

Analysis of the safety impact of mobile rail hydraulic spreader on residential building machines under the system of building machines

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Abstract. The construction industry in China is a labor-intensive industry, but the cheap labor force has begun to change in recent years, with labor costs rising. In some labor exporting provinces, there has even been a "battle for talent.". Based on this, the "14th Five Year Plan" construction industry development plan issued by the Ministry of Housing and Urban-Rural Development proposes to accelerate the coordinated development of intelligent construction and industrialization of new buildings, and promote digital design, intelligent production, and intelligent construction. With the continuous progress of science and technology, the construction industry has also made many technological innovations, and innovative changes have taken place in related technologies. The residential building machine has begun to replace the traditional climbing frame application. Through gradual improvement, the lightweight building machine applicable to this project is only 220T, and the combination of spreader and building machine makes the concrete pouring process more convenient and intelligent, significantly reducing the labor intensity of construction personnel. Based on this, the analysis of the impact of mobile rail hydraulic spreader on the safety of residential building machines is a key factor.

Keywords: Mobile track; Hydraulic spreader; safety analysis.

1. Project Overview

Poly Tianhui is located in Northwest Material Market in Qilihe District, Lanzhou City, adjacent to Hewanbao East Street on the west, Xijin West Road on the south, Lan Shi land on the north, and Gansu Commercial Storage and Transportation Limited Company on the east. The area to the east of the north parcel is a government planning school site, and construction has not started yet. The total construction area is about 266,000 m², the above-ground construction area is about 206,000 m² and the underground construction area is about 60,000 m².

The building 12# of this project will be constructed by using the integrated platform of high-rise building efficient construction equipment, i.e. residential building machine. The wheeled concrete spreaders are combined with the building machine, which are equipped with tracks and moving mechanism at the bottom of the supporting frame, so that the concrete spreaders can be moved through the tracks laid in advance during the work, without the need of car and fixed installation, so it is more flexible.



Fig 1. Engineering effect

2. Analysis of the effect of spreaders on the force of the building machine

Due to the fact that the spreader is arranged on the building machine bailey frame, we have to consider the relationship between the load on the bailey frame and the load on the spreader itself to ensure the safety of the spreader during the movement and work. We use Midas to model the calculation and analysis to verify the safety.

2.1. Model Establishment

The general arrangement of the building machine in this project is shown in Figure 2. The building machine is composed of 321 type bailey sheet, all materials of bailey sheet are Q345 steel, the plane size of a bailey sheet is 3000x1400, the calculation diagram is shown in Figure 3. Its upper and lower chords are 2C10a channel steel (C 100x48x5.3/8.5, the spacing is 8cm), web I8 (h=80mm, b1=b2=50mm, tf1=tf2=4.5 mm, tw=6.5mm, r1=6mm, r2=3mm). The connection of the bailey piece is pin joint. The "#" intersection of the four bailey pieces is connected by trusses, which are all composed of square steel: mouth 60x5, as shown in Figure 4.

