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Improvement of Mechanical Rebar Splices for N.P.P. Construction

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1. Introduction

All mechanical rebar splices used in domestic nuclear power plant construction sites have been made by foreign manufacturer. Among them, ERICO's Cadweld(sleeve with ferrous filler metal splices type) has been most commonly used in preceding nuclear power plants owing to the wide field application, but as it is foreign-made product, there is a long lead time(approximately 4 months) to deliver to the designated construction site. Furthermore, it is costly to store surplus products. Despite these demerits, there wasn't good alternatives besides ERICO's Cadweld. But, Cold Roll Formed Parallel Threaded type has been developed recently and used in Shin-Wolsong #1, 2

2. The types of Mechanical Rebar Splices

Permitted types of mechanical splices for rebars in nuclear power plants follow ASME Section Ⅲ Division 2, CC-4331.2. Types of Mechanical Rebar Splice are as follows ; 1. Sleeve with ferrous filler metal splices, 2. Taper threaded splices, 3. Swaged splices, 4. Threaded splices in thread deformed reinforcing bars, 5. Sleeve with cementitious grout, 6. Cold Roll Formed Parallel Threaded Splices.

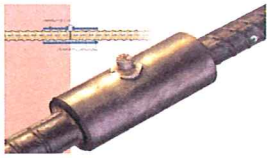

Fig. 1. Sleeve with ferrous filler metal splices

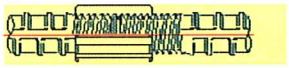

Fig. 2. Cold Roll Formed Parall Threaded Splices

Among above 6 mechanical splices, Cold roll formed parallel threaded type(BMS- Bar coupler) is the first product which had been developed by domestic company for localization and registered in ASME (2004).

3. Development of Mechanical Rebar Splices

3.1. Cold Roll Formed Parallel Threaded Splices

Cold Roll Formed Parallel Threaded type(BMS- Bar coupler) is a mechanical splicing method, which processes oval triangle screw as cold rolled mold at normal temperature without cutting-processing of rebar. The result of performance test of its spliced specimens and installation, inspection of Cold Roll Formed Parallel Threaded Splice is shown on paragraph 3.2 & 3.3.

3.2. Performance Test Result of Cold Roll Formed Parallel Thread Spliced Specimens

3.2.1. Test Requirement

Performance tests have been conducted to determine if splices meet the mechanical connection requirements of "Code for Concrete Reactor Vessels and Containment" (ASME SECTION Ⅲ Division 2, CC-4332.2)

a) Static Tensile Tests
- O Number of Performance Test
  - six splice specimens for each bar size and splice type
  - an unspliced specimen from the same bar for the spliced specimens
- O Average tensile strength of the splices
  - more than 90% of the actual tensile strength
  - more than 100% of the reinforcing bar being tested
- O Tensile strength of an individual splice system
  - more than 125% of the specified minimum yield strength of the specified bar.
- O For cold roll formed parallel threaded splices, one of the splice specimens shall be tested at 20°F (-7℃) or less.

b) Cyclic Tensile Tests
- O Number of Performance Test
  - Three splice specimens for each bar size and splice type
- O Each specimen shall withstand 100 cycles of stress variation from 5% to 90% of the specified minimum yield strength of the reinforcing bar (One cycle : an increase from the lower load to the higher load and return)

3.2.2. Performance Test Result

Tensile performance tests were conducted using ASTM A615 Grade 60 #8 ~ #18, #11+#14, #11+#18 rebars(total 80EA) which are required for nuclear power plant construction.

a) Static Tensile Tests

Spliced specimen's shape is shown in figure 3.

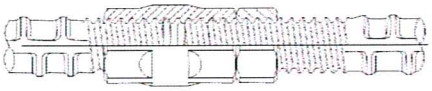

Fig. 3. BMS Bar coupler

The result of static tensile test for 6 specimens is shown rebar break shapes(table 1 and Figure 4) and also shown load-displacement curve(Figure 5). The results at 20°F(-7℃) are shown the same tensile result as in normal temperature and also the rebar break is as typical as tensile break in normal temperature.

