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CAPACITY ANALYSIS OF SPUN PILE WELDING JOINTS ∅ 300 mm

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***Abstract*— Welded joints with the SMAW (Shielded Metal Arc Welding) welding connection type on spun pile ∅ 300 mm must be calculated to have the same capacity as the pile and must withstand blows during the driving process. The strength of steel sheath on the piles with a minimum yield stress of 210 MPa (BJ 34), the breaking stress of the welding wire electrode was 60 ksi, we calculated the value of the connection loaded with tensile forces on the plate with yield and fracture conditions was sought and the value of the connection that was loaded with tensile forces on the weld at base material and welding, the result showed that the weld joint capacity value was 237,504.40 kg (237.50 tons or 2,329.13 kN). It was compared with the maximum force bore by 1 pile was 1,082.84 kN and the force on the anchor block was 495.40 kN, the capacity of the welded joint is safe against them.**

***Keywords*— Suspension Bridges, Spun Pile; Welding Electrode Wire, SMWA Welding Joints, Welding Joint Capacity.**

I. INTRODUCTION

The suspension bridge of Gunung Labuh Air Pandan Village – Kapur City, Bangka District, Bangka Belitung Islands Province for the 2019 Fiscal Year was built with a flexible symmetrical type 2019. The length of this bridge is 96 meters, with the substructure using a spun pile foundation ∅ 300 mm with a depth of 12 meters on the side of Kapur City and 14 meters on the side of Gunung Labuh Air Pandan Village based on sonder data that was carried out at the time of planning. Suspension bridge construction site ± 5.00 KM from the sea estuary on the Menduk River which separates Kapur City from Gunung Labuh Air Pandan Village. Procurement of the piles is carried out with the formation of a pile length of 6 meters on the side of Kapur City and 7 meters on the side of Gunung Labuh Air Pandan Village. At the time of the erection on the side of Kota Kapur, there was a drift of the Nipah tree clumps in the river as high as ± 2.00 meters above the flood water level and result in crashing into the bridge floor, so the superstructure of the bridge had to be raised ± 1.50 meters so that the drift does not hit the floor of the bridge. This resulted in an increase in the number of piles in 1 point on all sides, and the connection of 2 piles in 1 point. Calculation of the weld strength of the pile connection must be taken into account to determine whether the connection of 2 piles at 1 point is still able to withstand the load of the building on the bridge.

II. LITERATURE REVIEW

A. Welding Type and Welding Material

According to Amstead (1997), the strength of the weld is influenced by arc voltage, current, welding speed, penetration, and electrical polarity. Determination of the amount of current in metal joints using arc welding affects the efficiency of the work and welding materials. In addition to polarity, the determining factors that become one of the parameters in welding are: A clean surface will produce a much stronger welded joint, and surface oxides must be removed because they can be trapped in the frozen metal, thereby allowing weld defects to occur which cause reduced strength in the weld metal.

Based on the module SSEB – 03 = structural analysis and design, training of steel structure engineer of buildings published by the Ministry of Public Works, construction and human resource development agency, center for competency development and construction training in 2007, the types of welded joints used in the connection of these piles using a blunt welded connection with the SMAW (Shielded Metal Arc Welding) type, where this welded connection is the simplest type of welded connection for structural steel. Proper use of welded joints for spun pile connections using blunt welded joints with stud welding as the electrode. The classification of the electrodes used uses the E60xx type, where E = electrode, 60 = tensile strength of 60 ksi and xx = electrode usage. The welding connection used in the construction of this suspension bridge uses a welding wire with an electrode type E6013. This electrode is the same type as E6012, the difference is only in the potassium content. E6013 welding electrode wire has a higher potassium content than E6012 type wire, so for welding with low amperage E6013 is easier to use. Electrode type E6013 can be used on welding machines with AC or DC current, with all welding positions. This type of welding electrode wire has an outer layer that contains a lot of potassium titania. The tensile strength of this wire is 60,000 psi. E6013 welding electrode wire has a higher potassium content than E6012 type wire, so for welding with low amperage E6013 is easier to use. Electrode type E6013 can be used in welding machines with AC or DC current, with all

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According to the circular letter of the Minister of Public Works number 10/SE/M/2010 concerning the Implementation of Guidelines for Connection of Precast Concrete Piles for Bridge Foundations, reinforcing steel for connection of precast concrete piles must have a minimum yield stress of 410 MPa (BJ 55), while the sheath of the pile connection shall be made of steel with a minimum yield stress of 210 MPa (BJ 34). This can be seen in table 1 below.