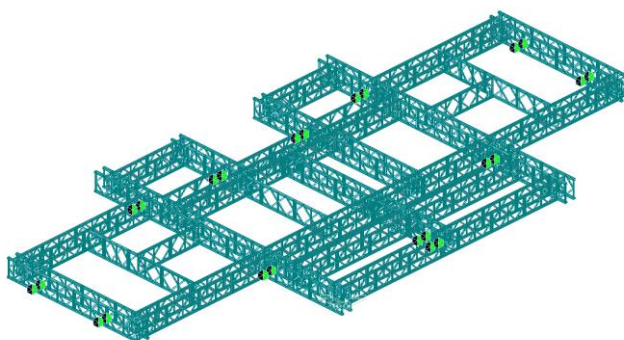


Fig 2. Layout of Horizontal Bailey Frame of Building Machine

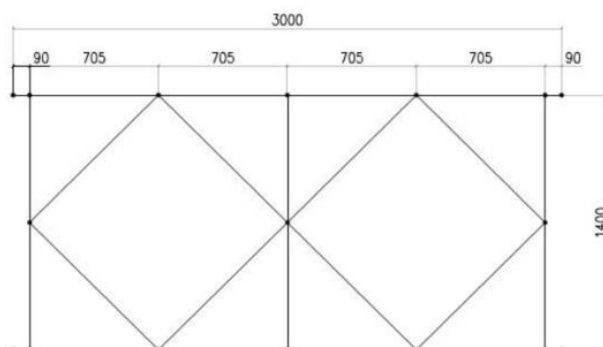


Fig 3. Simplified Calculation Model for Bailey Pieces

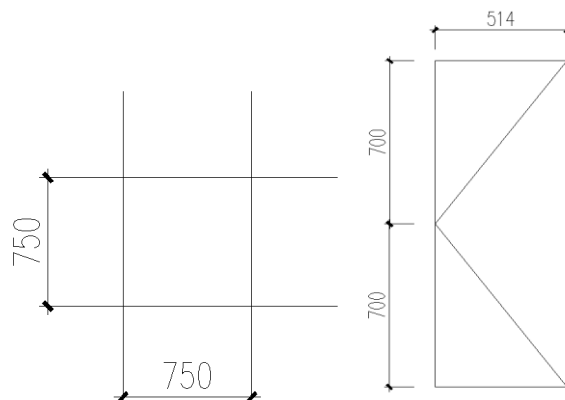


Fig 4. Bailey frame connection point truss

2.2. Boundary conditions

As shown in Figure 2, 11 positions of the building machine were connected to the original structure, and the connections were made with hinged joints.

2.3. Load calculation

The load of the building machine consists of constant load, the self-weight of the berber frame, the walkway plate and the railing, and the live load consists of the pedestrian load as well as the spreader motorized load.

The self-weight of the building machine is loaded by the program Z-direction downward, the walkway plate is a thick steel plate of 5mm, and the railing is square steel: 15x1.5mm. The pedestrian live load is calculated as 2.5kN/m². The arrangement diagram of the spreader is shown in Figure 5.

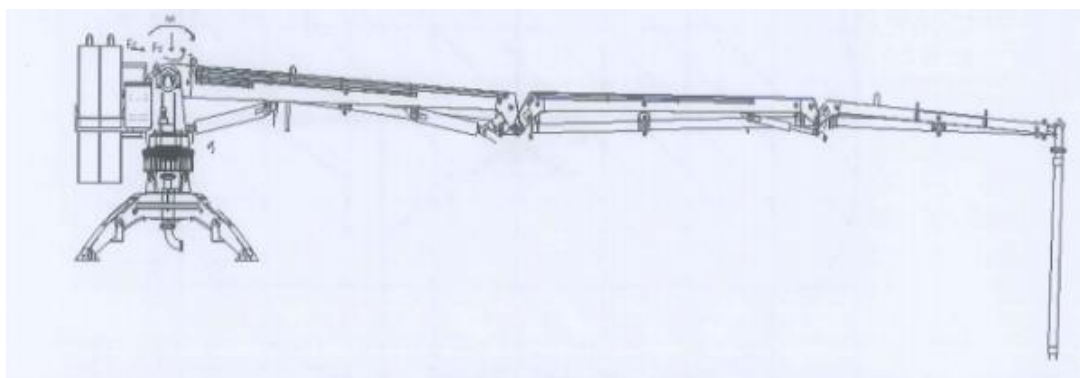


Fig 5. Schematic diagram of the distributor

According to the instruction manual of the spreader, its force is shown in Table 1. According to Building Structure Load Code GB50009-2012, Article 6.3.1, take its power coefficient as 1.1.

Table 1. Force Table of Bailey Frame of Building Machine

Title	Bending Moment(M)(kn.m)	Vertical force(Fv)(kn)	Horizontal force(Fc)(kn)	Torque (T)(kn.m)
Value	243	35	3	10

The location of the layout of the spreader track in the building machine is shown in Figure 6.