Table 1. The result of static tensile test (#8~#18)

Requirement of Tensile Strength	Result (%)	Mode of Failure
- more than 90% of the average tensile strength	95~107	Bar Break
- more than 100% of the reinforcing bar being tested	107~116	Bar Break
- more than 125% of the specified minimum yield strength of the specified bar	145~166	Bar Break

Fig. 4. Shapes of #18 rebar's failure

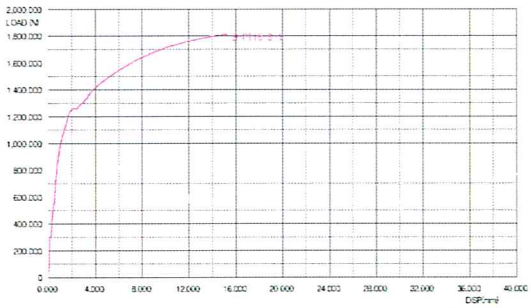

Fig. 5. Load – Displace. Curve(Static, #18)

b) Cyclic Tensile Tests

Each of the spliced specimens was given 100 cycles of tensile load varying from 5% of yield to 90 % of yield. The cyclic loading tests were performed well to the tensile strength point after 100 cycles of tensile test(as shown in figure 4 and figure 6).

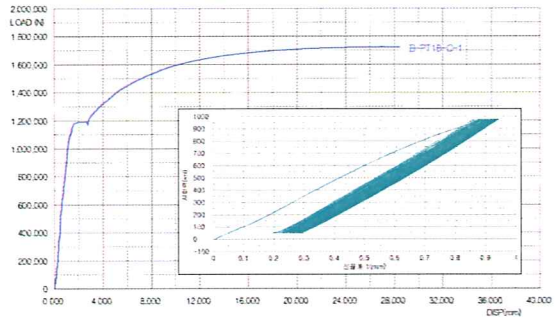

Fig. 6. Load – Displace. Curve(Cyclic, #18)

3.3 Field installation of BMS-Bar Coupler

Above performance test results of its spliced specimens show they fulfill the ASME code requirements. Therefore, Cold Roll Formed Parallel Threaded Splice can be used in N.P.P. Construction (SWN #1, 2)

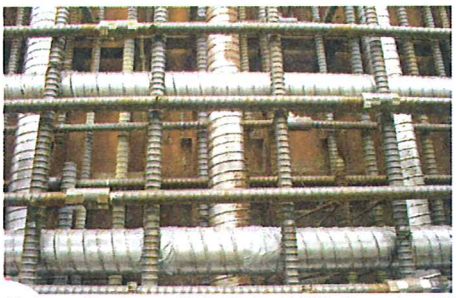

Fig.7. Installation of BMS in RCB Exterior Wall

3.4. Inspection for installation of BMS

We inspect processed products and connected couplers to check quality of construction by inspection tools.

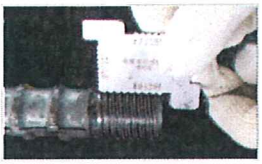

Fig.8. Product Inspection

Fig.9. Connection Inspection

4. Conclusion

Foreign-made mechanical splices can be replaced at the rate of 70% substitution by domestic products in the future, we can save ₩ 1.4 billion of construction costs in SWN #1,2. To enhance the nuclear power plant construction technology/method, it is necessary to develop the localization of BOP(Balance of Plant) material etc. Consequently, we expect that it will contribute to strengthen competitiveness of nuclear power plant construction through reduced construction cost and period.

REFERENCES

[1] The American Society of Mechanical Engineers, ASME Bioler and Pressure Vessel Code, Sec.Ⅲ Div.2, CC-4331.2. Permitted Types of Splices and Joints, 2004 Edition.
[2] Korea Electric Association, Korea Electric Power Industry Code, SNB 4331.2. Permitted Types of Splices and Joints, 2000 Edition.
[3] Korea Institute of Construction Material, Test Report of Mechanical Rebar Splice(BMS), April, 2007.
[4] Korea Hydro-Nuclear Power Co., LTD, Major Building and Related Structure, Construction Package Specification CP-A1, D.9 Mechanical Splices for Reinforcing Steel Bars.
[5] Boowon BMS Co., LTD, BMS-Bar Coupler Technical Manual, KEPIC TM-07N, 2007.
[6] Daewoo E&C, Work Procedure of Cold Roll Formed Parallel Threaded Splices, Feb, 2009.