

# Analysis and discussion on several problems when testing the thickness of reinforcement cover of concrete component

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**Abstract.** Reinforcement cover of concrete component plays a very important role to ensure the durability of various types of structures and the effective anchorage between steel reinforcement and concrete. This paper discusses and analyzes the problems occurred when testing the thickness of reinforcement cover of concrete component, so as to provide reference and help for related work.

## 1. Introduction

The concrete component is composed of two kinds of materials, namely concrete and steel reinforcement. Both materials work together to make them have better bearing capacity. The use of steel reinforcement can make up for the shortcomings of the poor tensile strength of concrete, so that the concrete can be effectively wrapped with the concrete with good compression strength. Nowadays, the design values of reinforced concrete cover is designed and constructed according to the requirements of GB50010-2010 (2015 Edition) "design specification for concrete structures" and with the combination of design drawings. The acceptance or inspection work is mainly based on the requirements of GB 50204-2015 "acceptance specification for concrete structure engineering construction quality". In this paper, several problems encountered in the process of field test are analyzed and studied.

## 2. Common problems

In the actual project, the upper negative bending moment of concrete component often sinks due to the trampling of workers during the construction. The insufficient lower positive bending moment and other construction defects make the great shift or deviation of steel reinforcement. They are the reasons why the thickness of reinforcement cover fails to meet the design requirements in actual project. So how to analyze and deal with excessive deviation (smaller or larger)? What is the relationship between the deviation problem and the size deviation? How to select components and evaluate the qualification rate? What is the significance of using GB/T50784-2013 to test the performance of the cover? And ext. The common problems above are discussed and analyzed in this paper.

## 3. Analysis of the influence of the thickness of cover on the bearing capacity of the component



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*3.1. The size of the component and the section of the steel reinforcement is the fixed, and the cover has different conditions.*

The thickness of the cover is calculated according to bending bearing capacity of positive rectangular section in GB50010-2010 (2015 Edition) "design specification for concrete structures", namely  $M = \alpha_1 f_c b x (h_0 - x/2) - f_y A_s (h_0 - a_s)$ . The formula above shows that there is linear relationship between the bending bearing capacity of positive section and the effective height of the section  $H_0$ .  $h_0 =$  the height of the section - the thickness of the cover - the radius of the steel reinforcement. Therefore, when the height and the steel reinforcement are in certain condition, the smaller the cover is, the greater the bearing capacity of the section will be. But it is not the smaller the cover is, the better it will be. The bond and durability of the concrete to the steel reinforcement should be considered.

*3.2. Analysis of the influence of plate thickness and thickness of cover on bearing capacity.*

One project has the structure of 3 frames, the strength grade of concrete is C30, the steel reinforcement is HRB400, two-layer and two-direction is 10@200, and the plate thickness is 100mm. The allowable deviation of plate thickness is from -5mm to +10mm, and the allowable deviation of cover thickness is from -5mm to +8mm, (the design value of cover is 15). The size of outdoor air conditioning board of the project is 800mm (length) x 600mm (width) x 100mm (thickness). (see table 1)

**Table 1** Different thickness and protective layer of floor (not a cantilever plate) of normal section flexural bearing capacity calculation. unit: kN·m/m

Protective thickness /mm	7	10	15	20	23	28
<b>thickness 95</b>	8.9	8.5	7.8	7.1	6.6	5.9
<b>thickness 100</b>	9.6	9.2	8.5	7.8	7.3	6.6
<b>thickness 110</b>	11.0	10.6	9.9	9.2	8.7	8.0

Among them, the design value is as follows: the plate thickness is 100mm; the cover thickness is 15mm; and the flexural capacity is 8.5 kN, m/m. According to the table, when the plate thickness is 95mm and the cover thickness is 23mm, the bearing capacity is 6.6kN·m/m, which is 78% of the design value. Therefore, in actual project, it is necessary to test the thickness of the plate when the thickness of the thickness deviation of cover is large. Finally, according to the numerical value of the thickness of the plate and the thickness of the cover, we can comprehensively determine whether the bearing capacity of the plate meets the design requirements. It is necessary to adopt the necessary measures to reinforce the plate which can not meet the requirements of the design. Now the commonly used reinforcement methods for bending components are bonding carbon fiber, adhesive steel method and so on.

**4. Analysis of the influence of the thickness of cover on the bearing capacity of the component**

According to the table above, when the plate thickness is 95 and the cover thickness is 7mm, the bearing capacity is 8.9 kN m/m. It can meet the requirements of bearing capacity, but the cover thickness is less than the diameter of steel reinforcement, which does not meet the standard requirements. This situation requires durability treatment, such as the use of polymer mortar. If it is found that there are many plates of which the thickness is less than 10mm in the project, it is recommended to adopt universal inspection to record the unqualified points, and to deal with the unqualified parts for durability, so as to ensure the durability of the components.

In the test of the air conditioning board mentioned above (the design value of negative bending moment is 20), the measured data are as follows: 12, 15, 16, 18, 20, 22, 20. The value 12 is less than the negative deviation of the design value, which does not meet the requirements of the specification and needs durability treatment. Long term outdoor components should strictly follow the standard requirements. Once unqualified components are found, they need to be dealt with. The smaller deviations need to be treated for durability. The larger deviation should be checked and analyzed, and the components that do not meet the requirements of bearing capacity need to be properly estimated for treatment.