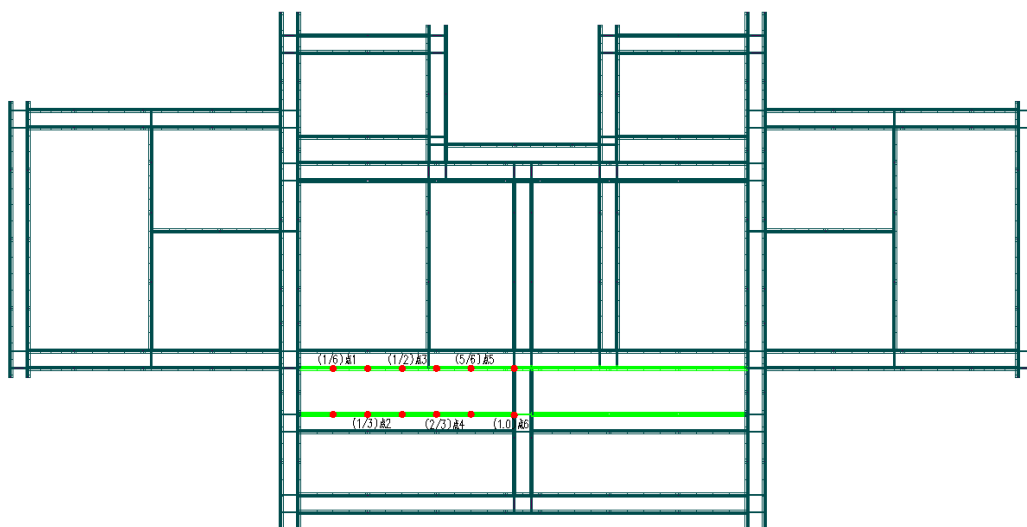


Fig 6. Schematic diagram of distributor track

The spreader load is applied by taking its symmetrical surface and applying live load to the nodes, which are located at 1/6, 1/3, 1/2, 2/3, 5/6 and 1.0 of the half position. The load application points are shown in Figure 6.

