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Research on anti-floating reinforcement of an existing project

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Abstract. Due to the lack of structural anti-floating, a certain part of the main structure has cracks, and the structure needs to be reinforced by buoyancy to make the project meet the requirements.After research, the Negative second floor of the original structure is reinforced with add the anti-floating anchors, apply pressure grouting for cracks in the plate, Paste carbon fiber cloth for the bottom of the plate and the damaged shear wall, externally-paste profile steel for the damaged column, and paste Carbon fiber sheet attached to damaged beam.the calculated of shear bearing and flexural capacity show that the board meets the requirements.

1. Introduction

With the continuous development of the construction industry, more and more buildings are standing in the crowd, and problems are emerging.Especially in Guizhou Province, the geological environment and hydrological conditions are complicated, and it is difficult to obtain accurate geological surveys. Therefore, some structural bearing capacity is likely to occur during the design and construction process, and reinforcement measures are required for buildings with insufficient structural capacity.An existing project in Guizhou has found that cracks have occurred in structural components due to insufficient structural anti-floating, and the structure needs to be anti-floating. For the reinforcement measures, this paper has made corresponding research.

2. Project Overview

The construction area of the project is 25,808.73m^2, and the building height is 8.55m. The basic form is pile foundation plus waterproof board, independent column base plus waterproof board and raft foundation.The foundation bearing layer is a medium-grade limestone, and the main structure is a two-layer underground frame structure. Because of insufficient anti-floating , Some frame columns, frame beams and bottom plates in the range of (1)~(10)/(A)~(M) axis of the negative one floor and Negative second floor of the project are deformed and cracked. Therefore, the damage status of concrete members in (1) ~(10)/(A)~(M) axis of the negativ one floor and Negative second floor of the project is detected.According to the test, the damage range of the structure is (1)~(10)/(A)~(M) axis; some column has cracking phenomenon, and there are mutation and dislocations in the cross section of individual frame columns; the negative second floor shear wall (1)~(7)/(A),and negative one floor of shear wall (1)/(A)~(B) has cracking phenomenon; a few beams have cracking phenomenon; negative second floor (1)~(2)/ (A)~(C), (3)~(4)/(J)~(K), (6)~(7)/(E)~(G) Plate has being crack.

3. Take reinforcement measures

In view of the engineering problems, the following reinforcement measures are proposed. pressure grouting is applied to the bottom and basis of the plate before reinforcement. anti-floating anchors are added to the negative second floor, and the head height of the water for the anti-floating is 4.3 m.Pressure grouting treatment for the board of crack, and the carbon fiber cloth is reinforced on the bottom of the board.the damaged column is reinforcement by externally pasted steel, externally attached carbon fiber sheet, and the enlarged section method. Before the reinforcement of damaged column, the pressing should be removed.The carbon fiber cloth method is used for reinforcement for the damaged beam. Before the reinforcement of damaged beam, the crack on the beam should be pressure grouted. the damaged shear wall should be reinforced with carbon fiber cloth.

The original structure is reinforced and the reinforcement measures are shown in the figure below.

