DETERMINATION OF LOCATION AND NUMBER OF BRACES FROM TOWER CRANE TO CONSTRUCTION BUILDING

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Abstract

This study focuses on the performance of tower crane considering the brace from the basic tower to the building. Using specialized Finite Element Method (FEM) software to calculate and design steel structure of tower crane; determining the number and erection position of steel braces from the basic tower to the building. Thereby, assessing the safety level as well as the working ability of the tower crane. Then make comments, reviews and suggestions for similar structures.

Keywords: *Tower crane; brace; steel structure; basic tower; specialized software.*

1. Steel structure of tower crane

1.1. Structural parts and calculation parameters of tower cranes

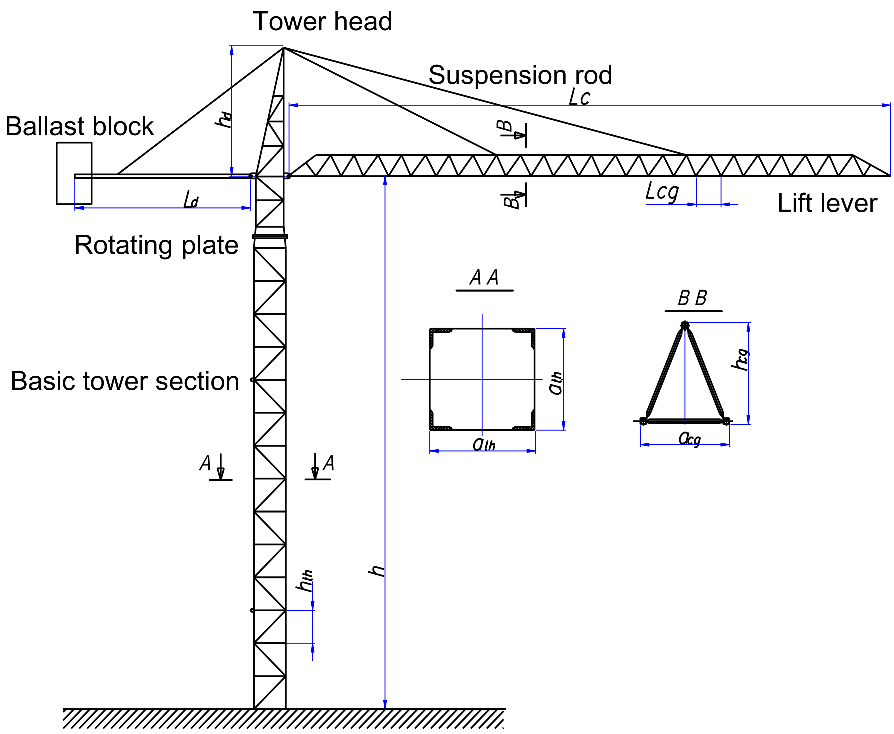

Fig. 1. Main structural parts of tower crane.

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In terms of structure, the tower crane has a stationary part (the basic tower section) and a rotating structure (rotating plate, lift lever, suspension rod, ballast block, tower top, cabin...). The position and shape of major cranes are shown in Fig. 1 [2, 3].

