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Oil Palm Harvesting Footbridge Manufacturing Analysis

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ABSTRACT
West Kalimantan, a province in Indonesia, has a large area of land that is very suitable for oil palm cultivation. Much of the province has been planted with oil palm plantations, often around ditches. Concrete footbridges, which are sturdy and durable structures, were designed and built to improve accessibility to oil palm plantations, enabling a more efficient harvesting process. This research focused on the use of normal concrete with a grade of 15 MPa, which demonstrated sufficient compressive strength according to plan. T-shaped oil palm footbridge beams of specified dimensions were constructed, and appropriate reinforcement was used to ensure their structural strength. The results of this study yielded a correlation between load and deflection for D12 and 2D12 flexural reinforcement. In this case, it was found that 2D12 beams can meet the criteria to become an oil palm footbridge with a maximum ability to carry a load of about 400 kg. With the construction of this concrete footbridge, the palm oil harvesting process can be significantly improved.
Keywords:oil palm, concrete footbridge, accessibility, T beam, allowable load

I. INTODUCTION

Indonesia's West Kalimantan Province possesses an optimal land area for the cultivation of oil palm, a significant export commodity and regional revenue generator. Despite this, the transportation of the harvest is impeded by the restricted access to oil palm plantations in the area, particularly during the wet season. To address this issue, a durable and cost-effective concrete footbridge was conceptualized. The objective of this study is to ascertain the optimal load capacity that the 6-meter footbridge can support, examine the properties of the concrete that will be utilized, and develop a robust footbridge model.

Establishing this concrete footbridge will facilitate access to previously untapped regions for oil palm cultivation, thereby augmenting the earnings of oil palm firms and farmers. Furthermore, enhanced accessibility can result in reduced expenses for crop transportation, thereby augmenting both the efficiency and safety of the process. The urgency of this research is to provide references for the construction of suitable concrete footbridges in West Kalimantan, which can be utilized extensively in oil palm plantation bridge infrastructure. This will enhance accessibility and safety, stimulate economic growth in the region, and mitigate the environmental consequences associated with less efficient modes of transportation.

Figure 1. Condition of oil palm footbridge
Source: Mongabay

Figure 2. The condition of the ditch needs a harvest footbridge
Source: Mongabay

II. METHOD

The present study presents two hypotheses: H0B posits that concrete footbridges

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do not meet the criteria for substantial infrastructure; and H1B contends that the reversal is true. The investigation was conducted at the Materials and Construction Laboratory of Tanjungpura University's Faculty of Engineering. The experimental approach involved fabricating test specimens in accordance with ASTM and SNI standards. These specimens comprised fine aggregate, coarse aggregate (with a maximum size of 25 mm), and steel reinforcement measuring D12 mm, D8 mm, and D6 mm. Compressive and flexural strengths were evaluated using concrete of quality fc' 15 MPa. The research objects comprise a population consisting of T beams measuring 6000 mm in span, 250 mm in width, and 250 mm in height; cubes measuring 150 x 150 x 150 mm; and cylinders measuring 300 mm in height and 150 mm in diameter. In the design of T beams, modeling of the applicability of concrete footbridges is also presented.

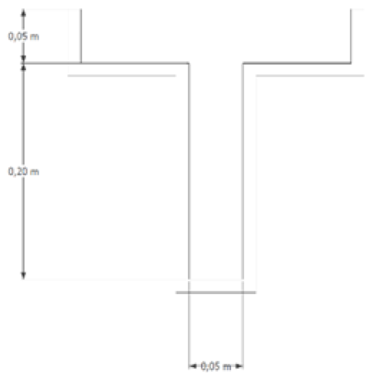

Figure 3. Front view T-beam design

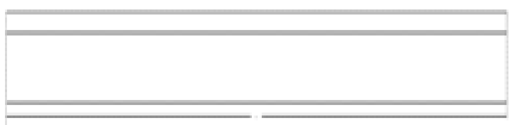

Figure 4. Side view T-beam design

2.1 Testing of Materials

Multiple procedures are required for material inspection. Before application, the specific gravity, volume weight, and particle fineness of the Portland Composite Cement used to produce the cement are evaluated. In addition to gradation, specific gravity, water absorption, volume weight, and aggregate deterioration, the coarse aggregates underwent a battery of visual inspections. The organic content, sediment content, moisture content, gradation, specific gravity, water absorption, and volume weight of the fine aggregates were all evaluated for similar characteristics. Leachability and acidity tests were performed on water extracted from the PDAM to ensure it met the requirements of the study.

