Design of Concrete Frame Structure Based on Engineering Quality

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Abstract. The project is a reinforced concrete frame construction office building, which contains 5 floors. Each floor's height is 3.6 meters . The whole elevation is 19.6 meters. In this area, the intensity of earthquake resistance is 7. The basic wind pressure is 0.75 kN/m2.The location type of the constructs is II. It has finished some assignments as follow : (1) the architectural design, (2) structure type choosing, (3) board structural design, (4) frame construction design, (5) foundation structural design, (6) staircase design and so on. Among them, It used the theory of plastic in the design of the floors and elasticity in the design of roof. When calculated the frame's cryogenic force under the vertical load function, It used the lamination calculation method. D method is used in the calculation of frame cryogenic force under the horizontal load function. In the design, the board's thick is 100mm, the beam's size is 250mm×450mm, the size of the calumniation is 500mm×500mm. It has used the reinforced concrete step-shape independent foundation, which is 0.6m height, and buried 1.5m depth. The analyzing process of some typical members of the structure were showed in the paper.

Introduction

In this design, the board is cast with C25 concrete. Determining the section size of reinforced concrete slabs: $\frac{h}{l_1} \geq \frac{1}{50}$, for two-way slabs, requirements for short to span. Structural arrangement diagram shows that the maximum value of the short side size of the B1 area lattice, $l_1 = 3900\text{mm}$, $\frac{h}{l_1} = \frac{h}{3900} \geq \frac{1}{50}$, and the two-way plate $h_{\min} = 80$ mm. Considering the thickness of the plate, the thickness of the plate is 100mm. So the thickness of the floor slab and roof panel is 100mm. Floor and roof were using cast-in-place reinforced concrete structure.

Structure type selection

Selection of Board Type. In this design, using C25 concrete beam. The frame girder height according to the beam span of 1/18 ~ 1/10 estimates, the size of beam section is estimated as follows:
Frame beam AB cross beam span L to take 6900mm.

h = (1/18～1/10)L = 380～680 take h=450mm

b = (1/2～1/3)h = 120～340 take b=250mm

Take AD cross beam b×h = 250mm×500mm

Frame beam

Span 3900mm maximum span L take

h = (1/18～1/10)L = 217～390 take h=400mm

b = (1/2～1/3)h = 133～200 take b=200mm

Take Stringer b×h = 200mm×400mm

Considering stiffness and other factors, the outer wall of Liang Chicun b * H = 300mm * 600mm

Table 1: Beam section size (mm) and concrete strength grade of each layer

Frame beam	Number	b×h	Layer	Concrete grade
Transverse beam	KJL-1	300×600	1－5	C25
	KJL-2	250×450	1－5	C25
Longitudinal beam	KJL-3	300×600	1－5	C25
	KJL-4	200×400	1－5	C25

Type selection of column. In this design, the column is cast with C30 concrete. Because the total height of the frame structure is less than 30m, and the seismic fortification intensity is 7 degrees, so the frame anti earthquake grade is three.The axial compression ratio is 0.9.The load standard value of each layer is 12 kN/m^2 .The load area of the side column and the middle column are 3.9×3.45 m^2 and 3.9×4.5 m^2 .

Considering the use of C30 concrete, $A \geq \frac{1.3N}{m f_c}$

Side column: $A \geq \frac{1.3\times3.9\times3.45\times5\times12\times10^3}{0.9\times14.3} = 81545mm^2$

Column is rectangular: b×h = 450×450 mm^2

Middle column: $A \geq \frac{1.3\times3.9\times4.5\times5\times12\times10^3}{0.9\times14.3} = 106363mm^2$

Column is rectangular: b×h = 450×450 mm^2

First floor pillar take: b×h = 500×500 mm^2

Basic design

Design of load calculation. Column axial force and shear force (corresponding control force take design of column) based on weight, the weight of the backfill.