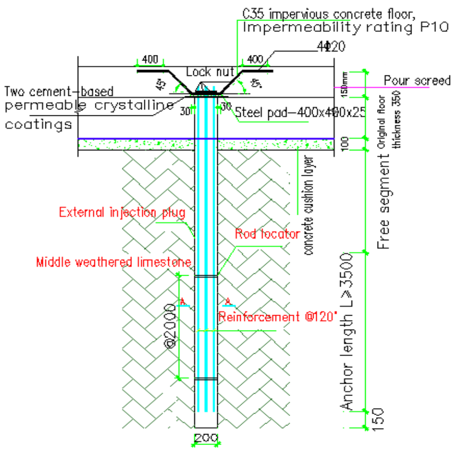

Figure 1. Uncasting concrete screed

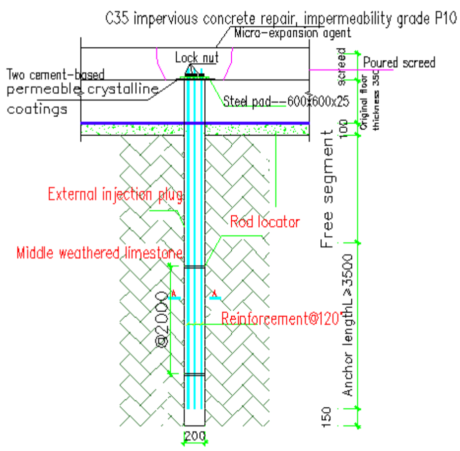

Figure 2. Pour screed concrete anchor practice

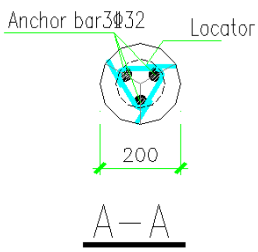

Figure 3. Anchor section

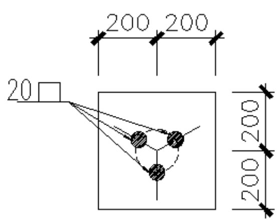

Figure 4. Uncasted water stop plate steel plate

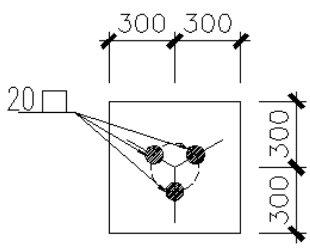

Figure5. Poured water-stop

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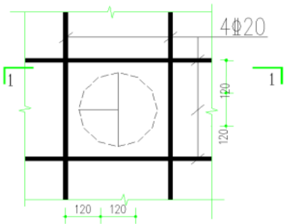


Figure 6. Anti-shearing steel bar arrangement in the board

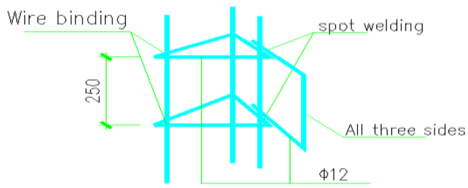


Figure 7. Locator

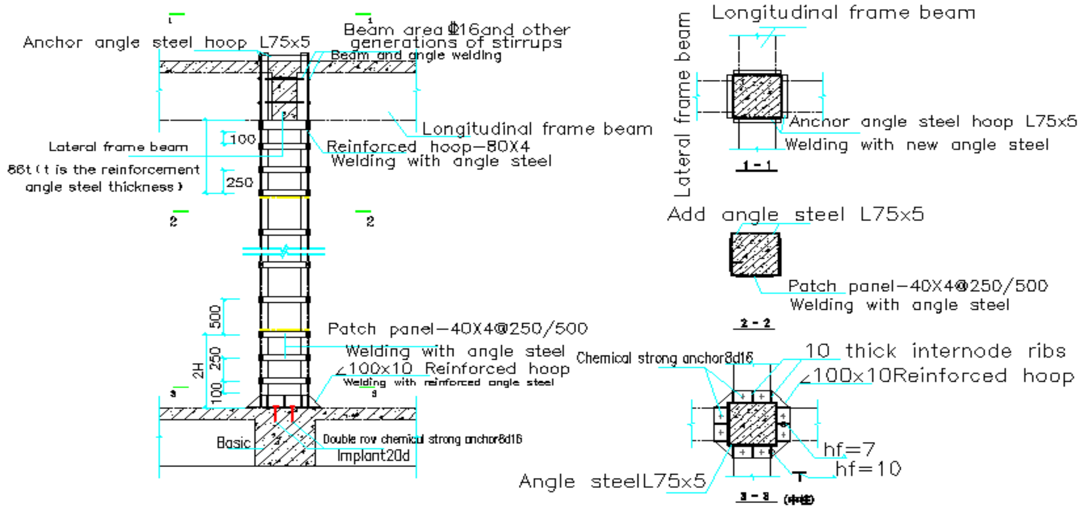
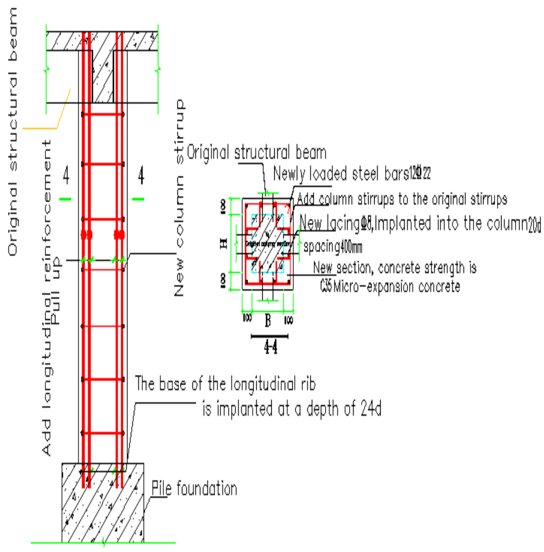


