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Analysis, Comparison and Optimization of T-type Section Beam and Rectangular Section Beam based on Engineering Training

Zhenming Guo, Yang Shi, Keyan Sun and Zhengyu Huang

School of Civil Engineering, Changchun Institute of Technology, Changchun 130012, China

Abstract

The research on the optimization of T-beam under the condition that both T-beam and rectangular section beam meet the section bearing capacity. Through theoretical calculation, component fabrication, experiment, and data collection and analysis, fully explore the advantages of a T-beam, optimize the experimental beam transport process, and apply it to practical teaching to improve the safety and convenience of the experimental process.

Keywords

Rectangular Beam; T-beam; Bearing Capacity; Cost Analysis; Transportation Device.

1. Section Design of T-beam and Rectangular Beam

Referring to the rectangular beam used in the student engineering training of Changchun Institute of Engineering, b × h=100 × 150mm, the concrete strength grade is C20, and the beam size reinforcement is shown in the figure. The bearing capacity of the rectangular beam is determined according to the material strength and the national standard Code for Design of Concrete Structures (GB 50010-2010) α

Reinforcement: tensile yield strength of main reinforcement and stirrup fy=300N/mm ^{2}, The thickness of main reinforcement protective layer is 25mm

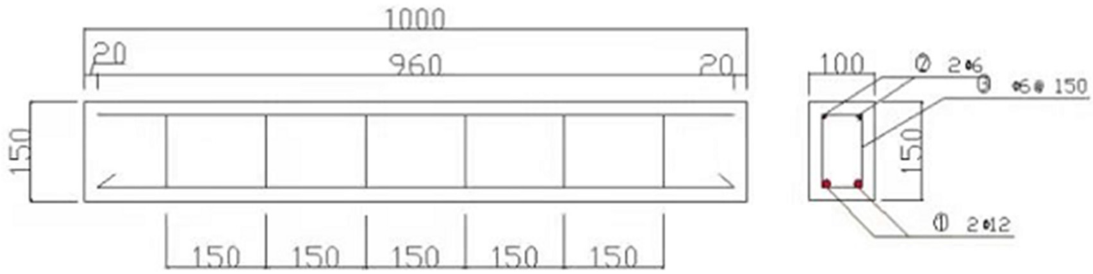

Fig 1. The beam size reinforcement

Experimental method:

Control experiment: the cost is analyzed by comparing the material consumption of the rectangular section beam and T-beam.

Experimental tools:

Jack, distribution beam, static resistance strain gauge, dial indicator, crack observation mirror and crack width measuring card, high-pressure pump, etc., a transport tool for building structure laboratory;

Experimental process:

(1) After the test piece is installed, check the test device, and ensure the position of the mounting support, test piece, and the beam is stable and free of inclination; Install the dial indicator based on accuracy and verticality; The manual hydraulic jack and pressure sensor

shall be connected to the sensor and dynamometer, and the position shall be accurate, stable and free of tilt.

(2) After the installation of the instrument, check whether the experimental device is stable, accurate, and free of tilt, and check whether the instrument works normally.

(3) Measure the actual size of the beam section and span, and the position of the loading device.

(4) Carry out 1-3 levels of preload on rectangular components, the preload value shall not exceed 1/2 of the calculated value of time cracking load, and each level shall be stable for 1 minute, then unload, and check whether the instrument is normal during the loading process;

(5) Gradually load according to the determined loading index, and the time between two loadings is 2-3 minutes. Observe whether there are cracks on the beam during the interval after each loading stage. The load lasts for 2 minutes, and record the readings of the resistance meter and dial indicator;

(6) When it is close to cracking and failure, it can be loaded in half or 1/4 stages;

(7) When obvious large cracks appear on the beam, remove the dial indicator, load the component to complete failure, and record the maximum value of concrete strain and load.

(8) According to the reading in the dial indicator, calculate the measured midspan deflection value of the beam under various loads;

(9) According to the strain gauge reading of the stressed main reinforcement, calculate the average value of the reinforcement strain in the member span;

(10) Replace the rectangular component with a T-shaped component and repeat the above operation;

(11) Through calculation, the bearing capacity of T-beam meets the requirements;

(12) Calculate the material consumption of rectangular and T-shaped components, and calculate the cost of cost analysis;

2. Data Analysis and Calculation:

Calculate the height of pressure zone:$a_s = C + d_{Sv} + d + \frac{d'}{2} = 25 + 6 + 6 = 37(mm)$

$a_s' = 25 + 3 + 6 = 34(mm)$

Effective height of beam:$h_0 = h - a_s$ =150-37=113(mm)

Pressure zone height:$x = \frac{A_s f_y - A_s' f_y'}{\alpha_1 f_c b} = \frac{226\times300-57\times300}{1.0\times9.6\times100}$=53(mm)

Calculate the flexural capacity of the section:

M_u:because:$x =< \xi_b h_0 =\times=(mm)$,and$x => 2a_s' =$

$M_u = A_s f_y (h_0 - a_s')$=226× $300 \times (113 - 34) = 5.35kN \cdot m$

$a_s = \frac{\gamma_0 m}{a_1 f_c b' f h_1^2} = \frac{53.5\times10^6}{9.6\times300\times150^2}$=0.082

ξ=1-$\sqrt{1 - 2\alpha_s}$=1-$\sqrt{1 - 2 \times 0.082}$=0.086

X=0.082×150=12.3mm<0.55×150

rs=1-0.5ξ=1-0.5×0.086=0.957

As=$\frac{5.35\times10^6}{300\times150\times0.957}$=124.23mm^2

Selected reinforcement:2Φ10

l=1000mm $b'f=\frac{10}{3}$ As=157mm^2

Hypothesis:b_f=300mm Design beam section size :b×h=180×300

ξ6h0=0.55×150 h0=150

$X=\frac{A_s f_y}{\alpha_1 f_c b_f'}=\frac{157\times300}{1.0\times9.6\times300}$=16.35mm<$\xi b_h$=0.55×150=82.5

