ON THE JOB TRAINING

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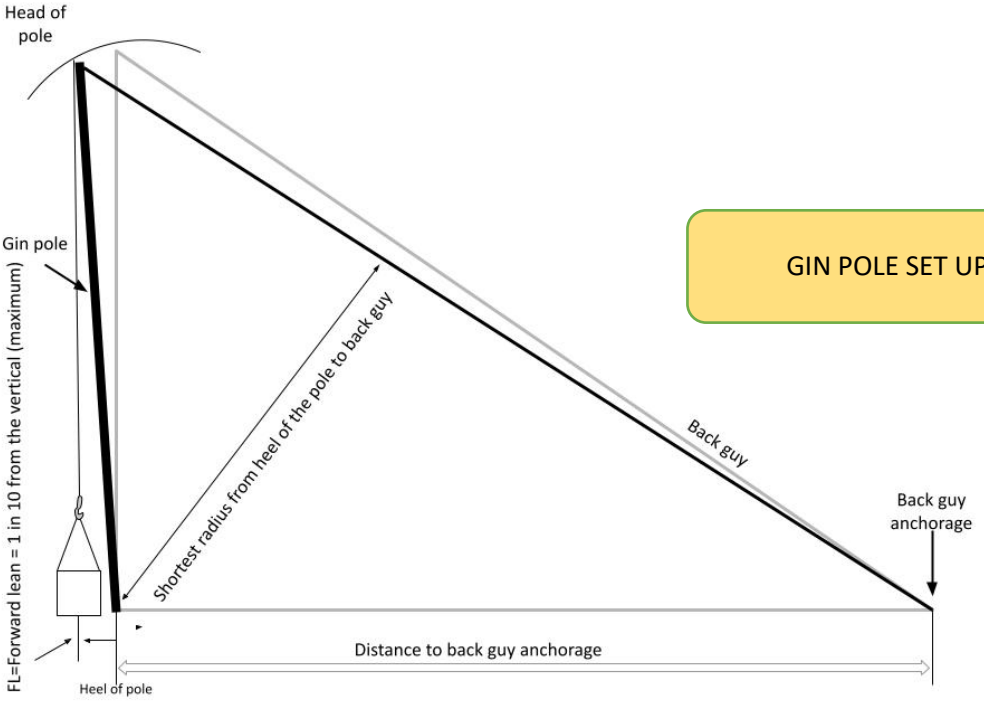
Advanced Rigging Calculations Worksheet

MARKING GUIDE

Version	Date	Author	Notes
1.1	1/6/2022	AD	Initial version
1.2	13/6/2022	BJ	Corrections, formatting and merging formula handout, answers, new questions
1.3	17/11/2022	BJ	Aligning calculations to NAI v1.6

Advanced Rigging Formulas / Quick Sheet
GIN POLES



GIN POLE SET UP

1. Minimum distance between heel of pole and back guy anchor

$$\text{Minimum Distance} = \text{Pole Height} \times 1.5$$

2. Maximum Forward Lean of Gin Pole

$$\text{Forward Lean} = \text{Pole Height} \times 0.1$$
OR
$$\text{Forward Lean} = \text{Pole Height} \div 10$$

3. Total Head Load on at Pole head.

$$\text{Total Head Load} = \text{Total Load} + \text{Load in the Lead Rope}$$

4. Tension in the Back Guy

$$\text{Tension} = \text{Total Head Load} \times \text{Forward Lean} \div \text{Shortest Radius}$$

5. Diameter of FSWR used in the Back Guy

$$\text{Diameter} = \sqrt{\text{Tension in the Back Guy} \div 8}$$

6. Compression Load on the Gin Pole

$$\text{Compression Load} = \text{Total Head Load} \times 1.125$$

SPAN LINE CALCULATIONS

1. Tension in Span Rope

Two Step Method

Step 1:

CALCULATE THE MINIMUM SAG: USE THR FORMULA YOU PREFER!

$\text{Minimum Sag} = \text{Span} \div 20$ **OR** $\text{Minimum Sag} = \text{Span} \times 0.05$

Step 2:

CALCULATE THE TENSION: USE THE FORMULA YOU PREFER!

$$\text{Tension in Span Rope} = \frac{Total\ Head\ Load \times Span}{4 \times Sag}$$

OR

$$\text{Tension in Span Rope} = \text{Total Head Load} \times \text{Span} \div 4 \div \text{Sag}$$

One Step Method

Simple:

ASSUMES YOU ARE USING MINIMUM SAG

$$\text{Tension in Span Rope} = \text{Total Head Load} \times 5$$

SWING STAGE CALCULATIONS

1. Maximum Rope Tension

$$\text{MRT} = (\text{WLL Hoist} \times 1.25) + \text{Total Rope Used Weight} + \text{Total Stabilising Weights}$$

2. Number of Counterweights Required

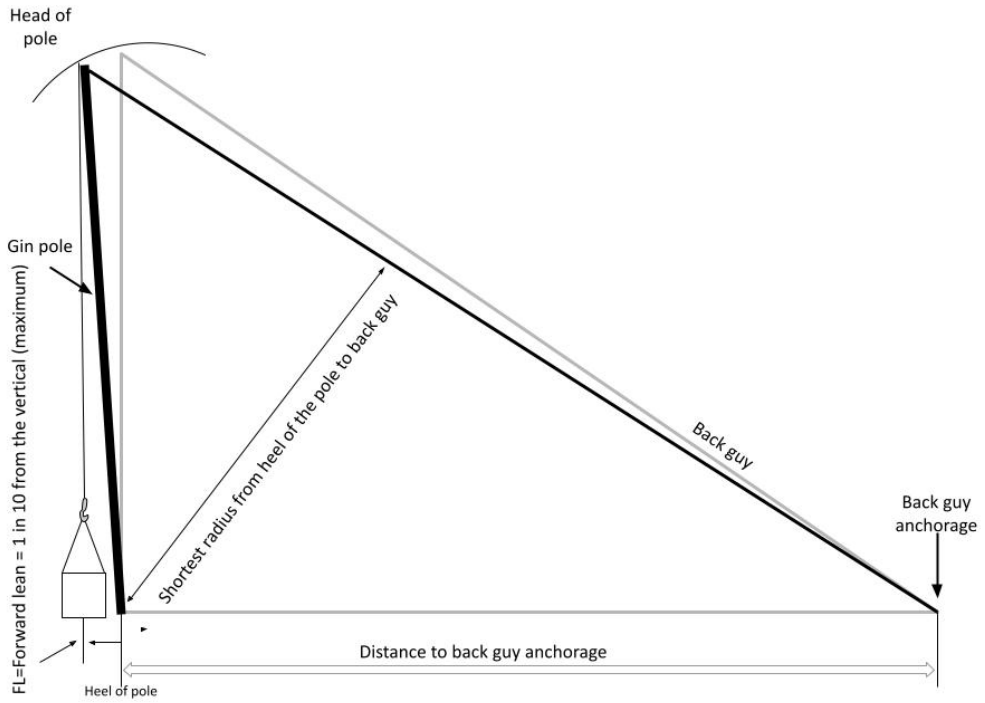
$$\#\ \text{Counterweights Required} = \text{MRT} \times \text{Outboard} \div \text{Inboard} \times 3 \div \text{Weight of single Counterweight}$$

3. Minimum Guaranteed Breaking Load of FSWR

$$\text{MGB} = \text{WLL Hoist} \times 10$$

Section 1: Gin Pole Calculations

Scenario: You need to set up a gin pole at the recommended maximum lean to lift a load. The guys will be anchored at the minimum distances from the foot of the pole. The lead rope will run parallel to the pole as shown in the diagram.