Figure 8. Bonded steel reinforcement column practice



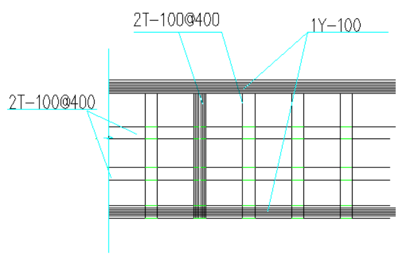
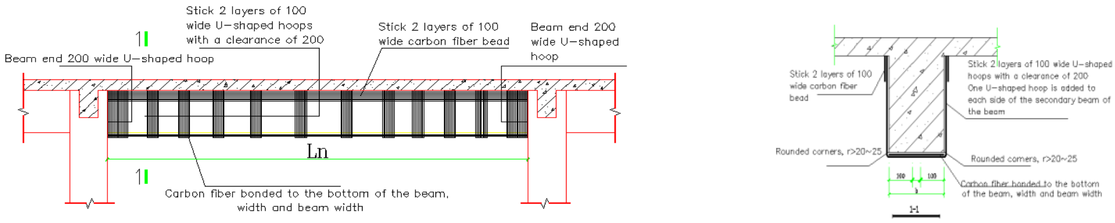


Figure 9. Increase section reinforcement

Figure 10. Carbon fiber cloth reinforcement Hear wall practice



(a) (b)

Figure 11. Paste fiber cloth

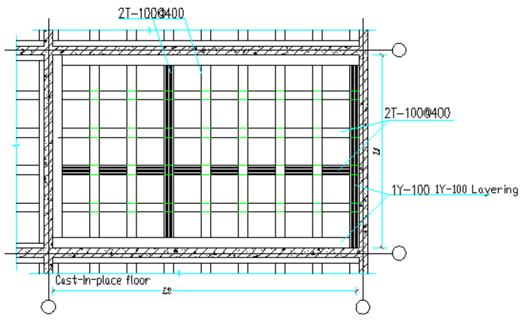


Figure 12. Bottom plate carbon fiber layout method

4. Structural reinforcement check

4.1. Anti-floating design water level calculation

According to the geological survey report, the anti-floating level is H=1469.4m, and The basement floor bottom level of the two-layer part of 1-32 is 1465.1m (the lane is also considered to be within this part), and the head height is 4.3m. The 32-42 axis basement floor has a bottom elevation of 1467.6m and a head height of 1.8m.

Upper load statistics:

(1)1-32 two-layer part

This load calculation is calculated by taking the 8.1×8.1 plate as an example.

Covering soil: $18 \times 0.7 = 12.6\ kN/m^2$.

Reinforced concrete slab weight: $0.71 \times 25 = 17.75\ kN/m^2$.