2.4. Calculation results

2.4.1 Displacement (1.0 permanent load + 1.0 live load)

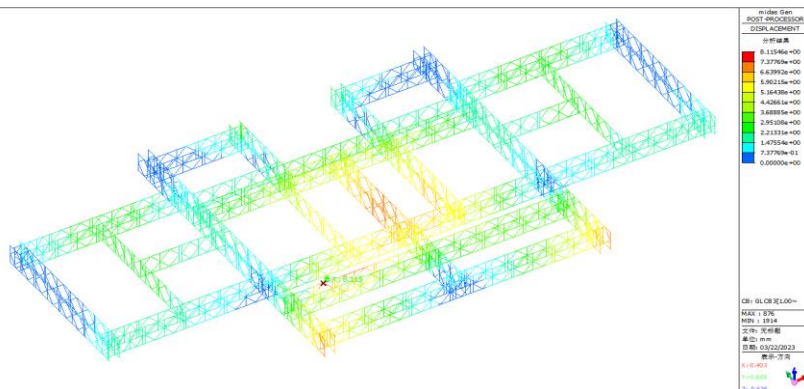


Fig 7. Displacement at 1/6

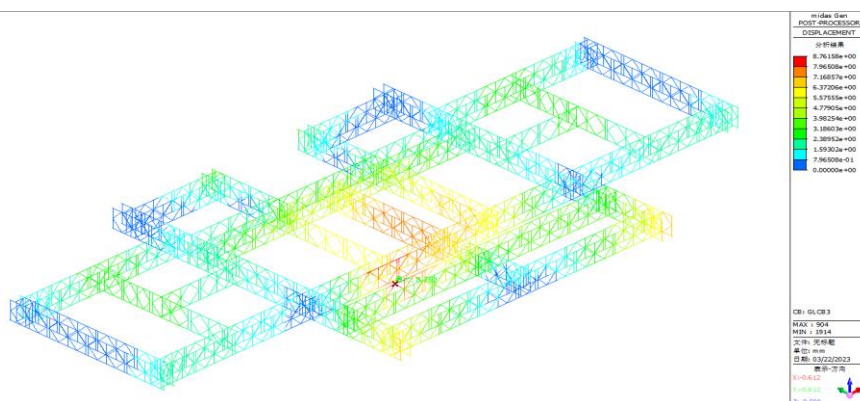


Fig 8. Displacement at 1/3

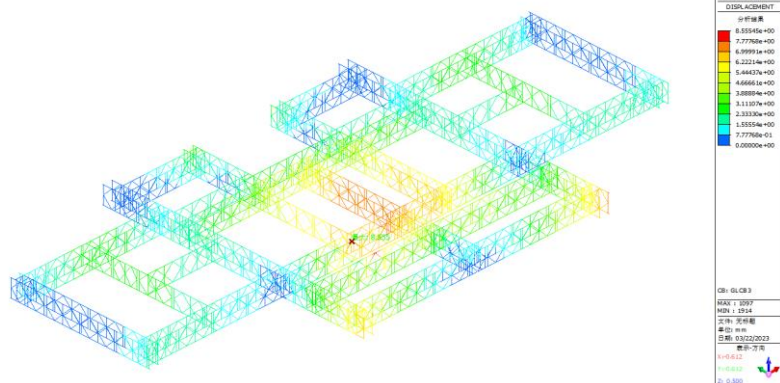


Fig 9. Displacement at 1/2

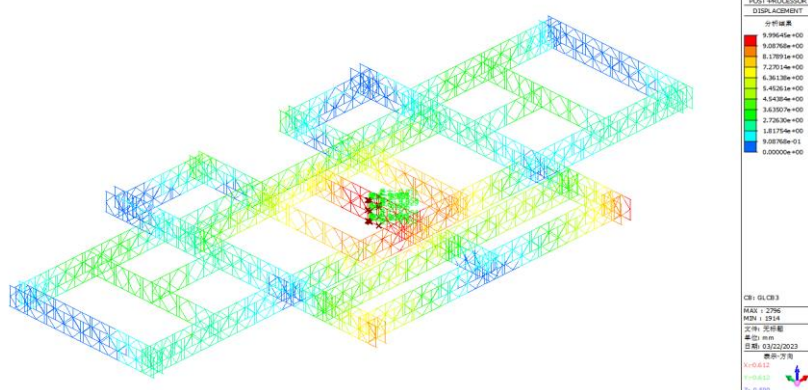


Fig 10. Displacement at 2/3

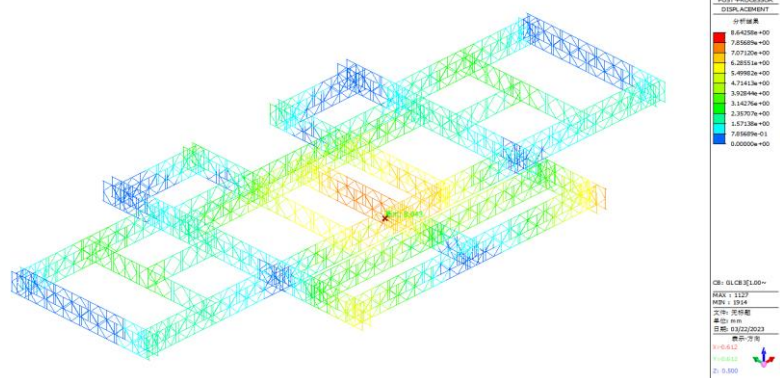


Fig 11. Displacement at 5/6

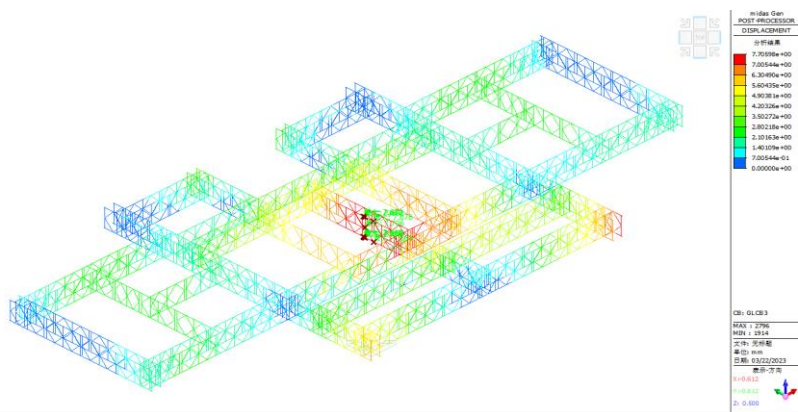


Fig 12. Displacement at 1.0

The maximum displacements during load application are shown in Table 2.

Table 2. Maximum Displacement During Load Application

Nodes	1	2	3	4	5	6
Displacement(mm)	8.115	8.726	8.555	9.996	8.643	7.692

The maximum displacement is 9.996mm, and its span is 19.80m, $9.996/19800=1/1980 < L/250$, the displacement can meet the requirements.