The load specifics are as follows:

- Height of pole: 10 meters
- Weight of load: 7 tonnes
- Load on the lead rope: 1.8 tonnes
- Shortest radius from heel of pole to back guy: 8100 mm

A. What is the recommended minimum distance between the pole heel and the back guy anchor? Show formula and all workings/calculations.

$$\begin{aligned}\text{Minimum Distance} &= \text{Pole Height} \times 1.5 \\ &= 10\text{m} \times 1.5 \\ &= 15\text{m}\end{aligned}$$

B. What is the recommended maximum forward lean on the pole? Show formula and all workings/calculations.

Option 1:

$$\begin{aligned}\text{Forward Lean} &= \text{Pole Height} \times 0.1 \\ &= 10\text{m} \times 0.1 \\ &= 1\text{m}\end{aligned}$$

Option 1:

$$\begin{aligned}\text{Forward Lean} &= \text{Pole Height} \div 10 \\ &= 10\text{m} \div 10 \\ &= 1\text{m}\end{aligned}$$

C. What is the Total Head Load (THL)? Show formula and all workings/calculations.

$$\text{Total Head Load} = \text{Total Load} + \text{Load in the Lead Rope}$$
$$= 7T + 1.8T$$
$$= 8.8T$$

D. What is the tension in the back guy? Show formula and all workings/calculations.

$$\text{Tension} = \text{Total Head Load} \times \text{Forward Lean} \div \text{Shortest Radius}$$
$$= 8.8T \times 1m \div 8.1m$$
$$= 1.0864T \text{ rounded up to } 1.087T \text{ or } 1087kg$$

E. What is the diameter of the FSWR in the back guy? Show formula and all workings/calculations.

$$\text{Diameter} = \sqrt{\text{Tension in the Back Guy} \div 8}$$
$$= \sqrt{1087kg \div 8}$$
$$= \sqrt{135.875}$$
$$= 11.7 \text{ rounded up to } 12mm$$

F. What is the compression load on the gin pole? Show formula and all workings/calculations.

$$\text{Compression Load} = \text{Total Head Load} \times 1.125$$
$$= 8.8T \times 1.125$$
$$= 9.9T$$

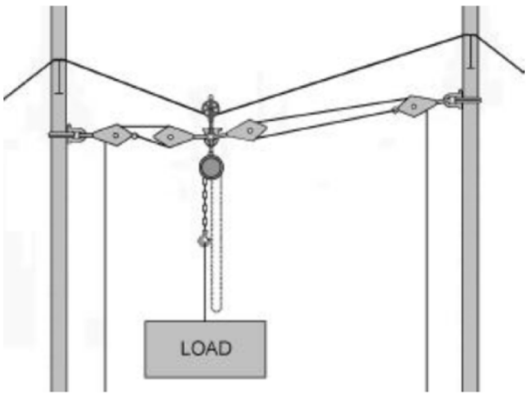
G. Determine the minimum pole size from the table below? (Circle your answer on the table below)

Oregon size in mmm	SAFE TOTAL LOAD AT POLE HEAD IN TONNES Length of pole in metres											Oregon size in mmm
	4.5	6	7.5	9	11	12	13.5	15	18	21	24	
	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	
100 x 100	1.05	0.75	-	-	-	-	-	-	-	-	-	100 x 100
150 x 150	3.0	2.6	2.0	1.7	-	-	-	-	-	-	-	150 x 150
200 x 200	6.5	6.0	5.25	4.5	3.75	3.2	-	-	-	-	-	200 x 200
250 x 250	12.0	11.0	10.0	9.0	8.0	6.5	6.0	5.0	-	-	-	250 x 250
300 x 300	[illegible]	[illegible]	[illegible]	[illegible]	14.0	12.0	11.0	9.0	7.0	-	-	300 x 300
350 x 350	26.5	26.0	24.0	23.0	22.0	20.0	18.0	17.0	13.0	11.0	-	350 x 350
400 x 400	-	-	-	-	-	30.0	28.0	26.0	21.0	17.0	14.0	400 x 400
450 x 450	-	-	-	-	-	-	-	-	30.0	26.0	27.0	450 x 450

300mm by 300mm Pole dimensions.

Section 2: Span Line Calculations

Scenario: You need to install a span rope fixed between two beams.



As shown in the diagram, a chain block or other lifting device will be supported from an inverted snatch block on the span rope to lift a load.

The load specifics are:

- Span between beams: 11 meters
- Weight of load: 600 kgs
- Weight of lifting gear and load in the hauling part: 50 kg

A. What is the tension in the span rope when the sag is at its recommended minimum? Show formula and all workings/calculations.

Option 1:	Option 2:
$\text{Minimum Sag} = \text{Span} \times 0.05$ $= 11\text{m} \times 0.05$ $= 0.55\text{m}$ Then: $\text{Tension in Span Rope} = \frac{\text{Total Head Load} \times \text{Span}}{4 \times \text{Sag}}$ $= \frac{650\text{kg} \times 11\text{m}}{4 \times 0.55\text{m}}$ $= \frac{7150\text{kgm}}{2.2\text{m}}$ $= 3250\text{kg}$	$\text{Tension in Span Rope} = \text{Total Head Load} \times 5$ $= 650\text{kg} \times 5$ $= 3250\text{kg}$

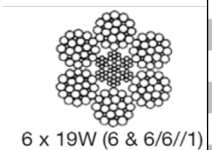
B. Based on your answer to the previous question, determine from the following wire rope chart below:

Part A: Minimum diameter of the main span rope? 22mm (red circle)

Part B: Minimum breaking force of the main span rope? 213kN (green circle)

