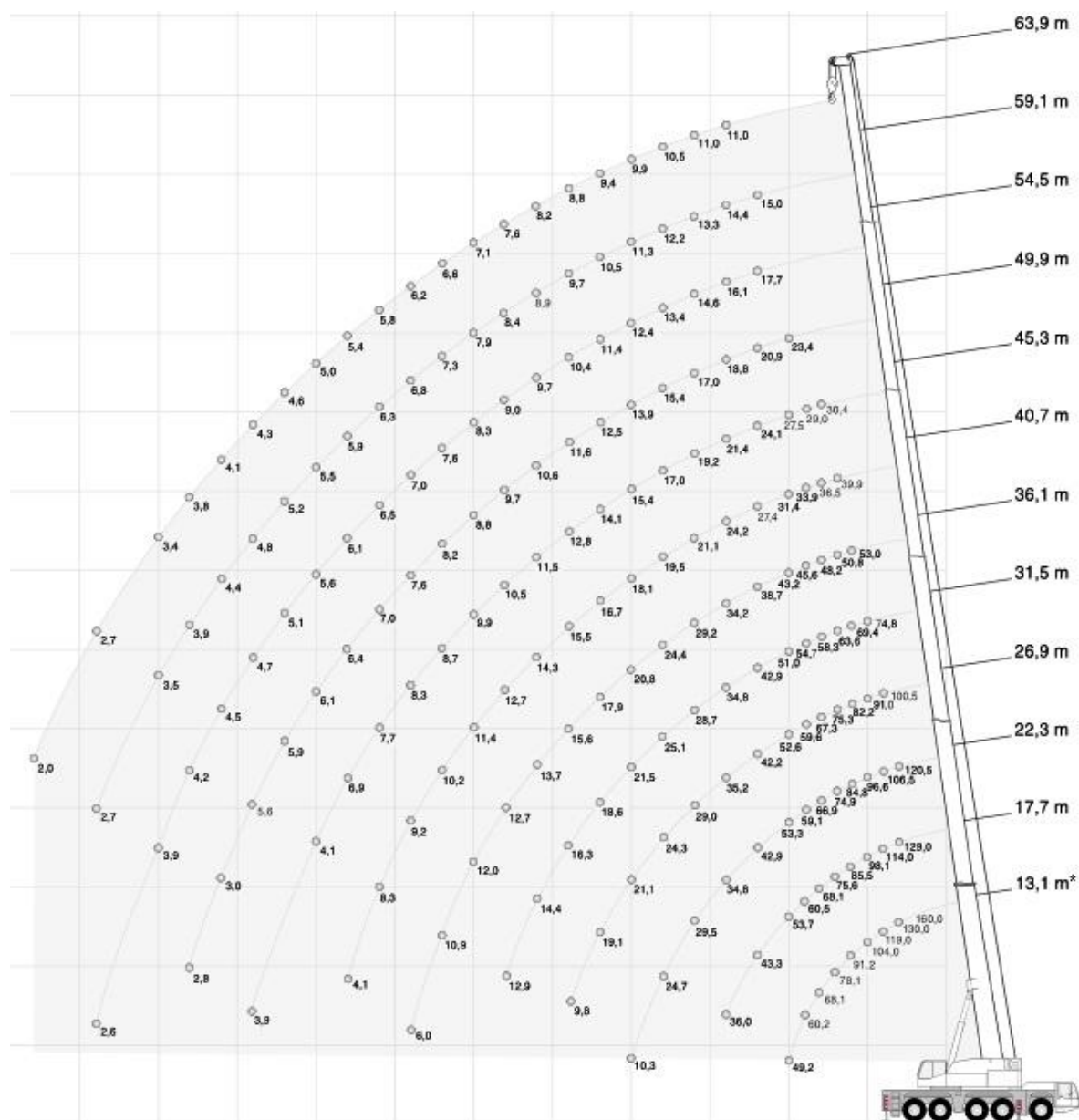


Fig. 3 Load diagram of the mobile crane

THE PROCESS OF THE DESIGN OF SUITABLE MACHINE SETS FOR MONTAGE

This part describes a way of the design of a suitable machine set that is used for montage works. The comparison can be made on the example of the tower crane, for which it is necessary to consider the establishment of the crane runway used for tower crane.

It is our task to assemble a prefabricated frame with ceiling panels. Frame dimensions are 30 x 18 x 9 meters, built-up area is 540 m² and enclosure is 4 860 m³.

The construction consists of 36 columns with weight 1,8 tons, 30 girders with weight 3,6 tons, 16 sway frames with weight 3,0 tons and 100 panels with weight 3,2 tons. Total weight of the frame is 541 tons.

Tower Crane MB1030 has tax about 500 CZK/hours, site assembly crane runway pay about 180 CZK/hours.

Lorry-Mounted Crane AD28T has a tax about 730 CZK/hours.

Flatbed with hydraulic lift arm has tax about 212 CZK/hours.

Element	Weights [tons]	Number of items	Values for Montage			
			Tower Crane with Crane Runway		Lorry-Mounted Crane	
			Time [hours/tons]	Total [hours]	Time [hours/tons]	Total [hours]
Column	1,8	36	1,2	(1,8*36*1,2) 77,8	1,5	97,2
Girder	3,6	30	0,9	(3,6*30*0,9) 97,2	0,9	97,2
Sway Frame	3,0	16	0,9	(3,0*16*0,9) 43,2	1,3	62,4
Panel	3,2	100	0,7	(3,2*100*0,7) 224,0	0,7	224,0
Total				(77,8+97,2+43,2+224,0) 442,2		480,8

Tab. 3 Time consumption of montage

Lorry-mounted crane starts to work only after the material is brought with the help of a platform car. The platform car finishes its activity earlier than the crane. If it is assumed that their working time will be shortened by one working field, these machines will work 4/5 from the total time. That is 4/5 * 121 hours.

Variant	A		B	
Machine Sets	Tower Crane	Crane Track	Lorry-Mounted Crane	Platform Car
Machine Operating Costs (CZK/hour)	500	180	730	212,0
Time of assembly (hours)	442,2	442,2	384,6	384,6
Machine Operating Costs (thousand CZK)	221,1	79,6	280,8	81,5
Total Costs (thousands CZK)	300,7		362,3	

Tab. 4 Financial comparison of chosen variants

CONCLUSION

The article shows options in the design of optimal lifting mechanisms in construction. It emphasizes especially the basic design possibilities that belong among the most frequently used. It is necessary to realize the connection between the crane type and the construction size. The higher construction is designed, the bigger amount of money will have to be invested and that is why a greater attention to construction planning will be necessary as well as the right option of the mechanization type. In order to be sure that the design of the machine sets is correct, it is inevitable to choose more elaborate design methods or methods that were mentioned above in combination with our own experience gained in other project types.

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