2.4.2 Stress (1.3 permanent load + 1.5 live load)

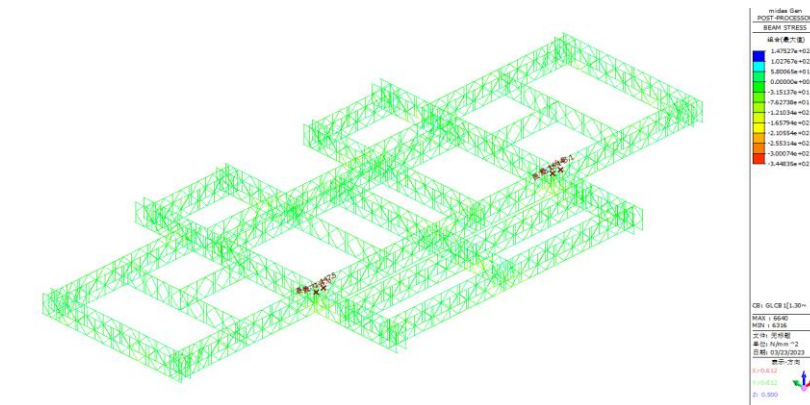


Fig 13. Maximum stress at 1/6

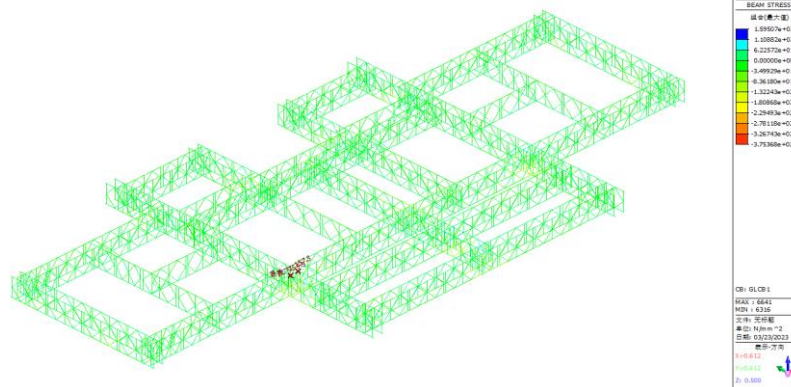


Fig 14. Maximum stress at 1/3

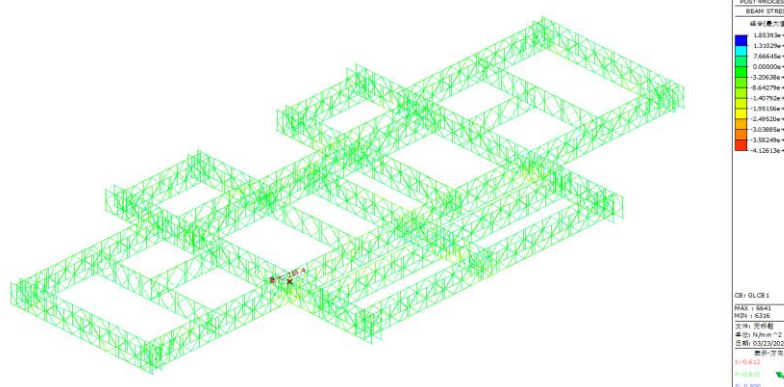


Fig 15. Maximum stress at 1/2

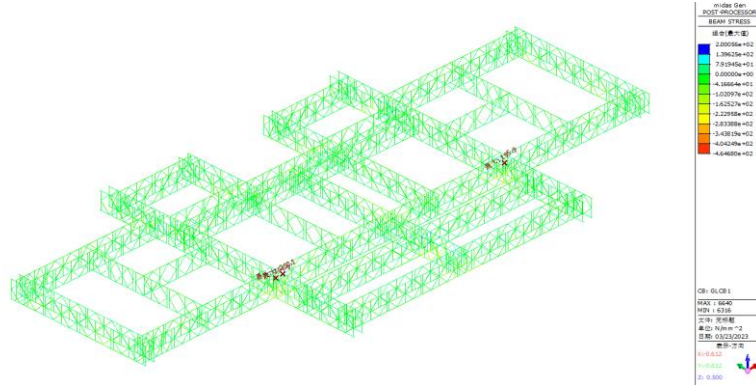


Fig 16. Maximum stress at 2/3

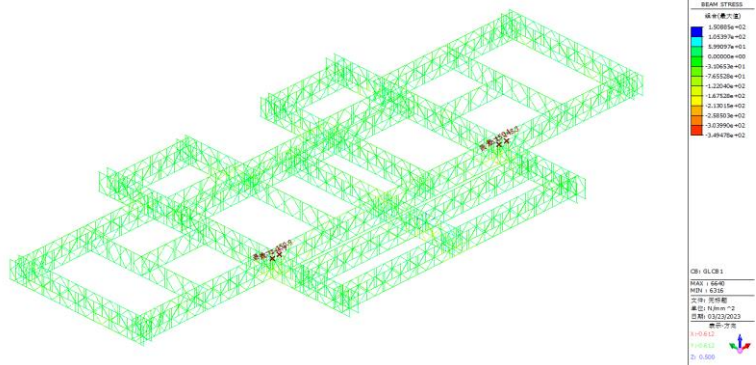


Fig 17. Maximum stress at 5/6

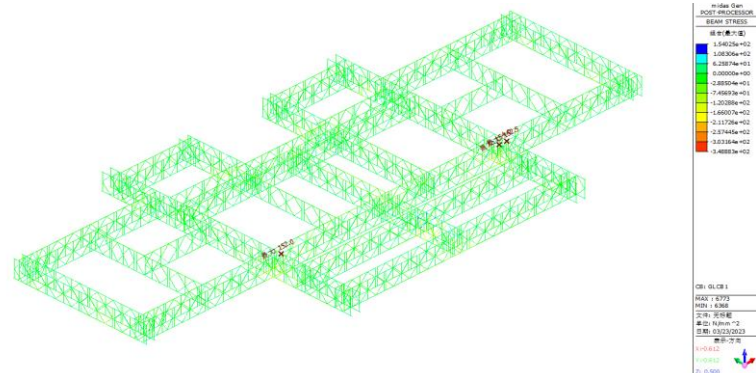


Fig 18. Maximum stress at 1.0

The maximum stresses during load application are shown in Table 3.

Table 3. Maximum Stress During Load Application

Nodes	1	2	3	4	5	6
Stress n/mm ²	147.5	159.5	185.3	200.0	150.8	154.0

The maximum stress point 4 arrangement is 200.0n/mm², and the maximum stress ratio is: 200.0/345=0.580<1, which meets the strength requirement.

As the calculation results show, the displacement and stress at point 4 are both maximum, and their displacements and stresses meet the strength and stiffness required by the design.