2.2 Testing and Design of Reinforcements for Concrete

Reinforcement with steel was utilized in accordance with the design. Further evaluations of concrete samples encompassed compressive strength, subsidence, and volume weight assessments. Table 1 provides the duration and quantity of test specimens corresponding to each sample variation.

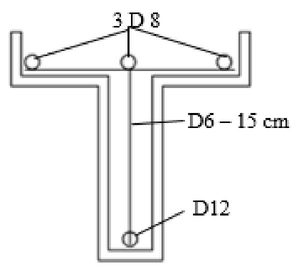

Figure 5. Design of flexural reinforcement for variation 1

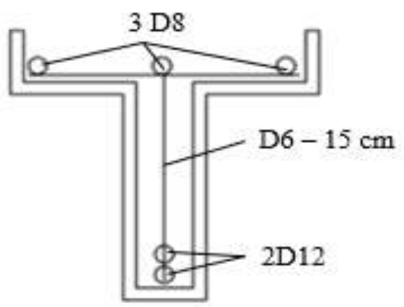

Figure 6. Design of flexural reinforcement for variation 2

Table 1. Time and quantity of test samples for a single sample variation

No	Sample	Testing Time (Days) and Number of Test Objects
		Cube and T-beam
		28
1	Volume Weight	25
2	Compressive Strength	25
3	T-beam Bending Strength	2

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2.3 Setting Of Bending Test

The beams' bending testing shall be conducted in accordance with the configuration illustrated in Figure 7.

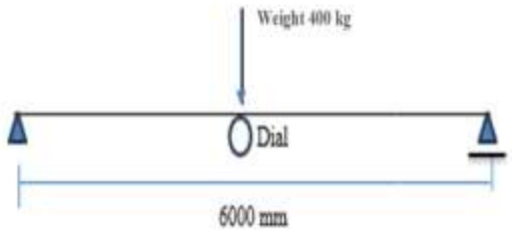

Figure 7. Setting of bending test

III. RESULT ANDDISCUSSION

3.1 Analysis of Material Testing

Concrete components, such as water, fine aggregate, cement, and coarse aggregate, must conform to technical specifications outlined in the Indonesian National Standard (SNI).

The moisture content (1.356%) and silt content (0.610%) of fine aggregates were evaluated in the experiments. The silt content of this fine aggregate is less than 5% by dry weight, which satisfies SNI specifications. The fine aggregates underwent a volume weight test under both solid and porous conditions; the result was a volume weight of 1,500 kg/L. Fine aggregate has the following specific gravimetric values: average evident specific gravity (2.649 g/mL), average surface dried specific gravity (2.605 g/mL), and average water absorption (1.031%). Based on the findings of the fine aggregate gradation test, the sand utilized complies with SNI 03-2384-2000 and is classified as zone III (rather fine sand), with a fine modulus of 3.04.

