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# Research and Application of Rebar Lofting Technique in Construction Engineering

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**Abstract.** Rebar turning sample refers to the construction technicians according to the drawings to calculate the quantity of the detailed processing list and draw the rebar processing sample sketch, turning sample in the past or today is a cumbersome, difficult technical mental labor. The calculation process is complex and cumbersome, requiring rich construction experience, accuracy, rationality and optimization, understanding norms, understanding atlas, understanding drawings, and difficult higher technical occupations. In the practical application process, it is divided into two categories, one is the budget sample, which refers to the steel bar sample of the drawing in the design and budget stage to calculate the content of steel bars in the drawing, for the steel bar cost budget, bidding work, steel bar settlement, etc. The function of rebar flipping mainly includes ensuring the strength and stability of the structure, improving the construction efficiency and construction quality, and avoiding the quality problems of rebar flipping, analyzing the basis of rebar flipping and the thinking of rebar flipping, combining with the examples of rebar flipping, analyzing the rebar flipping technology, optimizing the rebar flipping results, and carrying out the ingredients of the flipping results. This paper describes the application of rebar turning technique in the control of rebar loss rate and construction organization [6].

**Keywords:** Rebar lofting, collocation, rebar loss rate

## 1. Introduction

Steel bar engineering is the core part of construction engineering, which has a decisive influence on the safety performance and cost control of the whole building. Steel bar is one of the most important and major main materials in construction engineering. The proportion of steel bar engineering in civil construction cost of frame structure is about 31% [1], and that of shear wall and frame-shear structure is about 32% [1]. Rebar sampling involves many links such as structural design, construction drawing interpretation, material optimization and site construction, which is a key work in the construction process. In the construction process, accurate rebar sampling is used to transform the actual size, shape and position of the rebar into a detailed rebar material table, providing a reliable basis for the procurement, processing and installation of the rebar project, avoiding rework and controlling the loss of the rebar [2], which is a key link to achieve project cost control and improve economic benefits.

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## 2. Basis of Rebar Reversion

The basis of rebar turning sample includes construction drawings, rebar atlas and other relevant materials.

### *2.1. Associative Thinking*

Each structural member is not independent, and the reinforcement skeleton between the members meets and anchors each other, which has a spatial hierarchical logical relationship. For example, the leg distance of the column inner hoop can not be considered solely according to the column section size, the thickness of the protective layer and the number of column longitudinal reinforcement, but the position and number of beam longitudinal reinforcement in the same direction should be considered, and the arrangement of column longitudinal reinforcement and beam longitudinal reinforcement in the inner hoop should be ensured by properly adjusting the leg distance of the column inner hoop. Generally, the number of longitudinal ribs at the bottom of the frame beam is more than the top longitudinal ribs, the longitudinal ribs at the top support are more than the longitudinal ribs in the span, and the distance between the hoop legs in the beam should be comprehensively considered to ensure the arrangement of the longitudinal ribs of the beam.

### *2.2. Integrity Thinking*

Every member and every steel bar on the building structure can not be omitted, and the specifications, shape, Angle, and size of each steel bar turned out by the steel bar should be expressed completely. For example, when the column insertion reinforcement in the foundation raft is turned over, it should include the column longitudinal reinforcement, the closed stirrup of the column inside the raft, the positioning stirrup of the column longitudinal reinforcement on the raft, and the transverse stirrup in the anchoring area when the column protective layer thickness is less than 5d, so as to form a material list to meet the construction organization needs of the column insertion processing and installation. Another example is the node sample or construction practice that is not reflected in the structural plan, but is clear in the general instructions of the structural design, as well as some indispensable measures such as horse stool reinforcement and cushion reinforcement, which is easy to miss in the process of steel reinforcement sample, affecting the construction organization on site and causing a delay in the construction period.

### *2.3. Compliance Thinking*

The result of rebar retesting should be consistent with the design and comply with the mandatory provisions of the current national and local standards. For example, the anchorage length of longitudinal steel bars, the type, range and connection section of the joint, the leg distance of the stirrup, the Angle of the bend hook and the length of the straight section should meet the design requirements, and should not be lower than the mandatory requirements of the code. At the same time, the joint position and anchoring mode of the steel bar should be fully considered, and under the premise of meeting the requirements of the design drawings and specifications, the connection or anchoring should be avoided in the parts that are not suitable for construction.

## 3. Examples of Rebar Returning

### *3.1. Raft Rebar Turning*

Take the slab raft (partial) as an example to carry out the rebar reversing sample, as shown in figure 1. The thickness of the rebar protective layer is 50mm, and the rebar is mechanically connected.