Distribution point selection.

According to the working radius of the spreaders, its maximum elongation radius is 17m, the spreader work as far as possible to cover the floor range as shown in Figure 18, it can be seen that the spreader cover the maximum range at point 1, and the minimum coverage at spreader point 6. So here the points of spreader choose point 1 as well as its symmetry point.

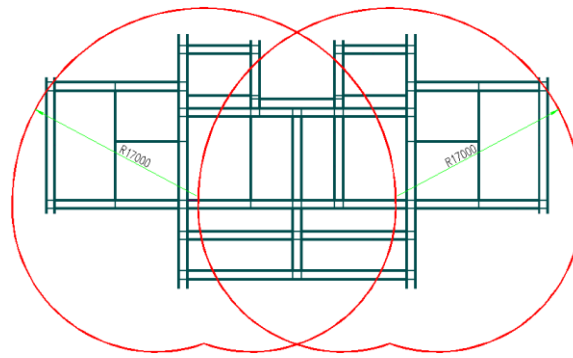


Fig 19. Pouring coverage of hydraulic spreader

3. Mobile spreader operating procedures

Take the panel remote control method as an example to briefly introduce the spreader operation.



Fig 20. Remote control for hydraulic distributor panel



Fig 21. Pouring Diagram of Distributing Machine

(1) After the installation of the spreader in place, hoist the hydraulic pump station and connect the hydraulic piping system. Check whether the hydraulic pipeline, power supply, surrounding environment and weather condition meet the requirements of test run.