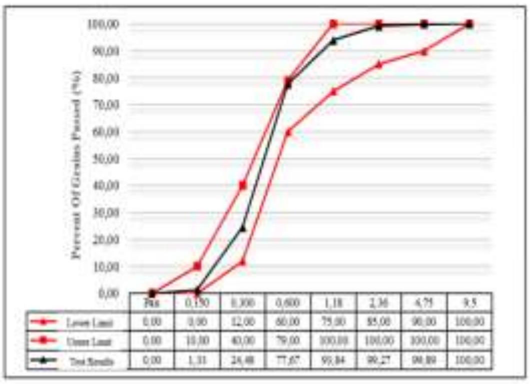

Figure8. Fine aggregate gradation analysis graph

The concrete mix material utilized in this investigation was Stone 2/3, which had a maximal aggregate dimension of 40 mm. Coarse aggregates were evaluated based on their water absorption (0.301 percent), volume weight (1.452 kg/L), specific gravity (2.676 g/mL surface dry, 2.688 g/mL dry, and 2.690 g/mL evident), and moisture content (0.411 percent). The results of aggregate wear testing indicated an average wear percentage of 15.10%, which is in accordance with the SNI 2417:2008 criteria for values falling below 50%. The examination of the gradation of the coarse aggregate indicated that it possessed a maximal size of 40 mm and a fine modulus of 3.39.

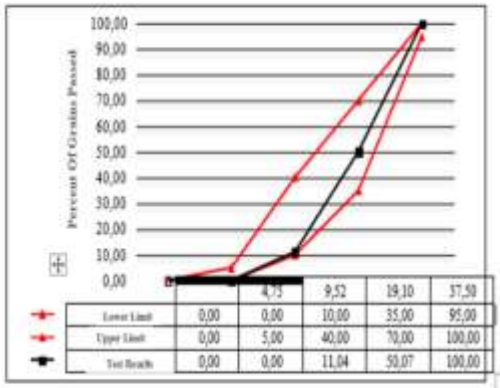

Figure9. Coarse aggregate gradation analysis graph

In accordance with the SNI 15-2531-1991 standard, the average specific gravity of Portland cement was determined to be 2.98 g/cm3. In accordance with the SNI 03-2530-1991 standard, Portland cement fineness testing was conducted utilizing a No. 160 sieve, yielding an average percentage of 100% passing both the No. 100 and No. 160 sieves.

The water purity or organic content is determined using a TDS meter, which yields a TDS of 31 mg/L. This value satisfies the maximum threshold of 500 mg/L specified by the SNI 3553 2015 standard. Furthermore, upon conducting a pH analysis of the water utilized in the test for the concrete mixture, it is determined that the pH value is approximately 7. This value aligns with the prescribed pH range of 6.5-8.5 as specified in the Permenkes 492/Menkes/Per/IV/2010 drinking water standard.

3.2 Concrete Mix Design

In accordance with the procedures for selecting mixtures and SNI 7656: 2012, the mix design for 15 MPa quality concrete has been computed..

Table2. Composition of concrete mix

No.	Material	Volume	Unit
1	Weight of cement	260,486	Kg
2	Weight of water	167,982	Kg
3	Weight of Coarse Aggregate	1011,408	Kg
4	Weight of Fine Aggregate	923,110	Kg
Total		2362,986	Kg

3.3 Slump Test

The significance of slump testing lies in its ability to ascertain the properties and degree of slipperiness of the manufactured concrete. The concrete mixture exhibited a slump degree of 75-80 mm, which corresponded to the intended slump range of 50-100 mm, as determined by the slump test results. Thus, the concrete mixture satisfies the specifications outlined in the standard concrete manufacturing plan.

Table3. Volume weight test result

No	Mixture	Slump Test (mm)
1	Mix 1	80
2	Mix 2	75

3.4 Volume Weight Test

The volume/fill weight of typical concrete in cubes and cylinders ranged from 2369.90 to 2408.89 kg/m3 on average after 28 days of solidification. This fulfills the typical concrete volume weight range of 2200-2500 kg/m3 and is consistent with the initial plan, which aimed for a concrete volume weight of 2362.986 kg/m3. The produced concrete thus satisfies the requirements for standard concrete.

Table 4. Average volume/fill weight

No	Sample	Average Volume Weight (kg/m^3)
		28 Days
1	Cube	2.408,890
2	cylinder	2.369,890

3.5 Compressive Strength Testing

The compressive strength of the concrete ranged from 12.918% and 15.131%, as determined by the conventional concrete compressive test on cube and cylinder samples. This value aligns with the initial strategic objective of achieving a compressive strength of 15 MPa. This information can be utilized in the design process for the forthcoming T beams, as the resulting concrete mixture conforms to the initial blueprint.