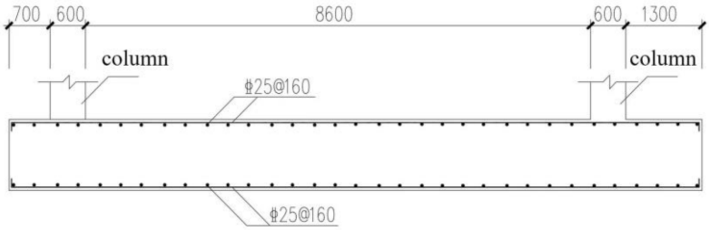


**Figure 1.** Raft section.

Taking the transverse reinforcement as an example, according to the detailed structural drawing of the 22G101-3 map, the connecting area of the through reinforcement at the bottom of the raft is within 1/3 clear span [3] (8600mm/3≈2866mm), and the connecting area of the through reinforcement at the top is within 1/4 clear span (8600mm/4≈2150mm) of the column and both sides. The bending hook at the end of the longitudinal bar is 12d=12×25mm=300mm, as shown in figure 2.

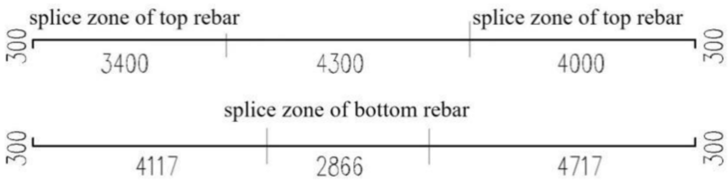


**Figure 2.** Steel bar schematic.

The length of the steel mechanical connection section is 35d=35×25mm=875mm. The horizontal section of the bottom through reinforcement = raft width - the thickness of the protective layer at both ends =700+600+8600+600+1300-50×2=11700 (mm), the length of the bottom reinforcement = horizontal section + (bending hook at the end -90° bending hook elongation value) ×2=11700+ (300-25×2) ×2=12200 (mm), Exceed the size of the original material (the length of the rebar raw material on the market is generally 9m and 12m), so the joint is needed, and the optimal length of the steel bar should be determined according to the size of the original steel bar on the site when the sample is turned over, and the size of the original steel bar should also be selected according to the actual situation of the project.

Generally, it is considered that the length of the left end steel bar and the right end steel bar are just connected in the connection area, and the distance between the two joints after adjustment is not less than the length of the connection section of the mechanical connection (that is, 35d). The rebar sample is as follows (unindicated unit: mm):

(1) Gluten: the total length of the steel bar is 12200, and the connection area is at the support, so the turning sample is 12000 +200.

(2) Bottom rib: the total length of the steel bar is 12200, and the connection area is in the span, 4367=300+4117-25×2≤ the length of the steel bar at the left end is 300+4117+2866-25×2=7233, which is 4400≤ the length of the steel bar at the left end is 7200; 5067=300+4717-25×2≤ Steel bar length at the right end ≤300+4717+2866-25×2=7833, which is rounded to 5100≤ steel bar length at the right end ≤7800. Obviously, can not simply according to the left and right end of the steel bar to turn the sample, otherwise the selection of 9m or 12m raw material, will cause a large number of material head. For example, steel bar =4.4m in the left end, 2 pieces of 9m raw material are broken, and 200 pieces of leftover material can be used for gluten, then steel bar =7.8m in the right side, 1 piece of 9m raw material is broken, and 1.2m of leftover material is caused by waste, but steel bar on the left side and steel bar on the right side are one-to-one corresponding, that is, steel bar on the left side is broken by 9m raw material, 4.4m and 7.6m of leftover material. The more the number of ribs, the more excess material, the greater the risk of waste. Therefore, it is necessary to use the batching-type sample method to resolve the remaining materials, such as the first bottom tendon =4400+7800, the second bottom tendon =7600+4600, the third bottom tendon =7400+4800, the bottom four bottom tendents =5000+7200... It can be seen that 4400+7600=4600+7400=4800+7200=12000, using this four cycles, each four bottom bars need 5 12m raw materials, the remaining material 1 4.2m and 1 7m, relative to the previous method to avoid a large amount of residual material (waste), and can continue to turn the sample size in a certain range. Make the steel bar more optimized.

### *3.2. Rebar Sample of Frame Column*

The frame column is taken as an example to carry out the rebar inversion sample, and the information of the frame column is shown in table 1.