## 5. Discussion and Research on the method of evaluating the thickness of the reinforcement cover of a single component

### 5.1. Test method table of beam and board component

According to JGJT152-2008 "technical specification for reinforcement detection in concrete" and GB 50204-2015 "acceptance specification for construction quality of concrete structures", the following types of components, testing items and methods and matters needing attention are shown in Table 2.

**Table 2.** Test method of component cover

Component type	Type of stress steel reinforcement	Testing number	Testing items and methods, and matters needing attention	Deviation requirement (mm)
Non Cantilever plate	Negative bending moment steel reinforcement; Lower force steel reinforcement	2%, not less than five, otherwise it should be tested in full	Choose 6 negative bending moment steel reinforcement from one direction of the four directions and test 3 different points in each steel reinforcement. The same position shall be measured 2 times and be subject to the data measured at the second time. The lower force steel reinforcement is a double-layer reinforcement. Compare the lower steel reinforcement with the design value or compare the upper steel reinforcement with the design value and the diameter of the lower force steel reinforcement.	+8, -5
Cantilever plate	Negative bending moment steel reinforcement	5%, not less than 10, otherwise it should be tested in full	Test 6 steel reinforcement and test 3 different points in each steel reinforcement. The same position shall be measured 2 times and be subject to the data measured at the second time.	+8, -5
Non cantilever beam	Upper force steel reinforcement; lower force steel reinforcement	2%, not less than five, otherwise it should be tested in full	Due to the influence of floor reinforcement, it is not easy to test the upper steel reinforcement. It is recommended to test 6 steel reinforcement and test 3 different points in each steel reinforcement. The same position shall be measured 2 times and be subject to the data measured at the second time.	+10, -7
cantilever beam	Lower force steel reinforcement	10%, not less than 20, otherwise it should be tested in full	Test 6 steel reinforcement and test 3 different points in each steel reinforcement. The same position shall be measured 2 times and be subject to the data measured at the second time.	+10, -7

What should be noted for beam component is that the general design values are the design values of the most lateral reinforcement. The acceptance specification requires that the design value to test the actual steel reinforcement should be the design value of the most outer reinforcement cover and the diameter of the stirrup.

### 5.2 Evaluation table of qualified rate of beam and board component

According to JGJT152-2008 "technical specification for reinforcement detection in concrete" and GB 50204-2015 "acceptance specification for construction quality of concrete structures", the following

qualification rate for different types of components are shown in Table 3.

**Table 3** Evaluation table of qualified rate of beams and plates components

Component type	Qualification rate	Whether qualified
Plate (non cantilever plate + cantilever plate)	The qualification rate is not less than 90%, and the range of deviation is between -3.5mm and 15mm	Qualified
	Any component with a qualified rate less than 90% or a deviation of less than -3.5mm or more than 15mm	Unqualified
	The qualification rate is less than 90%, but not less than 80%, and the range of deviation is between -3.5mm and 15mm.	In the same number of tests, the plate of which the qualified rate of the two sampling is not less than 90% is qualified, otherwise it is not qualified
Beam(non cantilever beam + cantilever beam)	The qualification rate is not less than 90%, and the range of deviation is between -2.5mm and 12mm	Qualified
	Any component with a qualified rate less than 90% or a deviation of less than -2.5mm or more than 12mm	Unqualified
	The qualification rate is less than 90%, but not less than 80%, and the range of deviation is between -2.5mm and 12mm.	In the same number of tests, the beam of which the qualified rate of the two sampling is not less than 90% is qualified, otherwise it is not qualified

## 6. Comparison and analysis of testing and acceptance criteria for the performance of reinforcement cover

According to the clause 9.3.5 in GB/T 50784 " technical specification for on-site test of concrete structures", when testing the structure performance, some requirements should be met. In this paper, two kinds of evaluation methods are compared and analyzed according to a project example. The actual value of the thickness of the reinforcement cover is shown in Table 4.

**Table 4** The measured value of steel protection layer thickness

Component name and location	Protective thickness ( mm )		
	The measured values	Design value	Allowable deviation
1-2×E-F axis of the floorslab of the first-floor	16 17 16 14 13 14	15	+8, -5
5-6×K-M axis of the floorslab of the first floor	20 20 21 20 23 23	15	+8, -5
7-8×E-1/E axis of the floorslab of the first floor	26 26 29 29 29 28	15	+8, -5
7-8×H-1/H axis of the floorslab of the first floor	9 8 14 12 11 13	15	+8, -5
1-2×F-G axis of the floorslab of the first floor	20 17 18 16 20 19	15	+8, -5
7-8×F-G axis of the floorslab of the first floor	16 17 16 17 15 16	15	+8, -5
7-8×D-E axis of the floorslab of the first floor	20 18 20 21 21 23	15	+8, -5
4-5×K-M axis of the floorslab of the first floor	20 21 22 24 22 22	15	+8, -5