$\frac{A_s}{b_h}=\frac{157}{180}$=0.87 $b=\frac{A_s\times1\%}{h}=\frac{157\times0.01}{180}$=9mm b=30mm

$As=\frac{a_1 f_c b_f' h_f'}{f_y}=\frac{9.6\times300\times15}{300}$=144mm2

157mm^2>144mm^2

Therefore, the neutral axis of the second type of T-section is in the beam rib,X $=\frac{A_s f_y-d_1 f_c(b_f-b)h'f}{a_1 hb}=\frac{157\times300-1.0\times9.6\times(300-30)\times15}{1.0\times9.6\times30}$

=28.54mm<0.55×150=82.5mm so there is no trouble of data

$\rho=\frac{A_s}{b_h}=\frac{157}{30\times180}$=0.029×100%=2.9%>0.2 so there is no trouble of data

$mv=\alpha1fc[(b_f'-b)h_f'(h_0-\frac{h_f'}{2})+b_x(h_0-\frac{x}{2})]$

$=10\times96\times[(300-30)\times15\times(150-\frac{15}{2})+30\times28.54\times(150-\frac{28.54}{2})]$

=6.6×106N·mm>5.35×106N·mm

2.1. Cost Analysis

The following will be calculated as the reference price

Concrete price:460yuan/m3

Φ6 Rebar price:5320yuan/t weight:0.222kg/m

Φ12 Rebar price:5190yuan/t weight:0.888kg/m

Φ10 Rebar price:5220yuan/t weight:0.617kg/m

Cement consumption of rectangular beam:100×150×1000=1.5×107mm3

Steel Consumption:Φ6:0.222×0.15×6+0.222×0.96×2=0.62604kg

Φ12:0.888×2×0.96=1.70496kg

Total price of rectangular beam:1.5×10-2×460+0.62604×5.32+1.70496×5.19=19.1yuan

Cement consumption of T- beam:

(300×15+165×30)×1000=9.45×106mm3

Φ10 Steel Consumption:0.617×2×0.96=1.18464kg

Total price of T-beam:9.45×10-3×460+1.18464×5.22=10.6yuan

It can be concluded that T-beam saves nearly half of the price compared with the rectangular beam.

Through the section design of the rectangular beam and T-shaped beam, it is obtained that the cost of T-beam is cheaper than that of the rectangular beam through the existing data calculation and the test under the condition that the same bearing capacity of the section is met.

3. A Laboratory Transport Device for Building Structures:

3.1. Technical Background

When transporting concrete beams, the concrete beams are transported to the experimental platform by forklift trucks in the surrounding of the experimental platform, and then transported manually by students. Through observation, it is found that there are certain dangers in the transportation of concrete beams. Optimizing the beam transport device can ensure students carry out experiments safely and improve teaching efficiency. There are two kinds of transportation devices commonly used in colleges and universities. One is the fixed

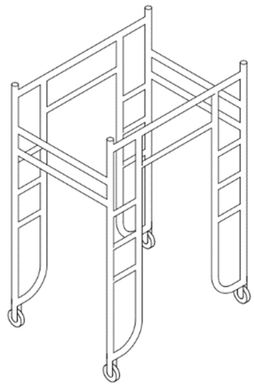

Fig 2. Transport beam frame map

Fig 3. Picture of real products

transportation device with only a short distance. This kind of transportation device is huge, complex in operation requires many people, and often needs to be carried with students manually. The other is a portable transport device, but it is also huge and not suitable for indoor teaching. And the teaching structure accuracy of transportation and installation is low. The transport device is equipped with three layers of adjustable height and fixed universal wheels, which improves the positioning accuracy of components. The device is compact and can be transported in a narrow area. And because the structure is simple and stable, the operation is easy to understand. It achieves the safety, efficiency, and simple operation we want.

3.2. Technical Solution

the handling tool is designed with simple operation as the core of the equipment, and its safety performance is guaranteed based on the steel frame. The bottom is equipped with a fixed universal wheel, which is convenient for sliding and can reduce the physical strength of personnel. With the help of the forklift, the experimental teaching structure is raised to the center of the transport tool. The transport tool has three layers of bearing rod placement layers, which can be selected according to the height of the test platform. Insert the bearing angle steel according to the required height and place the load to achieve the desired effect. Due to the compact ha ndling tools, personnel can be transported in a narrow area.

4. Conclusion

In this paper, experimental research is carried out on the bearing capacity, material, and cost of rectangular and T-shaped beams, revealing that the material used for T-beams will be far less than that of rectangular beams under the same bearing capacity, and the section size and reinforcement that can replace the T-shaped concrete beams used at the present stage can be

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found through calculation and experiment. T-beam can significantly reduce the production cost and reduce the amount of concrete waste after loading and damage.

This paper presents a transport device for building a structured laboratory, which is simple and stable in structure and easy to understand by personnel. Realize the transportation purpose of smaller size, safer, higher efficiency, and simple operation.

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References

[1] Zhang Zirong Basic Principles of Concrete Structures (Wuhan University Press).
[2] Tongji University Design Principles of Concrete Structures (China Construction Industry Press).
[3] Code for Design of Concrete Structures (GB 50010-2010).
[4] Zhang Shuguang Structural Tests of Civil Engineering.
[5] Test of Building Structures, 2nd Edition.