Table 2:Upper load of A column foundation

Types of internal force		$+M_{max}$	N_{min}	N_{max}
Axial force (*kN*)	Column	1118	1118	1760
	∑	1118	1118	1760
Torque (*kN·m*)	Column	180	180	29
	Shear stress	165	165	165
	∑	345	345	195
Shear stress(*kN*)	V	110	110	110

Table 3:Upper load of B column foundation

Types of internal force		$+M_{max}$	N_{min}	N_{max}
Axial force (*kN*)	Column	1184	1184	1868
	∑	1184	1184	1868
Torque (*kN·m*)	Column	191	191	24
	Shear stress	196	196	196
	∑	387	387	220
Shear stress(*kN*)	V	131	131	131

It can choose the independent column foundation because the engineering framework layer is not much, the foundation soil is uniform. According to geological reports based on depth of fill in the following. The strength grade of concrete based on C30, and the design value of concrete strength is f_c=14.3N/mm^2; f_t=1.43N/mm^2.

Independent foundation calculation of column.

Selection based depth of burial. According to the geological report, selected the actual depth of foundation d=1.5m, foundation heightThe bearing capacity of foundation depth correction h_0＝0.6m. According to the design data (red clay, the ratio is less than or equal to 0.8): the correction coefficient of bearing capacity of foundation width and depth of Foundation $h_b = 0.15$; $h_d = 1.4$ (the foundation and upper back fill density average) characteristic value of degrade bearing capacity f_{ak} =200kPa.

$$f_a = f_{ak} + h_b g(b-3) + h_d g_m(d-0.5)$$
$$= 200 + 1.4\times 20\times(1.5-0.5)$$
$$= 228kPa$$

Basic bottom size. Take N_{max} axial force combination, according to the central load calculation of base area:

$$A' \geq \frac{F_k}{f_a - g_G d} = \frac{1760.48}{228 - 20\times 1.5} = 8.89m^2$$

Taking into account the eccentric load stress distribution is not uniform, it will be calculated to increase the basal area of 10%~40%, then the Base resistance moment:

$$W = \frac{1}{6}lb^2 = \frac{1}{6}\times 4.0\times 2.5^2 = 4.17m^3 .$$

Checking calculation of bearing capacity of Foundation.

Calculation of ground reaction force: $\frac{P_{k,\max}}{P_{k,\min}} = \frac{F_k + G_k}{A} \pm \frac{M_k}{W} = \frac{F_k + G_k}{l\cdot b}\left(1 \pm \frac{6e_k}{l}\right)$

Eccentricity $e_k = \frac{M_k}{2(F_k + G_k)}$ Foundation and backfill soil weight $G_k = g_G dA$

Demand satisfaction : $\bar{p} = \frac{p_{k\max} + p_{k\min}}{2} \leq f_a$ and $p_{k\max} \leq 1.2 f_a$

Table 4:bearing capacity of Foundation

	M_{max}	N_{min}	N_{max}
$\frac{F_k}{lb}$	93	93	146
$\frac{G_k}{lb}$	30	30	30
$\frac{M_k}{W}$	69	69	38
$p_{k\max}$	192	192	215
$p_{k\min}$	54.15	54	137
$\overline{p}=\frac{p_{k\max}+p_{k\min}}{2}$	123	123	176

$$p_{k\max}=215.61kPa<1.2f_a=1.2\times 228=273.6kPa$$

$$p_{k\min}>0,\qquad \overline{p}=\frac{p_{k\max}+p_{k\min}}{2}\le f_a=228kPa$$

So the bearing capacity meets the requirements.

Calculation base net reverse force. Eccentricity $e_{n,0}=\frac{M}{F}=\frac{345.67}{1118.79}=0.31m$.