Round Strand 6 x 19 IWRC

Safety Factor 6:1

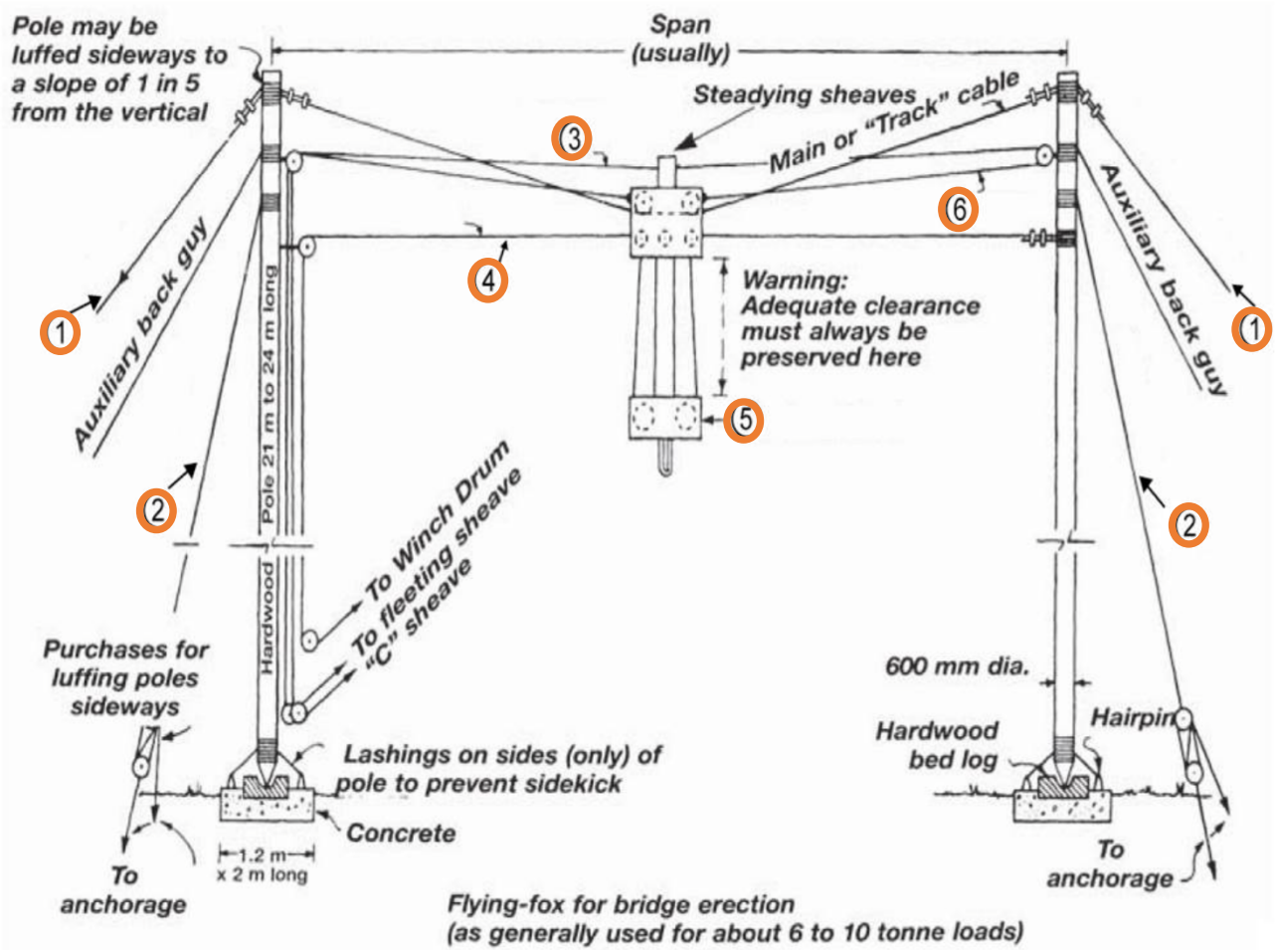


Note: Working Load Limit (WLL) is based on 1/6th of Minimum Breaking Force

Nominal Diameter (mm)	Working Load Limit (WLL) tonnes	Min.Breaking Force at 1570MPa kN	Average Mass kg/100m
6	0.26	15.8	11.4
7	0.36	21.5	15.6
8	0.48	28.2	20.4
9	0.61	35.6	25.8
10	0.75	44.0	31.8
11	0.90	53.2	38.5
12	1.07	63.3	45.8
13	1.26	74.3	53.8
14	1.47	86.2	62.4
16	1.92	113.0	81.5
18	2.43	143.0	103.0
20	2.99	176.0	127.0
22	3.62	213.0	154.0
24	4.30	255.0	183.0
26	5.05	297.0	215.0
28	5.86	345.0	250.0
32	7.65	450.0	326.0

C. Name the identified parts of the span line system using the terms from the list below:

TRANSVERSE ROPE
SIDE GUY
HOIST ROPE
TRANSVERSE ROPE
BOTTOM BLOCK
ANCHORAGE ROPE



1. Anchorage Rope
2. Side Guy
3. Transverse Rope
4. Hoist Rope
5. Bottom Block
6. Transverse Rope

Section 3: Swing Stage Calculations

Scenario: You need to erect a suspended scaffold from a counterweighted cantilevered suspension rig.

The scaffold is an individual cradle supported from two needles with one suspension rope and one scaffolding hoist per needle. The specifics are as follows:

- The needles have an outboard of 1.2 meters and an inboard of 5.8 meters
- The counterweights weigh 27 kgs each
- The rope is 50 meters long and weighs 34 kg per 100 meters
- The hoist's rated capacity: 850 kg
- Each stabilising weight: 12 kg

A. What is the maximum rope tension? Show formula and all workings/calculations.

$$\text{MRT} = (\text{WLL Hoist} \times 1.25) + \text{Total Rope Used Weight} + \text{Total Stabilising Weights}$$
$$= (850\text{kg} \times 1.25) + 34\text{kg} + 24\text{kg}$$
$$= 1062.5\text{kg} + 58\text{kg}$$
$$= 1120.5\text{kg}$$

B. Using a safety factor of 3, how many counterweights are needed at the inboard end of the needle? Show formula and all workings/calculations. Answer must be shown as a whole number.

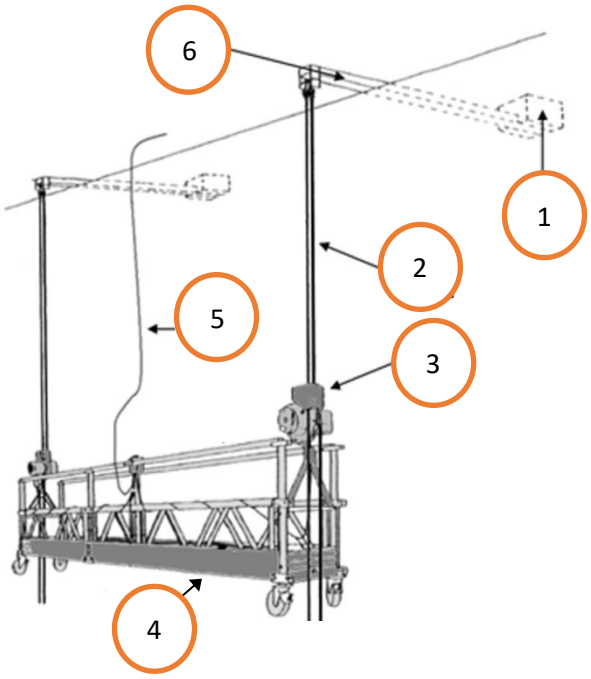
$$\#\ \text{Counterweights Required} = \text{MRT} \times \text{Outboard} \div \text{Inboard} \times 3 \div \text{Weight of single Counterweight}$$
$$= 1120.5\text{kg} \times 1.2\text{m} \div 5.8\text{m} \times 3 \div 27\text{kg}$$
$$= 25.8 \text{ rounded up to } 26 \text{ counterweights.}$$