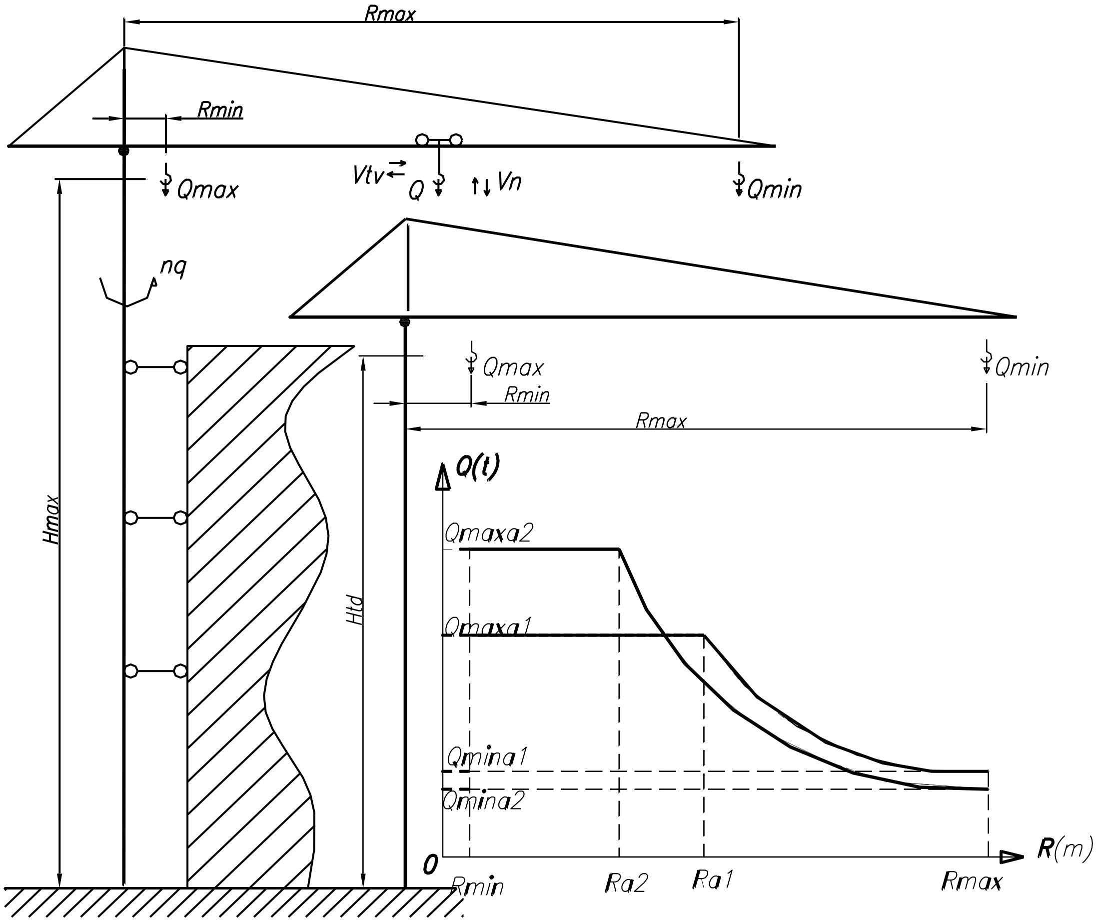

Fig. 2. Diagram of the technical characteristics of a tower crane.

The basic specifications of tower cranes are shown in Fig. 2, here:

- Maximum lifting height when the crane is linker to the building: H_{max} (m);
- Maximum lifting height when the crane is free standing: H_{td} (m);
- Smallest reach: R_{min} (m);
- Greatest reach: R_{max} (m);
- Reach: R_{a1} (m);
- Reach: R_{a2} (m);
- Maximum lifting capacity corresponding to reach from R_{min} to R_a;
- Minimum lifting capacity corresponding to reach R_{max} .

1.2. Brace the tower crane to the building structure

During operation, the basic tower can be fitted with column segments to gradually increase the working height of the crane. Meanwhile, the base structure of the tower will become less stable, when operating, it will easily cause large displacement, which can lead to structural damage, even crane collapses. To solve this problem, it is common to design steel braces to link the base of crane tower to the building. The brace position is usually located at the floor (or hard wall) of the building [2, 3].

Gradually raising the tower body height is done in the active tower crane stage. To increase the height of the tower body, an amplifier burner with an interlocking dual-combustion type is used, the shell of this dual-burning is a hydraulic jack system (4-jack 4-angle) with piston stroke equal to the height of one basic tower. Basic towers are usually made into sections that are similar in shape and size for interchangeability.

When the crane has many brace to the base of the tower with the structure, the sequence is calculated from bottom to top. That means solving the problem with 01 brace first, brace 02 is placed and checked after there is brace 01; brace 03 is selected after having brace 01, 02... after being calculated, selected will always be fixed at that position [2, 3].

2. The problem of designing tower crane braces

2.1. Problem 1: Calculating the height of crane (H_{td}) when free standing crane

This H_{td} height has important implications in the actual erection and operation of the tower crane. Specifically, if the crane operates independently (there is no adjacent building to brace to), it is not allowed to install the crane with working height: $H_{LV} > H_{td}$; While installing the crane to support the construction of the project, but the working height of the $H_{LV} < H_{td}$, the crane is not braced to the project.

Determining H_{td} is not too complicated, but requires calculating and comparing results many times, and having a scientific and reliable assessment tool.

2.2. Problem 2: Determining the number, the height of braces (H_{neo1}, H_{neo2}, H_{neo3} ...) and the corresponding working height (H_{max1}, H_{max2}, H_{max3} ...) when the Basic tower section is braced to structure building

The calculation of the number of braces, the brace position from the basic tower to the building, is of great significance. It helps to confirm the safety of the tower crane during use, in addition to help save time and construction costs.

From the design parameter of the project, determine the requirements for the maximum working height of the crane ($\boldsymbol{H_{LVmax}}$), this is an important parameter in calculating the number and position of steel braces. The number of braces of the base of the tower on the structure depends on the actual working height of the tower crane ($\boldsymbol{H_{LV}}$). In the design software, the brace will be shown as stiff support links, located at the corresponding brace positions on the tower base. The elevation of the brace is selected according to the floor level of the building. Place braces at each floor level, declare the link on the base of the tower. Turn the tower foot height to increase with each burn, calculate internal force, displacement of the tower crane structure, then inspect, evaluate, choose the brace option for $\boldsymbol{H_{LV}}$ the highest value. Compare the $\boldsymbol{H_{LV}}$ of the calculations, to find out the most beneficial brace position (the position for the largest height while ensuring the safety of the tower crane structure). After selecting $\boldsymbol{H_{neo1}}$, $\boldsymbol{H_{max1}}$, if $\boldsymbol{H_{max1}} < \boldsymbol{H_{LVmax}}$, arrange additional braces (2^{nd}, 3^{th}...).