Maximum and minimum net reverse force at the base edge

$$\frac{P_{n,\max}}{P_{n,\min}}=\frac{F}{lb}\left(1\pm\frac{6e_0}{l}\right)$$

$$=\frac{1118.79}{2.5\times 4.0}\times\left(1\pm\frac{6\times 0.31}{4.0}\right)=\frac{163.90kN}{59.86kN}$$

Reinforcement calculation. Net reverse force of column:

$$p_{n,1}=p_{n,\min}+\frac{l+a_c}{2l}\left(p_{n,\max}-p_{n,\min}\right)$$

$$=59.86+\frac{4.0+0.5}{2\times 4.0}(163.9-59.86)$$

$$=118.38kPa$$

Average value of net back force of cantilever: $\frac{1}{2}\left(p_{n,\max}+p_{n,1}\right)=\frac{1}{2}\times(163.9+118.38)=141.14kPa$

Bending moment:

$$M_1=\frac{1}{24}\left(\frac{p_{n,\max}+p_{n,1}}{2}\right)(l-a_c)^2\left(2b+b_c\right)$$

$$=\frac{1}{24}\times 141.14\times(4.0-0.5)^2\times(2\times 2.5+0.5)$$

$$=396.22kN\cdot m$$

$$A_{s,1}=\frac{M_1}{0.9f_yh_0}=\frac{396.22\times 10^6}{0.9\times 300\times 550}=2668mm^2$$

cross sections (side step):

$$p_{n,2} = p_{n,\min} + \frac{l + a_c}{2l}\left(p_{n,\max} - p_{n,\min}\right)$$
$$= 59.86 + \frac{4.0 + 2.0}{2 \times 4.0}(163.9 - 59.86)$$
$$= 137.89kPa$$

Average value of net back force of cantilever part: $\frac{1}{2}\left(p_{n,\max} + p_{n,2}\right) = \frac{1}{2} \times (163.9 + 137.89) = 150.9kPa$

Bending moment:

$$M_2 = \frac{1}{24}\left(\frac{p_{n,\max} + p_{n,2}}{2}\right)(l - a_c)^2 (2b + b_c)$$
$$= \frac{1}{24} \times 150.9 \times (4.0 - 2.0)^2 \times (2 \times 2.5 + 1.2)$$
$$= 155.93kN \cdot m$$
$$A_{s,2} = \frac{M_2}{0.9 f_y h_0} = \frac{155.93 \times 10^6}{0.9 \times 300 \times 250} = 2310mm^2$$

Comparison and, should be according to the reinforcement, $A_s = 2770mm^2 > 2668mm^2$.

Because the foundation is affected by the one-way eccentric load, the base reaction force in the short side direction can be evenly distributed: $p_n = \frac{1}{2} \times (163.9 + 59.86) = 111.88kPa$. The calculation method of the reinforcement side direction is the same, which can get the calculation of the section (column edge).

Bending moment:

$$M_2 = \frac{1}{24}\left(\frac{p_{n,\max} + p_{n,\min}}{2}\right)(b - b_c)^2 (2l + a_c)$$
$$= \frac{1}{24} \times 111.88 \times (2.5 - 0.5)^2 \times (2 \times 4 + 0.5)$$
$$= 158.5kN \cdot m$$
$$A_{s,3} = \frac{M_2}{0.9 f_y h_0} = \frac{158.5 \times 10^6}{0.9 \times 300 \times 550} = 1067mm^2$$

Cross sections (side step)

Bending moment:

$$M_2 = \frac{1}{24}\left(\frac{p_{n,\max} + p_{n,\min}}{2}\right)(b - b_c)^2 (2l + a_c)$$
$$= \frac{1}{24} \times 123.23 \times (2.5 - 1.2)^2 \times (2 \times 4 + 2)$$
$$= 78.78kN \cdot m$$

$$A_{s,4} = \frac{M_2}{0.9 f_y h_0} = \frac{78.78 \times 10^6}{0.9 \times 300 \times 250} = 1167mm^2$$

It should be according to the reinforcement and the actual match: $A_s = 1207mm^2 > 1167mm^2$.

Conclusions

The content of graduation project is divided into two main parts.The first part is calculation of gross output, and then to aggregate them together . According to the related consumption quota, the cost and the material and the mechanical consumption of the project are obtained.The second part is the construction organization design.According to the characteristics of the project and the construction conditions of a reasonable division of the construction segment and determine the flow direction, select a reasonable construction plan.According to the calculation of reasonable arrangements for the location of the yard and the use of human resources, human resources, material and resources to achieve the optimal ratio, to create more economic benefits.

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