C. Using a safety factor of 10, what is the minimum guaranteed breaking load of the suspension rope? Show formula and all workings/calculations.

$$\text{MGB} = \text{WLL Hoist} \times 10$$
$$= 850\text{kg} \times 10$$
$$= 8500\text{kg}$$

D. Name the identified parts of the span line system using the terms from the list below:

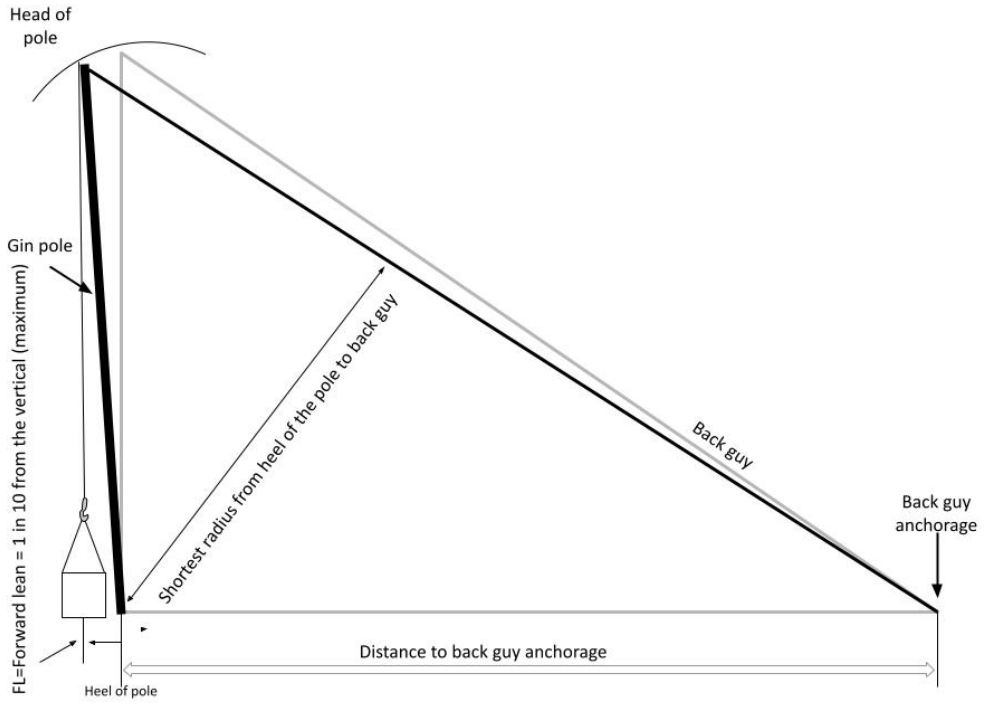
ELECTRIC SCAFFOLD HOIST
POWER CABLE
COUNTERWEIGHT NEEDLE
SUSPENSION AND SECONDARY ROPES
MODULAR SWING STAGE SCAFFFOLD (CRADLE)
COUNTERWEIGHTS



1. Counterweights
2. Suspension and Secondary Ropes
3. Electric Scaffold Hoist
4. Modular Swing Stage Scaffold (Cradle)
5. Power cable
6. Counterweight Needle

Section 4: Gin Pole Calculations

Scenario: You need to set up a gin pole at the recommended maximum lean to lift a load. The guys will be anchored at the minimum distances from the foot of the pole. The lead rope will run parallel to the pole as shown in the diagram.



The load specifics are as follows:

- Height of pole: 7 meters
- Weight of load: 10 tonnes
- Load on the lead rope: 2.1 tonnes
- Shortest radius from heel of pole to back guy: 6000 mm

A. What is the recommended minimum distance between the pole heel and the back guy anchor? Show formula and all workings/calculations.

$$\begin{aligned}\text{Minimum Distance} &= \text{Pole Height} \times 1.5 \\ &= 7\text{m} \times 1.5 \\ &= 10.5\text{m}\end{aligned}$$

B. What is the recommended maximum forward lean on the pole? Show formula and all workings/calculations.

Option 1:

$$\begin{aligned}\text{Forward Lean} &= \text{Pole Height} \times 0.1 \\ &= 7\text{m} \times 0.1 \\ &= 0.7\text{m}\end{aligned}$$

Option 1:

$$\begin{aligned}\text{Forward Lean} &= \text{Pole Height} \div 10 \\ &= 7\text{m} \div 10 \\ &= 0.7\text{m}\end{aligned}$$

C. What is the Total Head Load (THL)? Show formula and all workings/calculations.

$$\text{Total Head Load} = \text{Total Load} + \text{Load in the Lead Rope}$$
$$= 10\text{T} + 2.1\text{T}$$
$$= 12.1\text{T}$$

D. What is the tension in the back guy? Show formula and all workings/calculations.

$$\text{Tension} = \text{Total Head Load} \times \text{Forward Lean} \div \text{Shortest Radius}$$
$$= 12.1\text{T} \times 0.7\text{m} \div 6\text{m}$$
$$= 1.4117\text{T rounded up to } 1.412\text{T or } 1412\text{kg}$$

E. What is the diameter of the FSWR in the back guy? Show formula and all workings/calculations.

$$\text{Diameter} = \sqrt{\text{Tension in the Back Guy} \div 8}$$
$$= \sqrt{1412\text{kg} \div 8}$$
$$= \sqrt{176.5}$$
$$= 13.3 \text{ rounded up to } 14\text{mm}$$

F. What is the compression load on the gin pole? Show formula and all workings/calculations.

$$\text{Compression Load} = \text{Total Head Load} \times 1.125$$
$$= 12.1\text{T} \times 1.125$$
$$= 13.6125\text{T rounded up to } 13.613\text{T}$$

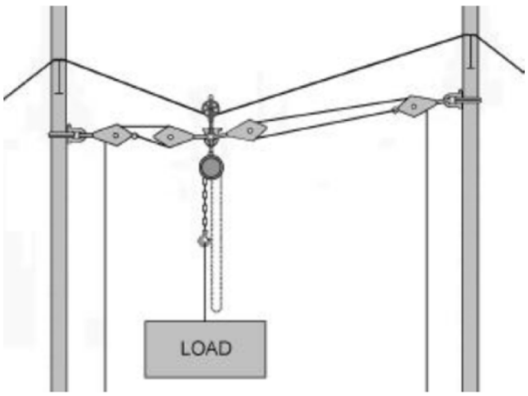
G. Determine the minimum pole size from the table below? (Circle your answer on the table below)

Oregon size in mmm	SAFE TOTAL LOAD AT POLE HEAD IN TONNES Length of pole in metres											Oregon size in mmm
	4.5	6	7.5	9	11	12	13.5	15	18	21	24	
	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	
100 x 100	1.05	0.75	-	-	-	-	-	-	-	-	-	100 x 100
150 x 150	3.0	2.6	2.0	1.7	-	-	-	-	-	-	-	150 x 150
200 x 200	6.5	6.0	5.25	4.5	3.75	3.2	-	-	-	-	-	200 x 200
250 x 250	12.0	11.0	10.0	9.0	8.0	6.5	6.0	5.0	-	-	-	250 x 250
300 x 300	18.0	17.0	16.0	15.0	14.0	12.0	11.0	9.0	7.0	-	-	300 x 300
350 x 350	26.5	26.0	24.0	23.0	22.0	20.0	18.0	17.0	13.0	11.0	-	350 x 350
400 x 400	-	-	-	-	-	30.0	28.0	26.0	21.0	17.0	14.0	400 x 400
450 x 450	-	-	-	-	-	-	-	-	30.0	26.0	27.0	450 x 450

300mm by 300mm Pole dimensions.