2.3. Load cases and load combination

Tower crane design load cases depending on properties and functions, are arranged into groups (43 groups) [2], with names and properties as described in Table 1.

Table 1. (Extract) groups of basic loads when calculating tower crane structures (43 groups)

No	Group	Explain
0	Static load	The weight of the structure itself and the parts on it
1	QR1	Load due to the lift is within reach R1
2	QR2	Load due to the lift is within reach R2
3	QR3	Load due to the lift is within reach R3
4	QRT3	Load due to the lift is within reach R3 (try load)
5	QR4	Load due to the lift is within reach R5
6	QR5	Load due to the lift is within reach R5
7	QR6	Load due to the lift is within reach R6
8	QR7	Load due to the lift is within reach R7
…	…	…
40	LTR6	Load due to the centrifugal force of the rotation of the lifting object at R6
41	LTR7	Load due to the centrifugal force of the rotation of the lifting object at R7
42	LTQ	Load due to the centrifugal force of the rotation of the boom and its components

The load combination, which is formed from basic load groups and depends on the problem form [4, 5, 6], has 24 combined loads as follows:

Table 2. Load combinations excluding large strain (24 combinations groups)

Name	Combination case	Combined component
TH1	Working status without the lift wind at the range R1	γ.(0+1+27+28+35)
TH2	Working status without the lift wind at the range R2	γ.(0+2+27+29+36)
TH3	Working status without the lift wind at the range R3	γ.(0+3+27+30+37)
TH4	Working status without the lift wind at the range R4	γ.(0+4+27+31+38)
TH5	Working status without the lift wind at the range R5	γ.(0+5+27+32+39)
TH6	Working status without the lift wind at the range R6	γ.(0+6+27+33+40)
TH7	Working status without the lift wind at the range R7	γ.(0+7+27+34+41)
TH8	The lift is at R1, the wind is parallel to the lift lever	γ.(0+1+27+28+35)+10+12
TH9	The lift is at R2, the wind is parallel to the lift lever	γ.(0+2+27+29+36)+10+13
TH10	The lift is at R3, the wind is parallel to the lift lever	γ.(0+3+27+30+37)+10+14
TH11	The lift is at R4, the wind is parallel to the lift lever	γ.(0+4+27+31+38)+10+15
TH12	The lift is at R5, the wind is parallel to the lift lever	γ.(0+5+27+32+39)+10+16
TH13	The lift is at R6, the wind is parallel to the lift lever	γ.(0+6+27+33+40)+10+17
TH14	The lift is at R7, the wind is parallel to the lift lever	γ.(0+7+27+34+41)+10+18
TH15	The lift is at R1, the wind is perpendicular to the lift lever	γ.(0+7+27+34+41)+11+19
TH16	The lift is at R2, the wind is perpendicular to the lift lever	γ.(0+7+27+34+41)+11+20
TH17	The lift is at R3, the wind is perpendicular to the lift lever	γ.(0+7+27+34+41)+11+21
TH18	The lift is at R4, the wind is perpendicular to the lift lever	γ.(0+7+27+34+41)+11+22
TH19	The lift is at R5, the wind is perpendicular to the lift lever	γ.(0+7+27+34+41)+11+23
TH20	The lift is at R6, the wind is perpendicular to the lift lever	γ.(0+7+27+34+41)+11+24
TH21	The lift is at R7, the wind is perpendicular to the lift lever	γ.(0+7+27+34+41)+11+25
TH22	The state does not work, wind storm	0+26
TH23	Static load test state at range R3	0+4
TH24	Static load test state at R7 range	0+7

The factor γ is chosen from 1.00 to 1.20 depending on the lifting equipment group.

2.4. Specialized software CraneVN

CraneVN is specialized software for design and calculation of tower crane steel structures according to TCVN. This is the software designed and programmed by the authors: Tran Nhat Dung (Le Quy Don Technical University), Pham Quang Dung, and Duong Truong Giang (National University of Civil Engineering).

This article was done with the help of a Finite Element Method (FEM) software called CraneVN [1]. This is the specialized software for the calculation of tower crane steel structures according to the spatial model. The program is designed for the purpose of handling design problems and test problems of tower crane. CraneVN has a Vietnamese interface with Menu and Toolbar system, capable of generating data quickly. All figures and results from CraneVN can be displayed in graphic format, can easily save file or print. CraneVN is used to survey the numerical test problem in item 3 below. CraneVN is used for numerical test problem in item 3 below [2, 4].