(2) Turn on the power, start the motor, measure whether the power supply voltage meets the requirements, and observe whether the pressure of the hydraulic pump station pressure gauge is normal.

(3) Deployment of the spreader arm

The remote control is shown in Figure 19, and the sequence of its unfolding is according to the following steps:

a. Firstly, extend I arm and press "1" button, the angle of I arm must be greater than 60° to prevent interference with other parts (such as concrete pump, etc.) in the process of unfolding;

b. Extend II arm and press "2" button, then extend III arm and press "3" button.

(4) Rotating of spreader arm

Press "4" or "South" button when the spreader arm needs to rotate. When rotating, you need to pay attention to the cable direction.

(5) Retracting the spreader arm

The sequence of retracting the spreader arm is as follows:

a. Firstly, retract the III arm and press the "West" button;

b. Extend I arm so that its angle with the ground is greater than 60° , and press "1" button;

c. Retract the II arm and press the "down" button, then retract the I arm and press the "East" button, then the hose at the end of the III arm will automatically fall to the bracket;

d. Retract the I arm or drop it to the bracket set for it.

4. Safety Precautions

4.1. Safety precautions for spreader operation

(1) Each time you start the equipment, you should let the hydraulic pump idle for a while. If the temperature is low, the idling time should be extended appropriately and the hydraulic oil temperature should be raised to 15°C or more before it can work normally.

(2) You cannot unfold II arm and III arm when the boom is in a folded state to avoid interference between the boom sections.

(3) Each control button performs one action, and only one button can be pressed at a time during operation, that is, after completing one action and then the next action, so as to avoid misoperation when the spreader is working.

(4) In the operation process, when the three arms in a straight line up should avoid more than 80° (angle with the ground), this condition will produce a large inertia force and tilting moment. Similarly, when the three arms are in a straight line and in the horizontal position, should also try to avoid directly lifting the I arm cylinder, because at this time the maximum working torque, the system pressure is at its maximum and the cylinder action is slow. If you need to lift I arm at this moment, you should lift I arm slightly first, then retract III arm (or II arm) as much as possible, repeat several times to reduce the working moment of the boom and then lift I arm cylinder.

(5) The hose at the arm side of the spreader is not allowed to be bent in the process of pouring concrete.

(6) During the pouring process, it is not allowed to check or loosen the joints of the concrete pipeline, and should be as far away from the spreader arm as possible, and all kinds of checks should be placed after the construction.

(7) If the spreader arm is found to be sinking during the working process, it should be stopped immediately for inspection and troubleshooting.

(8) Do not make gravel and other foreign objects fall into the rotation bearing to avoid damage to the machine.

(9) The spreader shall not be used as lifting equipment under any circumstances, such as hoisting, dragging heavy objects, etc.

(10) Walking control and distribution control can only be controlled separately, that is, it cannot rotate and move the arm when walking; it cannot move walking when distributing. Turn off the controller in advance.

(11) Should immediately insert the pin and rotate a cycle after walking in place to ensure fixed in place.

4.2. Pouring concrete precautions

- (1) Regardless of the distance of concrete conveying, the inner wall of the concrete pipe should be fully wetted before pumping. A certain amount of cement mortar can be pumped first for wetting;
- (2) The concrete pumped must be fully mixed and homogeneous;
- (3) If the pouring is temporarily interrupted, it should first reverse the pumping for 2 ~ 3 strokes to depressurize the concrete line, and then pump the concrete repeatedly in the forward and reverse directions to maintain the fluidity of the concrete;
- (4) When the pouring pause is long, the concrete should be sucked back into the hopper, mixed and pumped again;
- (5) When there is a long pause, the concrete should be circulated every 20 minutes by pumping it forward and backward;
- (6) If the pipeline is blocked, the concrete should be pumped back to the hopper immediately, then mix and troubleshoot in time.

5. Conclusion

The 12 # high-rise residential building in this project adopts the residential building machine and the mobile track spreader. We demonstrate the safety of load and construction through Midas structure calculations. The whole floor can be completely covered by using a spreader in moving track. The automatic hydraulic spreading method significantly reduces the labor intensity of workers and improves the pouring efficiency. Through technological innovation, the expected effect has been achieved. It is expected that this technology can create more high-quality social benefits in projects similar to the high-rise residential building machine system.

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