Section 5: Span Line Calculations

Scenario: You need to install a span rope fixed between two beams.



As shown in the diagram, a chain block or other lifting device will be supported from an inverted snatch block on the span rope to lift a load.

The load specifics are:

- Span between beams: 18 meters
- Weight of load: 900 kgs
- Weight of lifting gear and load in the hauling part: 75 kg

A. What is the tension in the span rope when the sag is at its recommended minimum? Show formula and all workings/calculations.

Option 1:	Option 2:
$\text{Minimum Sag} = \text{Span} \times 0.05$ $= 18\text{m} \times 0.05$ $= 0.9\text{m}$ Then: $\text{Tension in Span Rope} = \frac{\text{Total Head Load} \times \text{Span}}{4 \times \text{Sag}}$ $= \frac{975\text{kg} \times 18\text{m}}{4 \times 0.9\text{m}}$ $= \frac{17550\text{kgm}}{3.6\text{m}}$ $= 4875\text{kg}$	$\text{Tension in Span Rope} = \text{Total Head Load} \times 5$ $= 975\text{kg} \times 5$ $= 4875\text{kg}$

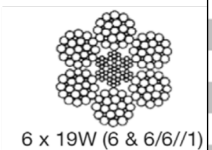
B. Based on your answer to the previous question, determine from the following wire rope chart below:

Part A: Minimum diameter of the main span rope? 26mm (red circle)

Part B: Minimum breaking force of the main span rope? 287.0kN (green circle)

Round Strand 6 x 19 IWRC

Safety Factor 6:1

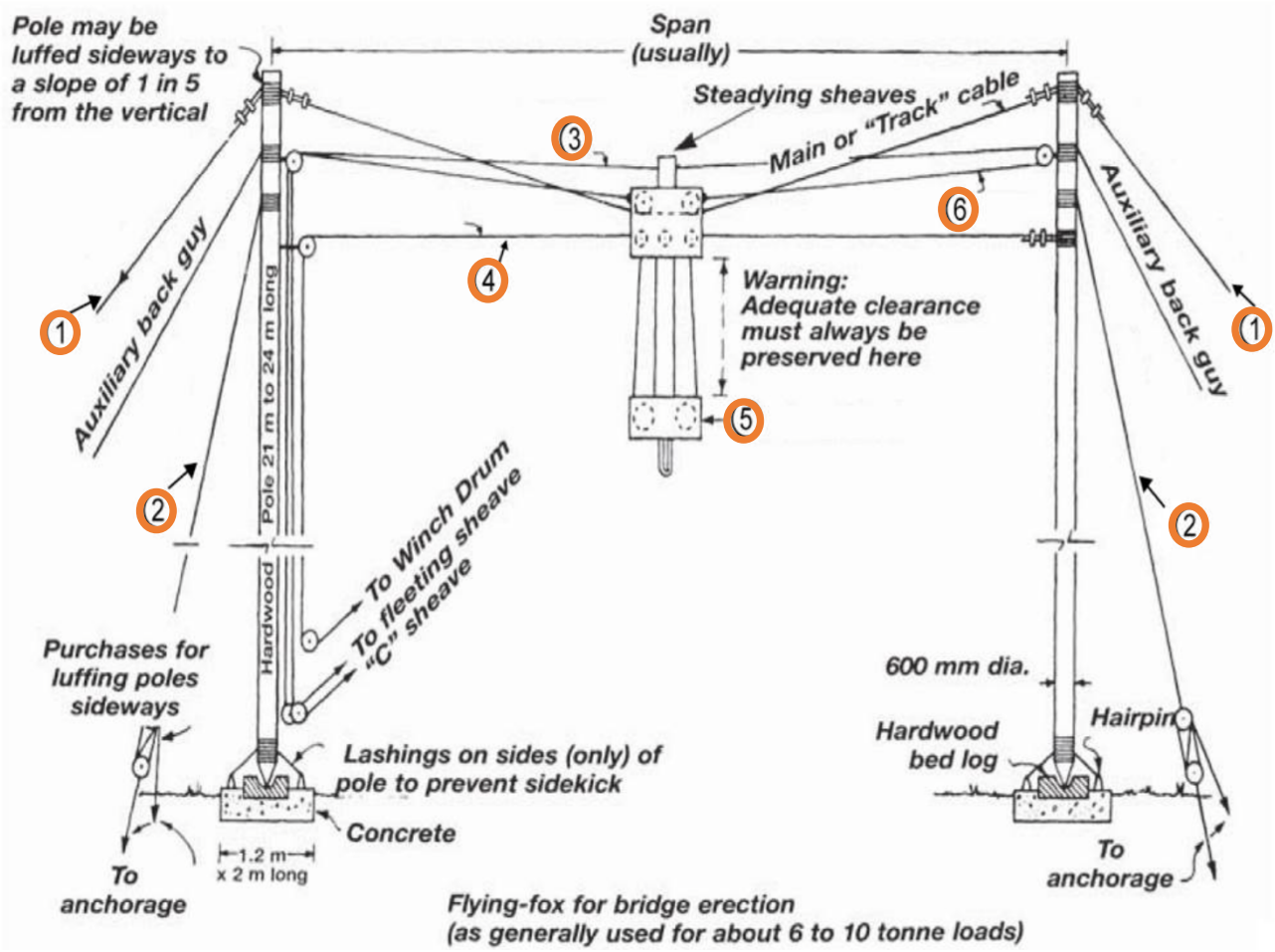


Note: Working Load Limit (WLL) is based on 1/6th of Minimum Breaking Force

Nominal Diameter (mm)	Working Load Limit (WLL) tonnes	Min.Breaking Force at 1570MPa kN	Average Mass kg/100m
6	0.26	15.8	11.4
7	0.36	21.5	15.6
8	0.48	28.2	20.4
9	0.61	35.6	25.8
10	0.75	44.0	31.8
11	0.90	53.2	38.5
12	1.07	63.3	45.8
13	1.26	74.3	53.8
14	1.47	86.2	62.4
16	1.92	113.0	81.5
18	2.43	143.0	103.0
20	2.99	176.0	127.0
22	3.62	213.0	154.0
24	4.30	250.0	183.0
26	5.05	297.0	215.0
28	5.86	345.0	250.0
32	7.65	450.0	326.0

C. Name the identified parts of the span line system using the terms from the list below:

TRANSVERSE ROPE
SIDE GUY
HOIST ROPE
TRANSVERSE ROPE
BOTTOM BLOCK
ANCHORAGE ROPE



1. Anchorage Rope
2. Side Guy
3. Transverse Rope
4. Hoist Rope
5. Bottom Block
6. Transverse Rope

Section 6: Swing Stage Calculations

Scenario: You need to erect a suspended scaffold from a counterweighted cantilevered suspension rig.