The thickness of the bottom plate is 350mm, the thickness of the negative two-layer top plate is 200, and the thickness of the negative one is 160mm.

Concrete plain screed, 7~15cm on site, calculated according to 5cm: $0.05 \times 20 = 1\ kN/m^2$.

Beam and column calculation:

$$(0.3 \times (0.6-0.2) \times 4 \times 2 + 0.4 \times (0.9-0.2) \times 2 \times 2 + 0.6 \times 0.6 \times 2 \times 8.1) \times 25/(8.1 \times 8.1) = 3.0\ kN/m^2.$$

Dead load calculation (favorable load): $12.6+17.75+1+3.0=34.35\ kN/m^2$.

So $34.35\ kN/m^2 < 43.0 \times 1.05 = 45.15\ kN/m^2$

The area's anti-floating does not meet the requirements.

(2)32-42of One layer part

This load calculation is calculated by taking the 8.1×8.1 plate as an example.

Covering soil: $18 \times 0.7 = 12.6\ kN/m^2$.

Reinforced concrete slab weight: $0.05\times20=1$ kN/m^2

The thickness of the bottom plate is 350mm, and the thickness of the negative layer is 160mm.

Concrete plain screed, 7~15cm on site, calculated according to 5cm: $0.05\times20=1$ kN/m^2

Beam and column calculation:

$(0.3\times(0.6-0.2)\times4+0.4\times(0.9-0.2)\times2+0.6\times0.6\times2\times4.0)\times25/(8.1\times8.1)=1.5$ kN/m^2.

Dead load calculation (favorable load): $12.6+12.75+1+1.5=27.85$ kN/m^2.

So 27.85 kN/m^2 $>18\times1.05=18.9$kN/m^2

The area is resistant to floats.

4.2. Anti-floating anchor calculation

(1) Buoyancy calculation of anchor

The original structure has a dead weight of 34.35 kN/m^2.The head height of groundwater buoyancy of 4.3m is $4.3\times10=43$ kN/m^2.

(The anti-buoyancy (kN) of the anchor rod) =1.05×(the groundwater buoyancy-the original structure is dead load)=10.8kN/m^2.

(2)Calculation of tensile bearing capacity of single anchor

Using a bolt with a diameter of 200mm, the circumference of the bolt is Ur(m)=0.628m.The effective anchorage length hr(m)=2.6 m in the anchorage section embedded in the rock stratum.Empirical coefficient ξ = 0.8.The bond strength characteristic value of cement mortar and concrete to rock is f(MPa)=0.4 (less than the value of the geological survey report).

Anchor rod pullout bearing characteristic value Rt(kN)=Ur hrξf X1000= 522.496 kN

Required bolt root n=the anti-buoyancy/anchor pull-out bearing capacity characteristic value of the anchor= 10.8 × 8.1 × 8.1 / 522.496 = 1.36.

The actual 8.1×8.1 unit takes 2 anchors (pile base parts), and the 1-11 axis independent base part spans 4 anchors.

The bearing capacity of the overall anti-floating single anchor is: 10.8×8.1×8.1/2=354.294 kN.

Review the anti-buoyancy of a single anchor: the head area of the anchorage of the 8.1m×8.1m plate is 8.1×8.1-2×2.7×2.7=51.03m^2, and the standard of anti-floating force of each anchor is: (43-0.35×0.25-0.05×20)×51.03/4=424 kN.Then the actual bearing capacity of each anchor is 424 kN.

(3)Calculation of cross-sectional area of anchor bar

Anchor rod body tensile safety factor K b=1.8.Anchorage tensile strength design value fy=360 N/mm^2.

The total area of the anchor steel bar section:

$$As\geq K\ b\times NaK/\ fy(mm^2)=1000\times1.8\times424/360=2120\ mm^2$$

Actual matching steel area As (332) = 2413mm^2.

(4)Calculation of the anchor length of the anchor anchor and the formation

Anchor diameter D = 200 mm.Standard value of ultimate bond strength of rock and soil layer and anchor frb (kPa) = 1800kPa.Bolt anchor solid pullout safety factor K=2.2.