Table-1 Mechanical Properties of Structural Steel

Steel Type	**Minimum Breaking Stress, f_u (MPa)**	**Minimum Yield Stress, f_y (MPa)**	**Minimum Stretch (%)**
BJ 34	340	210	22
BJ 37	370	240	20
BJ 41	410	250	18
BJ 50	500	290	16
BJ 55	550	410	13

The use of welding materials adapts to the basic materials of the steel elements to be joined and has a low hydrogen membrane. The use of this welding material must be completely freshly opened from the packaging, not leftover welding material from previous use. E 60XX electrodes are used to weld carbon steels containing up to 0.3% carbon element (which includes structural steels such as profile steels, bar steels, and plate steels). The E70XX electrode has a wider range of applications than the E 60XX series.

B. Watermark Extraction

In spun pile piles, the steel sheath must have the mechanical properties of the structural steel in Table 1. This steel sheath is fabricated on the head and bottom of the pile with the same dimensions, has a groove wide enough so that the width and thickness of the weld can produce a joint capacity that is at least the same as the pile capacity, and must withstand blows during the driving process. The size of the circular steel sheath can be seen in table 2 below and Figure 1 shows the construction of the round pile connection by welding.

Table-2 Size of Round Steel Sheath

D (mm)	**T (mm)**	**H (mm)**	**a (mm)**
300	60	100	8
350	65	100	10
400	75	150	10
450	80	150	10
500	90	150	10
600	100	150	10

D is pile diameter (mm)
T is the thickness of the circular steel sheath (mm)
H is the height of the round steel sheath (mm)
a is the welding thickness (mm)

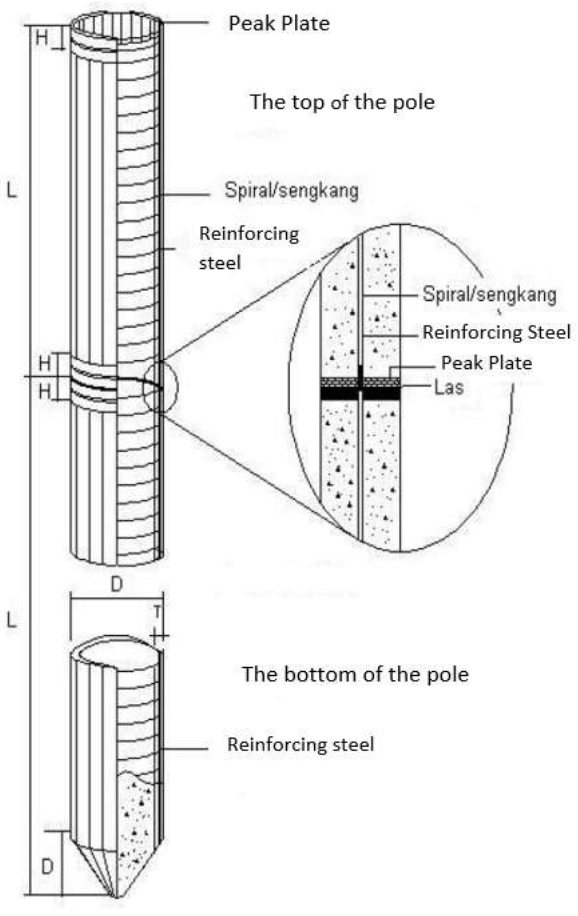

Fig. 1 Construction of Round Pile Connections with Welding

c. Suspension Bridge Design Criteria

The suspension bridge in Gunung Labuh Air Pandan Village – Kota Kapur has a length of 96 meters. The construction of this suspension bridge follows the design criteria following the

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Bridge Director's Letter number BM0502-Bt/105 dated May 31st, 2019 regarding Submission of Detailed Drawings and Design Criteria for the Symmetrical Pedestrian Suspension Bridge.