The scaffold is an individual cradle supported from two needles with one suspension rope and one scaffolding hoist per needle. The specifics are as follows:

- The needles have an outboard of 0.8 meters and an inboard of 5.6 meters
- The counterweights weigh 25 kgs each
- The rope is 50 meters long and weighs 34 kg per 100 meters
- The hoist's rated capacity: 750 kg
- Each stabilising weight: 15 kg

A. What is the maximum rope tension? Show formula and all workings/calculations.

$$\begin{aligned}\text{MRT} &= (\text{WLL Hoist} \times 1.25) + \text{Total Rope Used Weight} + \text{Total Stabilising Weights} \\ &= (750\text{kg} \times 1.25) + 34\text{kg} + 30\text{kg} \\ &= 937.5\text{kg} + 64\text{kg} \\ &= 1001.5\text{kg}\end{aligned}$$

B. Using a safety factor of 3, how many counterweights are needed at the inboard end of the needle? Show formula and all workings/calculations. Answer must be shown as a whole number.

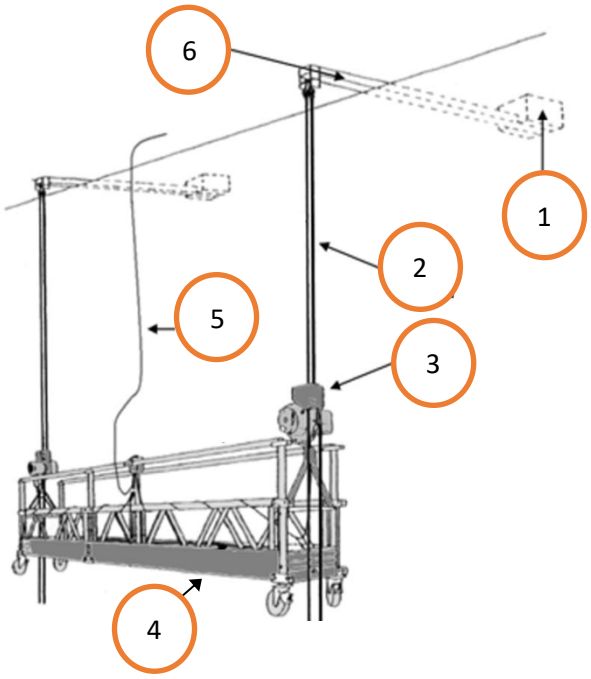
$$\begin{aligned}&\#\ \text{Counterweights Required} = \text{MRT} \times \text{Outboard} \div \text{Inboard} \times 3 \div \text{Weight of single Counterweight} \\ &= 1001.5\text{kg} \times 0.8\text{m} \div 5.6\text{m} \times 3 \div 25\text{kg} \\ &= 17.2 \text{ rounded up to } 18 \text{ counterweights.}\end{aligned}$$

C. Using a safety factor of 10, what is the minimum guaranteed breaking load of the suspension rope? Show formula and all workings/calculations.

$$\begin{aligned}\text{MGB} &= \text{WLL Hoist} \times 10 \\ &= 750\text{kg} \times 10 \\ &= 7500\text{kg}\end{aligned}$$

D. Name the identified parts of the span line system using the terms from the list below:

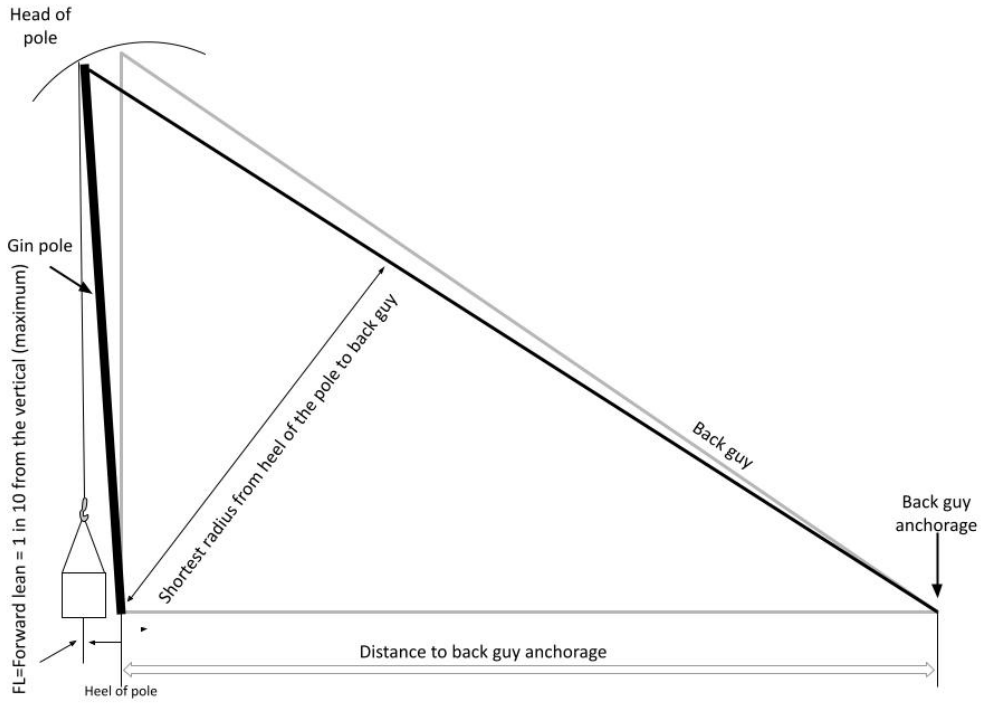
ELECTRIC SCAFFOLD HOIST
POWER CABLE
COUNTERWEIGHT NEEDLE
SUSPENSION AND SECONDARY ROPES
MODULAR SWING STAGE SCAFFFOLD (CRADLE)
COUNTERWEIGHTS



1. Counterweights
2. Suspension and Secondary Ropes
3. Electric Scaffold Hoist
4. Modular Swing Stage Scaffold (Cradle)
5. Power cable
6. Counterweight Needle

Section 7: Gin Pole Calculations

Scenario: You need to set up a gin pole at the recommended maximum lean to lift a load. The guys will be anchored at the minimum distances from the foot of the pole. The lead rope will run parallel to the pole as shown in the diagram.