3. Numerical test determines the number and placement of braces

3.1. The figures describe tower cranes and construction works

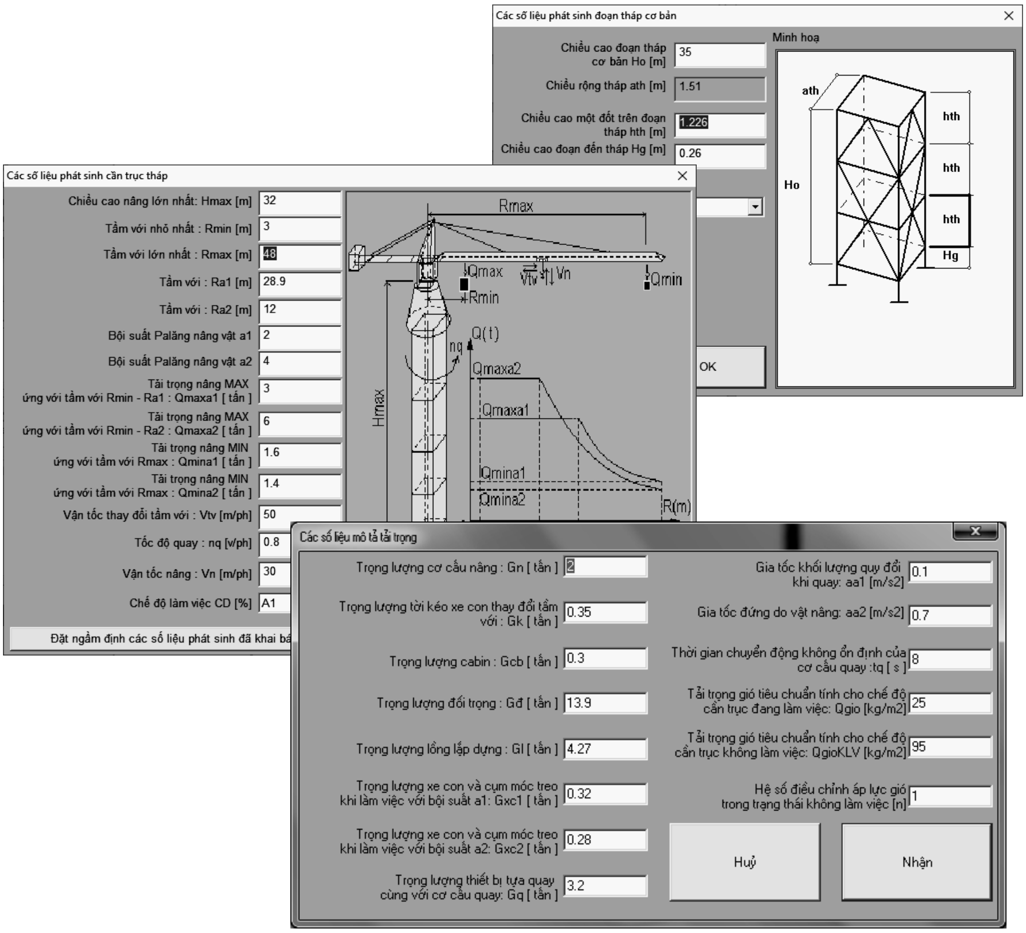

Fig. 3. Calculation parameters of tower cranes.

a) Description of calculation parameters of tower cranes: Tower crane has a maximum reach of 48 m. When braced to the structure, the maximum lift when the reach of $\boldsymbol{R_{min}}$ is 6 tons; when the R_{max} is 1.4 tons. Each tower base has a height of $\mathbf{\Delta H}$ = 1.226 m. Crane steel, which is high strength steel, has a strength limit $[\boldsymbol{\sigma_{gh}}]$ = 4100 kG/cm^2. For more descriptions of the crane, see Fig. 3.

b) Description of construction works: The construction work is a 24 floors building, 02 basements, the complete height is about 82 m above the ground. Of which: 1st floor: 5.70m high; Floor 2÷24 (high 3.3 m/floor); Total height of the whole house: 5.7 + 23 * 3.3 = 81.6 m. With such a building height, the maximum crane height will be $\boldsymbol{H_{LVmax}} \approx 82 + 5 = 87$ m.

c) Describe the problems to be solved: With the above works, the initial construction phase of the work, the tower crane must exist in the state of self-standing. So we need to determine the maximum free standing height of a tower crane ($\boldsymbol{H_{td}}$).

When the tower crane increases gradually, it is necessary to brace the tower crane to the building. Brace position will be based on the floor level of the building and is selected so that the height of the crane's $\boldsymbol{H_{LV}}$ is maximum. In design calculation, with the help of specialized software, we will in turn place the bearing links at different positions (from low to high, equivalent to the height of the floors). At each test turn, change the height of the crane (starting from $\boldsymbol{H_{td}}$ upwards), the height increase step is equivalent to 01 tower leg ($\Delta H = 1.226$ m). The calculation results after each test (for brace position) and calculation (for changing the height of the tower foot), will be calculated and compared to find the best brace position (i.e. brace position for maximum working height in all calculations).