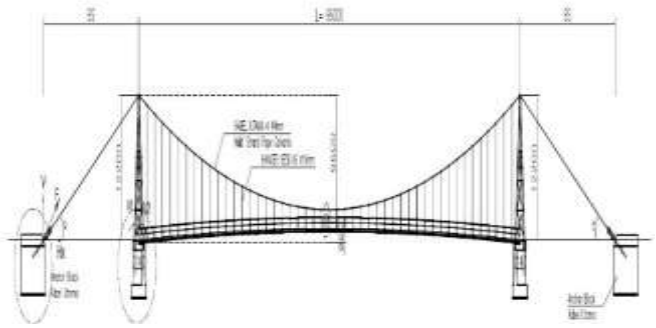

Fig. 2 Longitudinal Section of Suspension Bridge L = 96.00 Meters

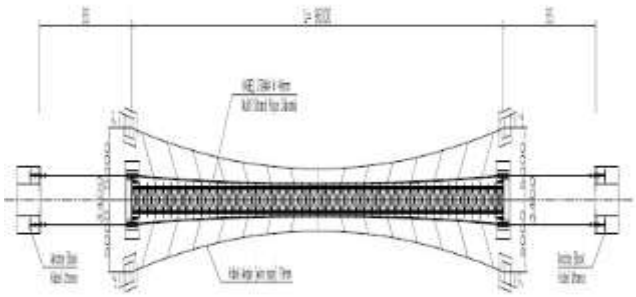

Fig. 3 Top View of Suspension Bridge L = 96.00 Meters

This criterion states that the anchor block has a cable tensile force (F) with a certain distance (α). The tensile force is used as a vertical force balanced by the structure's weight (dead load) and the horizontal force (shear) is balanced by passive resistance and shear force (concrete with soil) taking into account the groundwater level (mat). This can be seen in table 3, table 4, and table 5 below.

Table-3 Force on Block Anchor (1 Cable – 1 Side)

Condition	BS (m)	α (deg)	Block Anchor Reaction (KN)			
			Hx	Hy	V	F
1	24	27	441.4	0	224,91	495.4
2	17,6	35	405.81	0	284,15	495.4
3	12,3	45	350.3	0	350,3	495.4

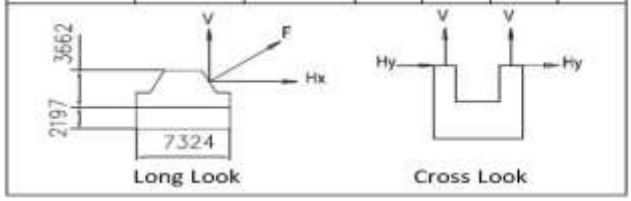

Table-4 Force on Pillar (1 Cable – 1 Side)

Condition	BS (m)	α (deg)	Pillar Reaction					
			Hx (kN)	Hy (kN)	Mx (kN.m)	My (kN.m)	V1 (kN)	V2 (kN)
1	24	27	21,7	0	0	−3,9	−255,61	−315,76
2	17,6	35	37,4	0	0	−5,2	−147,3	−429,3
3	12,3	45	78,5	0	0	−10,5	318	−878,5

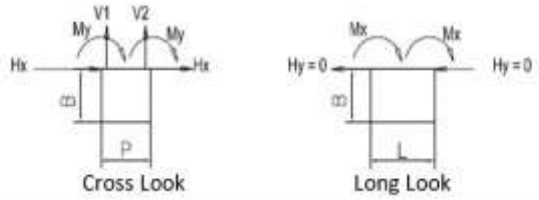

Table-5 The Reaction of Floor Cross Girder (1 Cable – 1 Side)

Condition	**BS (m)**	**α (deg)**	**The Reaction of Floor Cross Girder**		
			Hx (kN)	**Hy (kN)**	**V (kN)**
1	24	27	16,7	2,3	-3,3
2	17,6	35	16,7	2,3	-3,3
3	2,3	45	16,7	2,3	-3,3

Information:
1. Reaction forces based on service conditions (SLS).
2. The direction of the force is based on the global coordinate axes.