1-2×G-H axis of the floorslab of the second floor	23 22 23 22 21 23	15	+8, -5
2-3×C-E axis of the floorslab of the second floor	18 19 22 25 22 25	15	+8, -5
1-2×A axis of the cantilever plate of the first floor	27 30 27 27 33 34	25	+8, -5
2-3×A axis of the cantilever plate of the first floor	27 28 30 28 26 28	25	+8, -5
1-2×A axis of the cantilever plate of the second floor	32 28 33 33 30 32	25	+8, -5
2-3×A axis of the cantilever plate of the second floor	26 29 32 33 37 28	25	+8, -5
8-9×A axis of the cantilever plate of the second floor	34 33 27 31 33 25	25	+8, -5
2-3×G axis of the beam of the third floor	20 20 22 20	28	+10, -7
7-8×K axis of the beam of the second floor	27 30 31 28 27	28	+10, -7
1-2×E axis of the beam of the second floor	28 26 29 39	28	+10, -7
7-8×G axis of the beam of the first floor	25 22 24 30	28	+10, -7
1-2×E axis of the beam of the first floor	27 28 32 24 23	28	+10, -7
2-3×E axis of the beam of the first floor	33 34 36 35	28	+10, -7
2×E-1/E axis of the beam of the first floor	34 37 33 30 33	28	+10, -7
5-6×K axis of the beam of the second floor	31 30 32 32 31	28	+10, -7
1-2×G axis of the beam of the second floor	22 21 21 23	28	+10, -7
1-2×F axis of the beam of the second floor	32 30 31 32 28	28	+10, -7
5×K-2/H axis of the cantilever beam of the second floor	36 34 36 38 41	28	+10, -7
6×K-2/H axis of the cantilever beam of the second floor	39 39 41 37 37	28	+10, -7
7×M-N axis of the cantilever beam of the second floor	31 31 38	28	+10, -7
8-9×F axis of the cantilever beam of the second floor	29 20 24 26 24	28	+10, -7
8-9×E axis of the cantilever beam of the second floor	32 33 34	28	+10, -7
8-9×1/K axis of the cantilever beam of the second floor	37 34 31 34	28	+10, -7
8×A-B axis of the cantilever beam of the second floor	30 28 29 32	28	+10, -7
8-9×K axis of the cantilever beam of the second floor	29 27 28 28	28	+10, -7
8-9×M axis of the cantilever beam of the second floor	28 28 27 32	28	+10, -7
8-9×2/H axis of the cantilever beam of the second floor	30 32 33	28	+10, -7
8-9×N axis of the cantilever beam of the second floor	36 32 32	28	+10, -7

**Table5** Detection value of steel protection layer thickness

Inspection lot	The minimum value (mm)	The maximum (mm)	The mean (mm)	The standard deviation	Presumptive interval; lower limit value. (mm)	Presumptive value (performance test)	According to the evaluation form of qualified rate (i.e., according to GB 50204-2015)
Cantilevered plate	8	29	19.6	4.7	20.6;18.6	29 (unqualified)	83.2% , Thickness deviation is not satisfied, unqualified
Non-cantilevered plate	25	37	30.0	3.0	30.9;29.1	30.9 (qualified)	91.0% , Thickness deviation is not satisfied, unqualified
Non-cantilevered beam	20	39	28.5	5.0	29.8;27.2	29.8 (qualified)	91.0% , Thickness deviation is not satisfied, unqualified
Cantilevered beams	20	41	32.0	4.8	33.2;30.8	33.2 (unqualified)	91.0% , Thickness deviation is not satisfied, unqualified

Notes: the presumed value of performance test is measured according to the "technical standard for on-site test of concrete structures". When the difference between the upper and lower limit values and 10% of the average value are estimated, the test value of the concrete cover thickness of the is determined.

From table 5 we can see that presumed value of the thickness performance of the reinforced concrete cover is not necessarily related with the measurement and evaluation based on GB 50204-2015. The performance testing is the overall evaluation of the project of all components, which emphasizes the numerical average of four types of components. It has poor component, and it may be presumed to be able to meet the design requirements. The test according to GB 50204-2015 is mainly to check whether there is poor component and the qualified rate, and both of them need to meet the requirements. It is a strict basis to appraise a project. This paper suggests that the project should not only meets the qualification , but also consider the presumed value of tested performance of four kinds of component, so as to reflect the overall performance of cover thickness in the project.

## 7. Conclusion

The thickness of reinforcement cover can not be ignored as an index of acceptance. It is related to the bearing capacity and durability of the components and structure, so that engineers and technicians can not neglect this index, otherwise it may cause unnecessary troubles in the future. This paper makes an analysis on the problems when testing the thickness of reinforcement cover. Through the example of project, it analyzes the influence of the thickness of the cover on the bearing capacity and durability of the component, and proposes that the floor detection, calculation and analysis should be carried out for the component with large deviation in the cover. It puts forward the table of the test method of component cover and the evaluation table of the qualified rate of the beam and plate component. It proposed that the evaluation project should not only consider the qualified rate, but also refer to structure performance so as to test whether the presumed value meets the design requirements.

## References

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