When the work continues to rise, if the $\boldsymbol{H_{LV}} > \boldsymbol{H_{max1}}$, it must arrange a second brace for the crane. Similarly, when $\boldsymbol{H_{LV}} > \boldsymbol{H_{max2}}$, there must be a third brace for the crane. Determining the optimal position of brace 2, brace 3... is the same as calculating the position for brace 1. The calculation will stop when the maximum working height of the crane exceeds the value of $\boldsymbol{H_{LVmax}} = 87$ m with current test project.

3.2. The order to solve the problems

Problem 1: Calculate the height of crane ($\boldsymbol{H_{td}}$) when free standing crane

Gradually increase the height of the foot of the tower until there is a certain element with a stress beyond the strength limit of steel ($[\boldsymbol{\sigma_{gh}}] = 4100$ kG/cm^2). Stop calculating when the element with excess stress occurs $[\sigma_{gh}]$. The height of the calculation (N-1), is the height of the free standing $\boldsymbol{H_{td}}$.

Problem 2: Determine the number and position of braces to connect the tower base with the building

- *Problem 2(1): Determine H_{neo1} and H_{max1} when the crane has 01 brace*

Calculate the position of brace 01 placed on the basic tower so that the working efficiency of the structure is the best. The first test (N = 1), starting with choosing $H_{neo1} = 6.13$m (almost coinciding with the level of the 2nd floor), at the calculation n, crane height $\boldsymbol{H_{max1}} = \boldsymbol{H_{td}} + \boldsymbol{n} \times \boldsymbol{\Delta H}$. Calculate displacement and internal force for the crane. Check the durable, displacement conditions of the crane, to determine the height: H_{max1}, of the current test (N).

Move to the next test (N = N + 1), increase the calculated height of brace $\boldsymbol{H_{neo1}}$ by

01 floor (next floor); reset the calculation parameter n = 1, crane height: $\boldsymbol{H_{max1} = H_{td} + n \times \Delta H}$. Calculate displacement, internal force and perform tests, compare with the standard and with the previous test results, to find $\boldsymbol{H_{neo1}}$ with maximum $\boldsymbol{H_{max1}}$ result. Compare $\boldsymbol{H_{max1}} > \boldsymbol{H_{LVmax}}$ = 87 m if not, continue, calculate with 2nd brace.

▪ *Problem 2(2): Determine H_{neo2} and H_{max2} when the crane has 02 braces*

Proceed as with Problem 2(1) find $\boldsymbol{H_{neo1}}$ and $\boldsymbol{H_{max1}}$. Start by choosing $\boldsymbol{H_{max2}} = \boldsymbol{H_{max1}} + \Delta H$. Selected brace position 1 will be fixed at elevation $\boldsymbol{H_{neo1}}$. The 2nd brace is considered from position $\boldsymbol{H_{neo2} = H_{neo1}} + \Delta H$. After calculating, check the condition: $\boldsymbol{H_{max2}} > \boldsymbol{H_{LVmax}}$ = 87 m if not, continue to design, calculate the 3rd, 4th brace...

▪ *Problem 2(3): Determine H_{neo3} and H_{max3} when the crane has 03 braces*

Do the same with Problem 2(2). Stop calculating if $\boldsymbol{H_{max3}} > \boldsymbol{H_{LVmax}}$. If not, then you must continue to calculate with the 4th, 5th brace...

3.3. Calculation results for problems

Problem 1: Calculate the height of $\boldsymbol{H_{td}}$ at the state of free standing crane