The load specifics are as follows:

- Height of pole: 13.5 meters
- Weight of load: 5 tonnes
- Load on the lead rope: 1.1 tonnes
- Shortest radius from heel of pole to back guy: 10400 mm

A. What is the recommended minimum distance between the pole heel and the back guy anchor? Show formula and all workings/calculations.

$$\begin{aligned}\text{Minimum Distance} &= \text{Pole Height} \times 1.5 \\ &= 13.5\text{m} \times 1.5 \\ &= 20.25\text{m}\end{aligned}$$

B. What is the recommended maximum forward lean on the pole? Show formula and all workings/calculations.

Option 1:

$$\begin{aligned}\text{Forward Lean} &= \text{Pole Height} \times 0.1 \\ &= 13.5\text{m} \times 0.1 \\ &= 1.35\text{m}\end{aligned}$$

Option 1:

$$\begin{aligned}\text{Forward Lean} &= \text{Pole Height} \div 10 \\ &= 13.5\text{m} \div 10 \\ &= 1.35\text{m}\end{aligned}$$

C. What is the Total Head Load (THL)? Show formula and all workings/calculations.

$$\text{Total Head Load} = \text{Total Load} + \text{Load in the Lead Rope}$$
$$= 5\text{T} + 1.1\text{T}$$
$$= 6.1\text{T}$$

D. What is the tension in the back guy? Show formula and all workings/calculations.

$$\text{Tension} = \text{Total Head Load} \times \text{Forward Lean} \div \text{Shortest Radius}$$
$$= 6.1\text{T} \times 1.35\text{m} \div 10.4\text{m}$$
$$= 0.7918\text{T rounded up to } 0.792\text{T or } 792\text{kg}$$

E. What is the diameter of the FSWR in the back guy? Show formula and all workings/calculations.

$$\text{Diameter} = \sqrt{\text{Tension in the Back Guy} \div 8}$$
$$= \sqrt{792\text{kg} \div 8}$$
$$= \sqrt{99}$$
$$= 9.9 \text{ rounded up to } 10\text{mm}$$

F. What is the compression load on the gin pole? Show formula and all workings/calculations.

$$\text{Compression Load} = \text{Total Head Load} \times 1.125$$
$$= 6.1\text{T} \times 1.125$$
$$= 6.8625\text{T rounded to } 6.863\text{T}$$

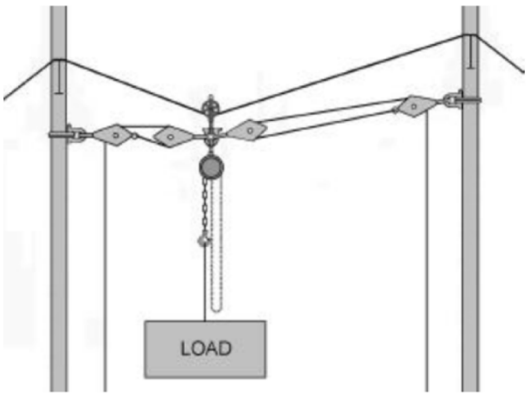
G. Determine the minimum pole size from the table below? (Circle your answer on the table below)

Oregon size in mmm	SAFE TOTAL LOAD AT POLE HEAD IN TONNES Length of pole in metres											Oregon size in mmm
	4.5	6	7.5	9	11	12	13.5	15	18	21	24	
	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	
100 x 100	1.05	0.75	-	-	-	-	-	-	-	-	-	100 x 100
150 x 150	3.0	2.6	2.0	1.7	-	-	-	-	-	-	-	150 x 150
200 x 200	6.5	6.0	5.25	4.5	3.75	3.2	-	-	-	-	-	200 x 200
250 x 250	12.0	11.0	10.0	9.0	8.0	6.5	6.0	5.0	-	-	-	250 x 250
300 x 300	19.5	17.0	16.0	15.0	14.0	12.0	11.0	9.0	7.0	-	-	300 x 300
350 x 350	26.5	26.0	24.0	23.0	22.0	20.0	18.0	17.0	13.0	11.0	-	350 x 350
400 x 400	-	-	-	-	-	30.0	28.0	26.0	21.0	17.0	14.0	400 x 400
450 x 450	-	-	-	-	-	-	-	-	30.0	26.0	27.0	450 x 450

300mm by 300mm Pole dimensions.

Section 8: Span Line Calculations

Scenario: You need to install a span rope fixed between two beams.



As shown in the diagram, a chain block or other lifting device will be supported from an inverted snatch block on the span rope to lift a load.

The load specifics are:

- Span between beams: 8 meters
- Weight of load: 475 kgs
- Weight of lifting gear and load in the hauling part: 50 kg

A. What is the tension in the span rope when the sag is at its recommended minimum? Show formula and all workings/calculations.

Option 1:	Option 2:
$\text{Minimum Sag} = \text{Span} \times 0.05$ $= 8\text{m} \times 0.05$ $= 0.4\text{m}$ Then: $\text{Tension in Span Rope} = \frac{\text{Total Head Load} \times \text{Span}}{4 \times \text{Sag}}$ $= \frac{525\text{kg} \times 8\text{m}}{4 \times 0.4\text{m}}$ $= \frac{4200\text{kgm}}{1.6\text{m}}$ $= 2625\text{kg}$	$\text{Tension in Span Rope} = \text{Total Head Load} \times 5$ $= 525\text{kg} \times 5$ $= 2625\text{kg}$

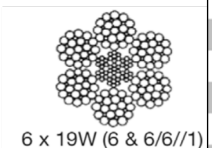
B. Based on your answer to the previous question, determine from the following wire rope chart below:

Part A: Minimum diameter of the main span rope? 20mm (red circle)

Part B: Minimum breaking force of the main span rope? 176kN (green circle)

