The Feasibility Study of Mechanical Splices and Headed Deformed Bars in the Electric Tower Foundation – A Case Study of Simply-Supported Beam

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Background

Due to transmission towers being located in mountain areas and according to the code of practice for design, the length of rebar of the tower is more than 10 meters in order to meet the needs of the length of the rebar. Nowadays, in order to effectively improve the inconvenience of transportation caused by the excessive length of the rebar, the feasibility of applying a mechanical coupler to replace the traditional lap spliced method in the electric tower foundation will be discussed in this study. In addition, in order to have expected strength in the anchoring method of the end of the rebar, standard hook is used to anchor the end of rebar indomestic. However, in practice, it is often difficult to construct the rebar and it may form honeycomb and even cause many other problems. In order to improve this problem, the new anchoring method of T-headed rebar has gradually developed. In this study, SD420W high-strength rebar will be used in combination with the mechanical coupler and T-headed rebar. A scaled-down experiment on the electric tower foundation will be used and compared with the structural behavior under different shear spans. In this study, a group used lap splice and standard hook, and another group used the mechanical coupler and T-headed rebar. According to different test conditions, the failure and mechanical behavior of the specimen are discussed. The results can provide the feasibility and applicability of the rebar mechanical coupler and T-headed rebar in electrical towers.

Figure 1 headed rebar

Research results

The Chinese Institute of Civil & Hydraulic Engineering referred to Specification ACI 318-19, construction experience, and expert's suggestions and formulated Concrete Structural Design Specification 401-110.

This specification already considers rebar spacing and end plate size. This study adopts 2 pieces and 3 pieces coupler as shown in figure 2.

According to ACI 318-19, the bond strength of Type 1 splices (Class B) must reach at least 125% of the rebar nominal yield strength (1.25fy), and Type 2 splices (Class SA) must reach at least 125%. In addition, it must also reach the specified value of ultimate tensile strength fu, and limit the sliding amount of the coupling, elongation, ductility, etc. Civil Engineering 401-110 defines that the SA grade must also meet the uniaxial tensile and sliding test. Regulations related to high plastic repeated load tests.

(a) 2 pieces

(b) 3 pieces

Figure 2 Mechanical Coupler

This study adopts the previous specification,refers to a four-pile foundation structure (figure 3), and then designs 1/3 scaled-down specimens. Figure 4 shows the cross-sectional configuration of the specimen. The compressive strength of the concrete is constant weight concrete of 21 MPa, the strength of the primary reinforcement of the specimen is SD420W, and 6 pieces of D19 rebars are used on the tension side and the pressure side, configured in a double-layer manner, and their rebar ratio is about 0.7%. The stirrup of the test body is made of D13 rebars of SD280W, and a group is arranged every 10 cm.

Figure 3 four-pile foundation structure

Figure 4 cross-sectional configuration

According to form and internal configuration, the specimen numbers are named SS2-SH-

LS, SS2-T-C60; SS4-SH-LS, SS4-T-C60, SS6-SH-LS; SS6-T-C60, as shown in figure 5. The first parameter represents the form of simple support beam and the number represents the shear span a; the second parameter represents the hook configuration of the rebar at both ends of the beam: the traditional standard hook is named SH, and the T-headed rebar is named T. The bearing area and thickness are in accordance with relevant specifications. The last parameter represents the configuration of the primary reinforcement of the specimen. The standard lap splicing is named LS, and its length is 120 cm. The rebar coupler used in this research is SA grade. However, this study considers the practical constructability and avoids the splicing position on the same section, so the mechanical coupler is 60 cm which named C60.

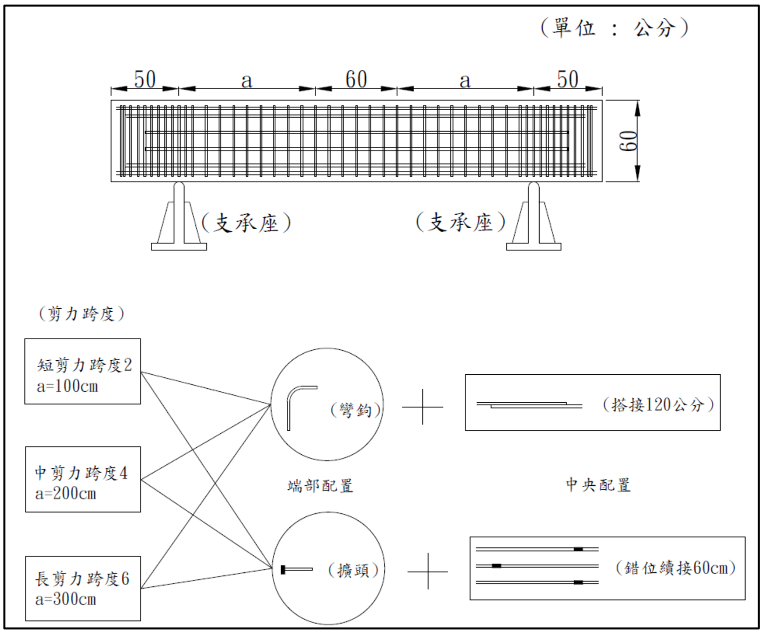

Figure 5 Design of simply supported beam specimen

This study investigates the experimental performance and compares the analytical results for SA grade mechanical coupler and T-headed rebar in the electrical towers. A total of six scaled-down simply-supported beam specimens are designed according to the actual four-pile foundation structure and complied with the latest ACI 318-19 and Concrete Structural Design Specification 401-110. The section of the supported beam is 40 by 60 cm, the shear span is 2, 4, and 6, and the corresponding total length is 360, 560, 760 cm, respectively. The nominal compressive strength of concrete is 210 kg/cm2, and the nominal yield strength of primary reinforcement and stirrup are 4200 and 2800 kg/cm2, respectively. The test variables include: the rebar at the center of the beam is lap spliced or using a mechanical coupler, and the rebar at both ends of the beam is a standard hook or T-headed rebar. Four-point flexural test results in the failure mode of the beams subjected to unidirectional loading. The vertical force and the vertical displacement at the center of the beam are recorded.

Summary

In this study, a total of 6 groups of simply supported beam experiments are completed, and it is confirmed that the feasibility of the center of the beam is equipped with SA-grade mechanical coupler and T-headed rebar in the tower foundations under the conditions of shear spans 2, 4, and 6. According to the 401-110, the group used the design of mechanical coupler in the beam and T-headed rebar which does not change the mechanical behavior of failure of the simply supported beam.

All of the results can meet the design requirements. The measured strength is more Than 30% higher than the nominal strength and the deformation ability was also improved. In another group, the center of the beam is lap spliced and both ends of the beam are the standard hook. Since the amount of rebars in the lap splicing is two times larger than the designed rebar. In these two groups, there was no obvious cracking at the beam end.

Overall, this study completed the experimental and analytical verification of large simply supported beams, and provided more options for the use of SA-grade friction-welded rebar couplers and steel sheet-welded expanded-head rebars in the tower infrastructure. We hope that the on-site constructability will be improved in compliance with the design specifications and standards.