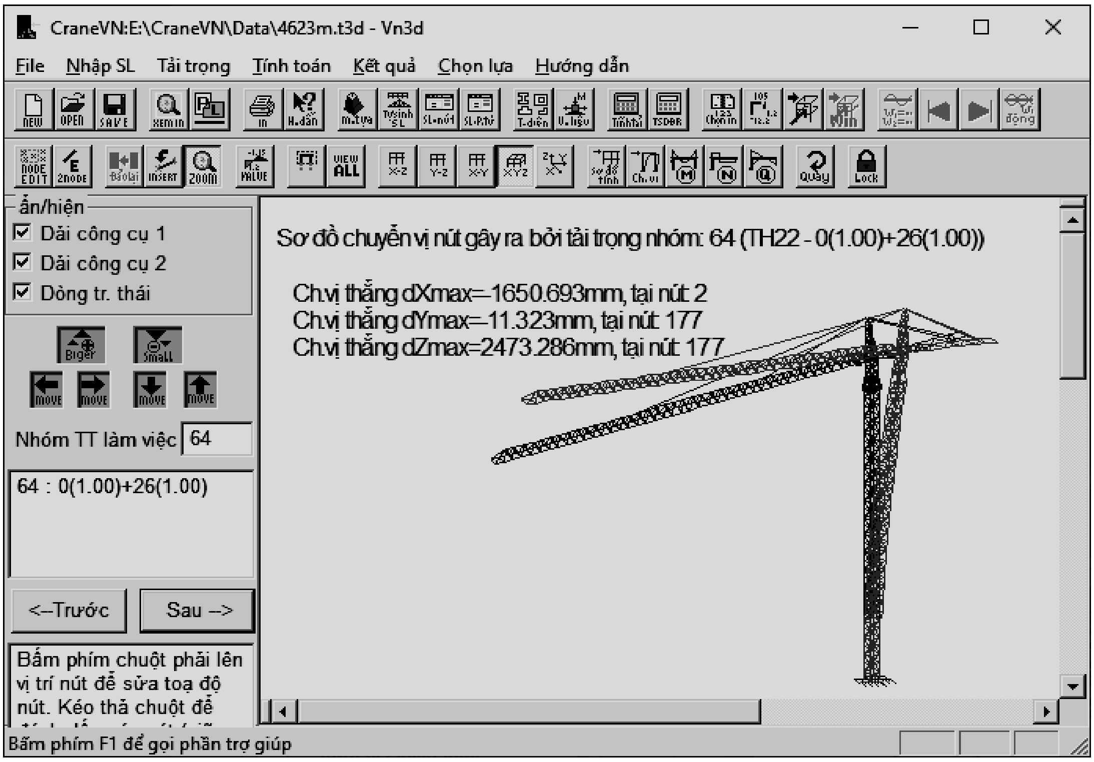

Fig. 4. Result of displacement caused by load combination TH22 (Problem 1, trial 6).

Choose the starting height $\boldsymbol{H_{td0}}$ = 40.10 m, gradually increase the tower height by 01 basic section of the tower, (ΔH = 1.226 m), for example, in turn n, choose:

$\boldsymbol{H_{td}} = \boldsymbol{H_{td0}} + \boldsymbol{n} \times \mathbf{1.226}$ **m** then recalculate, check internal force and stress until some element has a stress exceeding the strength limit of steel (**[σ_{gh}]** = 4100 kG /cm^2), then stop calculating.

The results in Table 3 show that, with 06 test index, the self-standing height of the tower crane reached $\boldsymbol{H_{td}}$ = 46.24 m, σ_{max} = 4198.0 > [σ_{gh}] = 4100 kG/cm^2. Therefore, we choose the limited self-standing height of tower crane as the height of the 5th test, we take the self-standing height of tower crane as $\boldsymbol{H_{td}}$ = 45.01 m; Maxima horizontal displacement value of the top of the tower when the crane is standing by itself reaches 1540 mm. This value is used as a condition to control displacement in the next problem.

Table 3. Calculation result of self-standing height H_{td}

Test index	1	2	3	4	5	6
Height Htt (m)	40.10	41.33	42.56	43.78	**45.01**	**46.24**
σ_{max} (kG/cm^2) **Location** **Combination group**	4027.2 node 55 (TH17)	4027.2 node 55 (TH17)	4027.2 node 55 (TH17)	4027.2 node 55 (TH17)	**4027.2** **node 55** **(TH17)**	**4198.0** **node 336** **(TH11)**
Maxima horizontal displacement at the top of the tower (mm)	1151 (TH22)	1240 (TH22)	1335 (TH22)	1435 (TH22)	**1540** **(TH22)**	**1651** **(TH22)**

Note: *Node 55 is of the lift lever; node 336 belongs to the basic tower section.*

Problem 2(1): Determine H_{neo1} and H_{max1} when the crane has 01 brace

- *Choose the brace position according to the floor level:* The result from Problem 1 shows that the self-standing working height of the tower crane is $\boldsymbol{H_{td}}$ **= 45.011 m**, this elevation will be selected as the minimum elevation when designing the 1st brace. The 1st brace elevation is from the 2nd floor level (5.70 m) to the floor with a height of about 35 m. Problem 2(1) can arrange tests at the brace positions as shown in Table 4.

Table 4. Elevation of brace position number 1 for the tests of Problem 2(1)

No	Brace elevation H_{neo1} (m)	Brace position at the building floor	Building floor level (m)	Note
I	6.130	2nd floor (1st floor is 5m70 high)	5.70	Brace elevation H_{neo1} is that of the node at the basic tower section with braced layout. Therefore, the brace elevation, may not be the same as the building floor levels.
II	9.800	3rd floor (2nd floor 3m30 high)	9.00	
III	12.260	4th floor	12.30	
IV	15.938	5th floor	15.60	
V	18.390	6th floor	18.90	
VI	22.068	7th floor	22.20	
VII	25.746	8th floor	25.50	
VIII	29.424	9th floor	28.80	
IX	31.876	10th floor	32.10	
X	35.554	11th floor	35.40	

At each test (N = I ÷ X), the starting height of crane is always $\boldsymbol{H_{max1}}$ = 45.01 m.