**Table 1.** Column reinforcement table.

| Column number | Elevation (m) | b×h(mm×mm) | Full longitudinal bar | stirrup | Storey height(m) | Remark |
|---|---|---|---|---|---|---|
| KZ1 | -5.500~-0.800 | 600×600 | 24C25 | C12@100/200 | 4.700 | Assume that the structure is grade 3 seismic, raft concrete C35, thickness 1000mm, double-layer bidirectional C25@200, protective layer 50mm, embedment position -0.800m. -0.8m~ 12.00m layer beam height should be considered by 800mm, 12.00~72.00m layer beam height should be considered by 600mm |
| | -0.800~4.000 | 600×600 | 24C25 | C12@100/200 | 4.800 | |
| | 4.000~12.000 | 600×600 | 24C25 | C10@100/200 | 4.000 | |
| | 12.00~36.000 | 600×600 | 24C22 | C10@100/200 | 3.000 | |
| | 36.00~72.000 | 600×600 | 24C20 | C10@100/200 | 3.000 | |

According to the information in the column reinforcement table, calculated according to the 22G101 map, the anchorage length of the column longitudinal reinforcement =34d=34×25=850mm, which is less than the thickness of the raft, then the length of the curved hook at the bottom of the column longitudinal reinforcement should be 150mm, and the length in the raft = raft thickness - protective layer thickness - two-way bottom reinforcement diameter of the raft =1000-50-25×2=900mm. The longitudinal column bars are mechanically connected, and the length of the connection section is 35d. The length of the connection section of the steel bar with a diameter of 25mm is 875mm, and the length of the connection section of the steel bar with a diameter of 22mm is 770mm. If the embedded part is -0.800, then the non-connected area at the lower part of the -0.800~4.000 floor ≥max (floor column net height /3, column section long side size, 500) =max (1334, 600, 500) =1334mm, the upper non-connected area ≥max (floor column net height /6, column section long side size, 500) =max (667,600,500) =667mm. All other floors are calculated according to max (floor column height /6, column section long side size, 500). The connecting area and non-connecting area of column longitudinal bars are shown in figure 3 (-5.500~15.000).

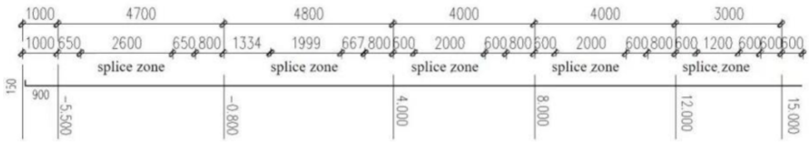


**Figure 3.** Connecting area and non-connecting area of column longitudinal bar.

Generally, consider the column longitudinal reinforcement beyond the floor level to the connection area, and stagger not less than the length of the connection section (i.e. 35d) according to 50% of the joint percentage. The rebar sample is as follows (unit: mm):

(1) The matching of the whole floor and the steel material is not fully considered. The sample is shown in figure 4. The length of the column longitudinal reinforcement on the raft 12C25 is 150+1600-2×25=1700, the length of the other 12C25 reinforcement is 150+2500-2×25=2600, and the reinforcement on the negative first floor is 5300. The first layer of reinforcement is 4100long, the second and third layers of reinforcement is 4000long, and the fourth layer of reinforcement is 3000 long. The above floors can be bonded to the top floor according to this length (except the top vertical reinforcement capping is also considered). From the basement to the 1st floor column reinforcement ingredients: 1.7+5.3+4.1=11.1m, with 12m raw material to cut the remaining material is 0.9m (other parts are difficult to consume), the 2nd and 3rd floor reinforcement 4m long can be broken 3 pieces of 12m raw material, that is, from the basement to the 3rd floor column longitudinal reinforcement 24C25 requires 40 pieces of 12m raw material, the remaining material 24 pieces of 0.9m. Other floors (except roof capping) are 3m, 12m of raw material can be broken into 4, no spare material. As shown in figure 4.

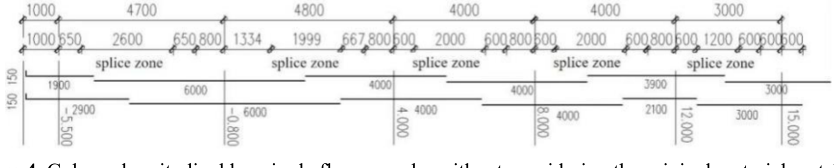


**Figure 4.** Column longitudinal bar single floor sample, without considering the original material matching.

### 3.3. Rebar Sample of Frame Beam

Frame beams are taken as an example to carry out the rebar inversion sample. The information of frame beams is shown in figure 5, and the thickness of the protective layer of beams and columns is 25mm.