Bolt anchor and length of anchorage section of the formation

$$La1\geq K\ Nak/(\pi Dfrb)=2.2\times397.3/(3.14\times0.2\times1800)=0.77m.$$

Calculation of anchorage length between anchor rod body and anchor mortar

Anchor bar diameter d=32mm.Anchor rod number n=3 (root).Design value of bond strength between steel bar and anchor mortar fb=2.1 (KPa).

Anchorage length between anchor rod body and anchoring mortar

$$La2 \geq K\ Nak/(n\pi d\ fb) = 2.2\times424/(0.032\times3.14\times3\times2.4\times1000) = 1.28m.$$

The bolt insertion length is 3.5m.

4.3. Base plate punching calculation

Under the action of concentrated reaction, the punching capacity of the plate without the stirrups or the bent steel bars shall comply with the following provisions:

$$F\ L \leq (0.7\beta hft + 0.25\ бpc,\ m)\ \eta umh0$$

Section height influence coefficient βh=1.0.The weighted average of the effective preloading stress of the critical section concrete by length бpc, m=1.0N/mm^2.Concrete axial tensile strength design value ft=1.43N/mm^2.Section effective height h0=300-50=250(mm).

Critical section perimeter um=3.14×2 (100+250/2)=1413mm.

η=min{η1,η2}

η1=0.4+1.2/βs βs=2

η1=0.4+1.2/βs=0.4+1.2/2=1.0

η2=0.5+αsh0/4um αs=40

η2=0.5+αsh0/4um = 0.5+40×250/(4×1413)=2.269

η=min{η1,η2}=1.0

(0.7βhft+0.25бpc， m)ηumh0
=(0.7×1.0×1.43+0.25×1.0) ×1.0×1413×250
=441.916kN

Concentrated reaction force design value = actual single anchor bolt tensile capacity = 397.3 <441.916KN.Therefore, the punching resistance meets the requirements, and it is not necessary to configure the stirrups or bend the reinforcing bars.

4.4. Floor bearing capacity calculation

Take the 8.1m×8.1m meter span for calculation. After the anti-floating anchor is added to the bottom plate, the plate span is calculated according to 4.05m, and the one-meter wide strip is taken for calculation.

The height of the water head is 4.3m, the weight of the plate is 0.350×25×1=8.75 kN/m, and the water buoyancy is 43×1=43kN/m. The force of the plate is calculated according to the basic combination:

$$1.4\times43-8.75=51.45$$

The maximum shear force of a 1 meter wide strip is: ql/2=51.45×4.05/2=104.2 kN.

The maximum bending moment of a 1 m wide strip is: ql2/12=51.45×4.052/12=70.32 kN·m.

The 1 m wide strip is subjected to the maximum bending capacity (calculated by the ⌀14@200 board with smaller reinforcement):

$$M \leq f_y A_s (h_0 - a_s') = 77.6kN \cdot m$$

The shear capacity is: $a_{cv} f_t b h_0 = 315kN$

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It can be seen from the calculation that the shear bearing capacity of the plate is satisfactory.

5. Conclusion and Prospect

the Negative second floor of the original structure is reinforced with add the anti-floating anchors, apply pressure grouting for cracks in the plate, Paste carbon fiber cloth for the bottom of the plate and the damaged shear wall, externally-paste profile steel for the damaged column, and paste Carbon fiber sheet attached to damaged beam.After calculation, the following conclusions are drawn:

(1)1-32 two-layer partial area anti-floating does not meet the requirements, 32-42 layer area anti-floating meets the requirements.

(2)The actual bearing capacity of each anchor is 424 kN, and the bolt insertion length is 3.5 m.

(3)The punching of the bottom plate meets the requirements, and it is not necessary to configure the stirrups or bend the steel bars.

(4)The shear bearing capacity of the plate is satisfactory.

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