For each test (N), perform n calculations, after each calculation, $\boldsymbol{H_{max1}}$ increased by one burn $\boldsymbol{\Delta H}$ = 1.226 m. If the result of calculating $\sigma_{max} > [\sigma_{gh}]$, or Maxima horizontal displacement > 1540 mm, stop calculation. Then, $\boldsymbol{H_{max1}}$ is the best result of the N test.

With Problem 2(1) solving the problem find the appropriate brace position $\boldsymbol{H_{neo1}}$ = 35.554 m, equivalent to the 11th floor level of the building. Then, $\boldsymbol{H_{max1}}$ = 71.983 m.

So we choose the 1st brace layout is location on the 11th floor, with the height of 35.554 m. This will be the input base for solving Problem 2(2) below.

Table 5. (Extract) calculation results of test index (N = I ÷ X) of Problem 2(1)

No	Test order	H_{neo1} (m)	H_{max1} (m)	σ_{max} (kG/cm²)			Maxima horizontal displacement (mm)
				Value	Location	Load Group	
I	1	**6.13**	45.011	4027.2	55	TH17	1273
04 test order	2	6.13	46.234	4027.2	55	TH17	1369
	3	**6.13**	**47.460**	**4055.9**	**320**	**TH11**	**1471**
	4	6.13	48.686	4041.6	323	TH22	**1578**
II	1	**9.800**	45.011	4027.2	node 55	TH17	1046
08 test order	**7**	**9.800**	**52.367**	**4027.2**	node **55**	**TH17**	**1523**
	8	9.800	**53.593**	**4213.2**	node **328**	**TH11**	**1739**
III	1	**12.260**	45.011	4027.2	node 55	TH17	913
08 test order	**7**	**12.260**	**52.367**	**4027.2**	node **55**	**TH17**	**1439**
	8	12.260	53.950	4027.2	node 55	TH17	**1545**
IV	1	**15.938**	45.011	4027.2	node 55	TH17	739
11 test order	**10**	**15.938**	**56.042**	**4027.2**	node **55**	**TH17**	**1488**
	11	15.938	57.271	4027.2	node 55	TH17	**1597**
V	1	**18.390**	45.011	4027.2	node 55	TH17	639
13 test order	**12**	**18.390**	**58.497**	**4027.2**	**node 55**	**TH17**	**1523**
	13	18.390	59.723	4027.2	node 55	TH17	**1634**
VI	1	**22.068**	45.011	4027.2	node 55	TH17	503
15 test order	**14**	**22.068**	**60.949**	**4027.2**	**node 55**	**TH17**	**1469**
	15	22.068	62.175	4027.2	node 55	TH17	**1577**
VII	1	**25.746**	45.011	4027.2	node 55	TH17	388
16 test order	**15**	**25.746**	**64.627**	**4027.2**	**node 55**	**TH17**	**1521**
	16	25.746	65.853	4027.2	node 55	TH17	**1632**
VIII	1	**29.424**	45.011	4027.2	node 55	TH17	290
20 test order	**19**	**29.424**	**67.079**	**4027.2**	**node 55**	**TH17**	**1472**
	20	29.424	68.305	4027.2	node 55	TH17	**1580**
IX	1	**31.876**	45.011	4027.2	node 55	TH17	234
22 test order	**21**	**31.876**	**69.531**	**4027.2**	**node 55**	**TH17**	**1496**
	22	31.876	70.757	4027.2	node 55	TH17	**1607**
X	1	**35.554**	45.011	4027.2	node 55	TH17	161
24 test order	**23**	**35.554**	**71.983**	**4027.2**	**node 55**	**TH17**	**1436**
	24	35.554	73.209	4027.2	node 55	TH17	**1544**

▪ **Problem 2(2):** Determine H_{neo2} and H_{max2} when the crane has 02 braces

Do the same with Problem 2(1). Finding $\boldsymbol{H_{neo2}}$ and $\boldsymbol{H_{max2}}$, begins by choosing $\boldsymbol{H_{neo2}} = \boldsymbol{H_{neo1}}$ + 3.3 m [height of 01 floor]. In 08 attempts to this problem (N = 1 ÷ VIII),

$\boldsymbol{H_{max2}}$ are considered starting from $\boldsymbol{H_{max2}} = \boldsymbol{H_{max1}}$ = 71.983 m. Each test, will conduct n calculations, after each calculation, the height of the crane will be increased by 1 column ($\boldsymbol{H_{max2}} = \boldsymbol{H_{max2}} + \Delta H$).