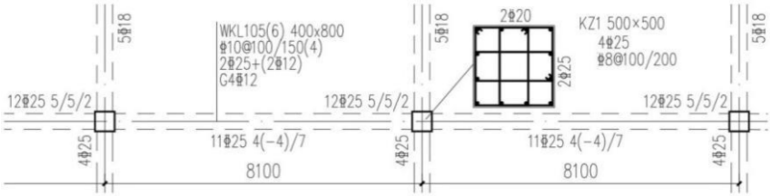


**Figure 5.** Frame beam (partial).

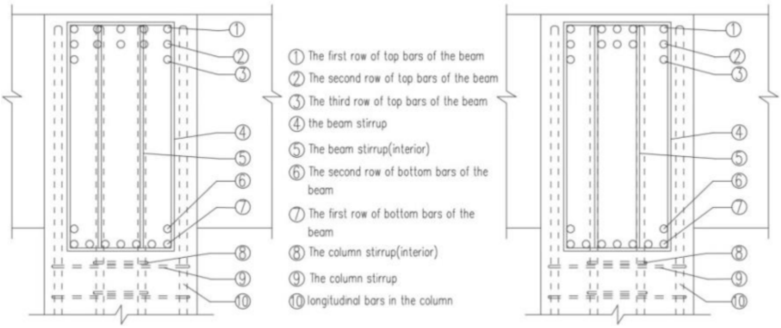


**Figure 6.** Steel reinforcement relationship of beam-column joints (excluding waist tendon and tension tendon)

(1) Stirrup turning sample: As can be seen from figure 6, the column longitudinal reinforcement is evenly divided according to the cross-section size, and the distance between the inner stirrup limbs is (500-25×2-8×2-25) /3+8+25+8×2≈177=180 (rounded), but the column longitudinal reinforcement is in collision with the beam longitudinal reinforcement, while the column longitudinal reinforcement gap is (500-25×2-8×2-25) /3-25≈111. The gap between the longitudinal ribs at the bottom of the beam = (400-25×2-10×2-25) /6-25≈25.8, so it is more reasonable to adjust the longitudinal ribs of the column to avoid the longitudinal ribs of the beam. In order to quickly and accurately arrange the column, CAD can be adopted, and the optimal limb distance of the column inner band is 200. Similarly, the internal hoop distance of the beam calculated according to the beam gluten =[(400-25×2-10×2-25) /4]×2+10×2+25≈198=200 (rounded), while the internal hoop distance of the beam calculated according to the beam bottom reinforcement =[(400-25×2-10×2-25) /6]×2+10×2+25≈147=150 (rounded), The difference between the two is 50, and the bottom bar interval is only 25.8. If the adjustment of the interval will cause the longitudinal bar collision and parallel, it is difficult to ensure the grip between the steel bar and the concrete, so the position of the second and fourth columns of gluten should be adjusted, and the inner hoop leg distance should be lofted according to 150.

(2) Longitudinal reinforcement sample: the 22G101 diagram requires that "the connection position of the upper part of the frame beam should be located in the middle of the net span /3, and the connection position of the lower part of the beam should be located in the range of the net span /3 of the support", which is a non-strong bar (it is

clear in the 17G101-11 diagram that "the core area of the frame column node should not adopt any form of joint [3]", which is a strong bar). JGJ107-2016 "Technical Regulations for Steel Mechanical connection" states that "I and II joints are high-quality joints, and the use of parts in the structure is not restricted, but the allowable percentage of joint area is different [4]". Therefore, the longitudinal reinforcement of the upper part of the beam can be turned over according to the previous turning method of "raft" and "frame column", and the connection joint is preferentially placed in the net span /3 range of the span, followed by the joint set in the support encryption area, try to avoid the joint in the encryption area, avoid the joint in the core area of the beam and column, select the optimal reinforcement type turning sample, make full use of raw materials, reduce residual materials and avoid waste. In the lower part of the beam, the joint is preferentially arranged in the unencrypted area of the net span /3 of the support, followed by the encrypted area, avoiding the joint in the core area of the beam and column. Through the comprehensive application of a variety of atlas and norms, combined with the needs of site construction, the standardization and rationality of rebar turning sample are improved [8].

## 4. Peroration

To sum up, reinforcement sample turning should not be carried out manually according to the standard structure of design drawings and atlas [4], limiting the result of sample turning to meet the requirements of design and specifications. Instead, it should be carried out with comprehensive consideration of design drawings, atlas, specifications, steel raw materials, construction schemes, construction organizations and other multi-dimensional considerations, and make full use of reinforcement thinking technology to control the loss rate of steel bars from the source. Reduce the residual material, avoid waste, convenient construction. At the same time, the fine-grained management of steel bar engineering on the construction site [5] is implemented to translate the accurate sample turning results into the engineering construction, guide the whole process management of procurement, batching, processing, semi-finished products and installation, and improve the comprehensive benefits of steel bar sample turning [7].

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