Table 5. Average compressive strength

No	Sample	Average Compressive Strength (MPa)
		28 Days
1	Cube	12,918
2	cylinder	15,131

3.6 Strength of Flexure Test

The initial variation, which incorporates a single flexural reinforcement, establishes a favorable correlation between the load and deflection of the T beam. Consequently, it becomes feasible to compute the maximum load that the T beam can endure in relation to the permissible deflection as specified in the reinforced concrete SNI standard. Based on the computed outcomes, the permissible burden for the initial T beam amounts to 372.22 kg.

Table 6. Deflection and load of variation 1.

No	Volume	Deflection
1	0	0,000
2	50	0,017
3	100	0,040
4	150	1,212
5	200	2,378
6	250	3,624
7	300	45,144
8	350	7,103

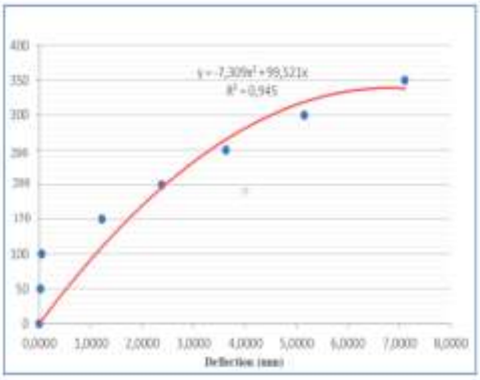

Figure 10. Deflection vs load graph for variation 1

The allowable load in the second variation, which incorporates two flexural reinforcements, is 414.581 kg, indicating a positive correlation between load and deflection in the T beam.

Table7. Load and deflection of variation 2

No	Volume (kg)	Deflection (mm)
1	0	0,000
2	50	0,400
3	100	1,960
4	150	2,442
5	200	4,020
6	250	5,330
7	300	6,710
8	350	8,420
9	400	10,760

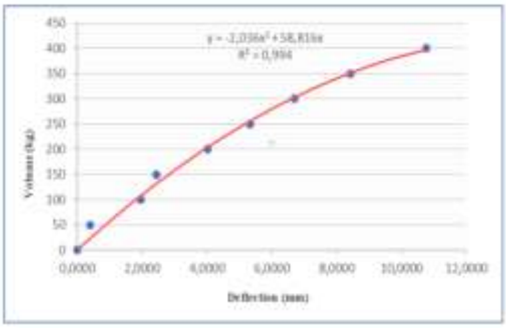

Figure 12. Graph of load versus deflection for variation 1

Therefore, it is evident that the T beam variation featuring two flexural reinforcements satisfies the necessary criteria in terms of allowable deflection and plan load. Consequently, it can be employed as a footbridge beam for oil palm harvesting in adherence to relevant standards.

Table 8. Maximum flexural strength

No	Variation	Bending Beam Clearance T (mm)	Permit Load (kg)	Planning Load (kg)
1	T Beam With 1 Bending Reinforcement	16,67	372,22	400
2	T Beam With 2 Bending Reinforcement	16,67	414,58	400

IV. CONCLUTION

1. The materials used in the production of ordinary concrete, including fine aggregate, coarse aggregate, cement, and water, comply with the applicable standards, according to the findings of the research.
2. A concrete mixture design was conducted to achieve a quality of 15 MPa. The composition of the materials utilized was as follows: cement (2600.486 kg/m3), water (167.982 kg/m3), stone (1011.48 kg/m3), and grit (923.11 kg/m3).
3. According to the results of the collapse test, the desired uniformity was achieved in the concrete mixture.
4. The compressive strength and volume/fill weight of ordinary concrete comply with the specification.
5. The results of flexural testing conducted on T-beams featuring two flexural reinforcements varied sufficiently to be utilized as a walkway for oil palm harvesting.

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