Solving Problem 2(2) is the same as doing Problem 2(1). Brace position 1 is chosen at 35.554 m, the brace position 2 will be detected by placing it from the 12th floor level upwards, the positions where braces 2 can be placed are shown in Table 6.

Table 6. Elevation possible braces number 2 for Problem 2(2)

No	**Brace elevation H_{neo2} (m)**	**Brace position at the building floor**	**Building floor level (m)**	**Note**
I	39.232	12th floor	38.70	Brace elevation H_{neo2} is that of the node at the basic tower section with braced layout. Therefore, the brace elevation, may not be the same as the building floor levels.
II	41.684	13th floor	42.00	
III	45.362	14th floor	45.30	
IV	49.040	15th floor	48.60	
V	51.492	16th floor	51.90	
VI	55.170	17th floor	55.20	
VII	58.848	18th floor	58.50	
VIII	61.300	19th floor	61.80	

Table 7. Calculation results for the trials (N = I÷VIII) of Problem 2(2)

No	**Test order**	**H_{neo1} (m)**	**H_{max1} (m)**	**σ_{max} (kG/cm^2)**			**Maxima horizontal displacement (mm)**
				Value	**location**	**Load cases**	
I	1	39.232	71.983	4027.2	node 55	TH17	857
05 test order	**4**	**39.232**	**75.661**	**4027.2**	**node 55**	**TH17**	**1087**
	5	**39.232**	**76.887**	**<u>4227.4</u>**	**node 311**	**TH17**	**1173**
II	1	41.684	71.983	4027.2	node 55	TH17	733
11 test order	**10**	**41.684**	**83.017**	**4042.5**	**node 320**	**TH11**	**1474**
	11	41.684	84.243	4072.8	node 323	TH22	**<u>1582</u>**
III	1	45.362	71.983	4027.2	node 55	TH17	588
14 test order	**13**	**45.362**	**86.695**	**4034.1**	**node 320**	**TH11**	**1530**
	14	45.362	87.921	4027.2	node 55	TH17	**<u>1641</u>**
IV	1	49.040	71.983	4027.2	node 55	TH17	468
14 test order	**14**	**49.040**	**87.921**	**4027.2**	**node 55**	**TH17**	**1385**
V	1	51.492	71.983	4027.2	node 55	TH17	397
14 test order	**14**	**51.492**	**87.921**	**4027.2**	**node 55**	**TH17**	**1231**
VI	1	55.170	71.983	4027.2	node 55	TH17	304
14 test order	**14**	**55.170**	**87.921**	**4027.2**	**node 55**	**TH17**	**1022**
VII	1	58.848	71.983	4027.2	node 55	TH17	223
14 test order	**14**	58.848	**87.921**	**4027.2**	**node 55**	**TH17**	**837**
VIII	1	61.300	71.983	4027.2	node 55	TH17	177
14 test order	**14**	**61.300**	**87.921**	**4027.2**	**node 55**	**TH17**	**725**

4. Conclusions

Result from Problem 2(1), and Problem 2(2), show that: with tower cranes and existing structures, only 02 braces need to be arranged, namely: brace number 1 located at elevation $\boldsymbol{H_{neo1}}$ **= 35.554 m** (equivalent to floor level 11), meanwhile, $\boldsymbol{H_{max1}}$ **= 71.983 m**; brace number 2 is located at elevation $\boldsymbol{H_{neo2}}$ **= 61.30 m** (equivalent to floor level 19), then $\boldsymbol{H_{max2}}$ reaches 87.921 m > $\boldsymbol{H_{LVmax}}$ **= 87 m**, enough to the current building project.

The article shows that calculating the brace position reasonably and conducive to the bearing capacity of the tower crane steel structure is a problem with scientific significance and practical significance. The article also shows that choosing the number and position of braces for cranes is a specific problem and should be calculated and tailored for each specific construction.

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XÁC ĐỊNH VỊ TRÍ VÀ SỐ LƯỢNG NEO LIÊN KẾT THÁP CƠ BẢN CỦA CẦN TRỤC THÁP VỚI CÔNG TRÌNH XÂY DỰNG

Tóm tắt: *Bài báo nghiên cứu về kết cấu thép cần trục tháp; đánh giá tầm quan trọng và ý nghĩa thực tiễn của các neo liên kết từ tháp cơ bản vào công trình xây dựng. Sử dụng phần mềm phần tử hữu hạn chuyên dụng để tính toán, thiết kế kết cấu thép cần trục tháp; xác định số lượng và vị trí lắp dựng neo thép từ tháp cơ bản vào công trình. Qua đó, đánh giá mức độ an toàn cũng như khả năng làm việc của cần trục tháp. Sau đó, đưa ra các nhận xét, đánh giá và đề xuất cho các kết cấu tương tự.*

Từ khóa: Cần trục tháp; neo liên kết, kết cấu thép; tháp cơ bản; phần mềm chuyên dụng.

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