III. RESEARCH METHODS

From the module SSEB – 03 = structural analysis and design, training of steel structure engineers of buildings published by the Ministry of Public Works, construction and human resources development agency, center for competency development and construction training 2007 page 136, analysis calculation Welded connection to the pile connection is carried out as a control of the load bore by 1 point of the pile. The forces that will be entered as a load on the pile are as follows:

1. Force carried by 1 pole
2. Tensile force on anchor block

The force bore by the piles was calculated based on the results of planning carried out by the core team of the National Road Planning and Supervision Work Unit (P2JN) Bangka Belitung Province. From the Detail Engineering Design image, it is found that the angle of the anchor block used is 35° and the force acting on the anchor block (1 cable – 1 side) with an anchor angle of 35° (according to DED) is F = 495.4 kN

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(based on the design criteria of a symmetrical pedestrian suspension bridge).

IV. RESULTS AND DISCUSSION

Based on the module SSEB – 03 = structural analysis and design, training of steel structure engineer of buildings published by the Ministry of Public Works, construction and human resources development agency, center for competency development and construction training 2007 page 136, connection strength welding can be calculated as follows:

a. Finding weld length

Welding wire used = E6013
Weld thickness (t) = 1.00 cm
∅ pile (D) = 350 mm
Weld length (Ag) = π.D
= π x 35 cm
= 109.96 cm

1. Find the electrode dropout voltage (f_{uw}) and the electrode yield voltage (f_{yw})

The welding wire used is E6013 with a value of f_{uw} = 60.00 ksi

f_{uw} = 60.00 ksi
= 4,218.41 kg/cm^2

f_{yw} = 0.60 x f_{uw}
= 0.60 x 4218.41 kg/cm^2
= 2,531.05 kg/cm^2

2. The connection is loaded with tensile force (take the smallest value between plate and weld strength)

1. Plate

a. Melting condition

Φ Nn = 0.90 x Ag x fy material
= 0.90 x 109.96 cm x 2,400.00 kg/cm^2
= 237,504.40 kg

b. Fracture condition

Φ Nn = 0.75 x Ag x f_{uw}
= 0.75 x 109.96 cm x 4,218.41 kg/cm^2
= 344,780.53 kg

2. Welding

a. Basic material

Φ R_{nw} = 0.90 x t x fy material x Ag
= 0.90 x 1.00 cm x 2,400.00 kg/cm^{2}x 109.96 cm
= 237,504.40 kg

b. Welding

Φ R_{nw} = 0.90 x t x f_{uw} x Ag
=0.90 x 1.00cm x 4.218.41 kg/cm^2 x 109.96 cm
= 257,472.92 kg

So the capacity of the welded joint is taken at the smallest value, which is 237,504.40 kg (237.50 tons or 2,329.13 kN).

b. Force bore by 1 pile

The force bore by 1 pile that has been calculated previously can be seen in the table below:

Table-6 Value of Force Beared by 1 Pile

No.	Load Combination	Style Value
1.	Combination 1 (100%)	1,037.31 kN
2.	Combination 2 (125%)	952.83 kN
3.	Combination 3 (140%)	1,082.84 kN
4.	Combination 4 (150%)	1,019.66 kN

Source: Data processed by Satker P2JN Bangka Belitung Province, 2019.

From table 6 above, it is found that the largest force value is found in the combination of load 3 (140%) with a force value of 1,082.84 kN. The force compared to the value of the capacity of the welded joint is 1,082.84 kN < 2,329.13 kN so the capacity of the welded joint is still safe against the force bore by 1 pile.

c. Force on anchor block (1 cable – 1 side)

In this suspension bridge, the distance between the pylon block to the anchor block is 17.60 meters with an anchor angle of 35° (Table 4), so that the force on the anchor block (F) compared to the capacity of the welded joint can be obtained that the value of F < the capacity of the welded joint, which is 495.40 kN < 2,329.13 kN, so that the capacity of the welded joint is still safe against the force on the anchor block.

V.CONCLUSION

From the calculation results above, it can be concluded that the value of the welded connection on the pile (by 2,329.13 kN) is still safe against the force bore by 1 pile (of 1,082.84 kN) and against the force on the anchor block (495.40 kN).

However, in practice, the welding operation must be completely filled, the surface and sides of the steel pile sheath must be clean of dirt and slag (residual welding) and the pile must be in an upright condition to avoid tilting the pile during connection.

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