Round Strand 6 x 19 IWRC

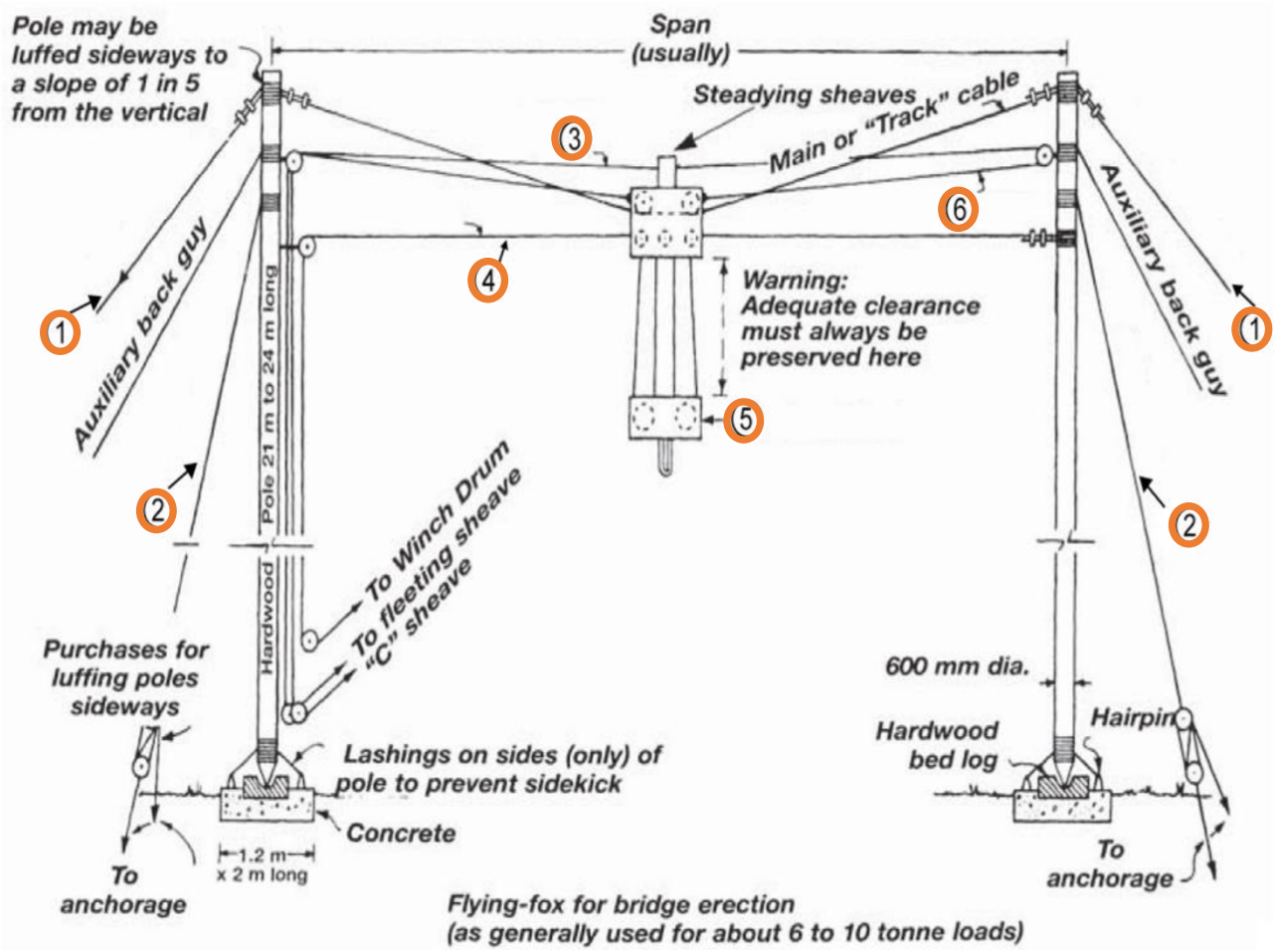
Safety Factor 6:1



Note: Working Load Limit (WLL) is based on 1/6th of Minimum Breaking Force

Nominal Diameter (mm)	Working Load Limit (WLL) tonnes	Min.Breaking Force at 1570MPa kN	Average Mass kg/100m
6	0.26	15.8	11.4
7	0.36	21.5	15.6
8	0.48	28.2	20.4
9	0.61	35.6	25.8
10	0.75	44.0	31.8
11	0.90	53.2	38.5
12	1.07	63.3	45.8
13	1.26	74.3	53.8
14	1.47	86.2	62.4
16	1.92	113.0	81.5
[illegible]	2.43	[illegible]	103.0
20	2.99	176.0	127.0
[illegible]	3.62	[illegible]	154.0
24	4.30	253.0	183.0
26	5.05	297.0	215.0
28	5.86	345.0	250.0
32	7.65	450.0	326.0

C. Name the identified parts of the span line system:



1. Anchorage Rope
2. Side Guy
3. Transverse Rope
4. Hoist Rope
5. Bottom Block
6. Transverse Rope

Section 9: Swing Stage Calculations

Scenario: You need to erect a suspended scaffold from a counterweighted cantilevered suspension rig.

The scaffold is an individual cradle supported from two needles with one suspension rope and one scaffolding hoist per needle. The specifics are as follows:

- The needles have an outboard of 1.4 meters and an inboard of 6.4 meters
- The counterweights weigh 22 kgs each
- The rope is 50 meters long and weighs 34 kg per 100 meters
- The hoist's rated capacity: 500 kg
- Each stabilising weight: 18 kg

A. What is the maximum rope tension? Show formula and all workings/calculations.

$$\begin{aligned}\text{MRT} &= (\text{WLL Hoist} \times 1.25) + \text{Total Rope Used Weight} + \text{Total Stabilising Weights} \\ &= (500\text{kg} \times 1.25) + 34\text{kg} + 36\text{kg} \\ &= 625\text{kg} + 70\text{kg} \\ &= 695\text{kg}\end{aligned}$$

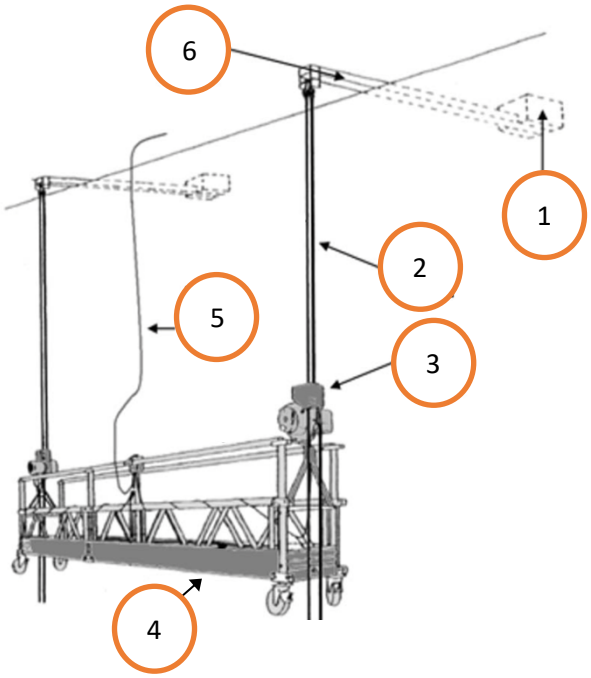
B. Using a safety factor of 3, how many counterweights are needed at the inboard end of the needle? Show formula and all workings/calculations. Answer must be shown as a whole number.

$$\begin{aligned}&\#\ \text{Counterweights Required} = \text{MRT} \times \text{Outboard} \div \text{Inboard} \times 3 \div \text{Weight of single Counterweight} \\ &= 695\text{kg} \times 1.4\text{m} \div 6.4\text{m} \times 3 \div 22\text{kg} \\ &= 20.7 \text{ rounded up to } 21 \text{ counterweights.}\end{aligned}$$

C. Using a safety factor of 10, what is the minimum guaranteed breaking load of the suspension rope? Show formula and all workings/calculations.

$$\begin{aligned}\text{MGB} &= \text{WLL Hoist} \times 10 \\ &= 500\text{kg} \times 10 \\ &= 5000\text{kg}\end{aligned}$$

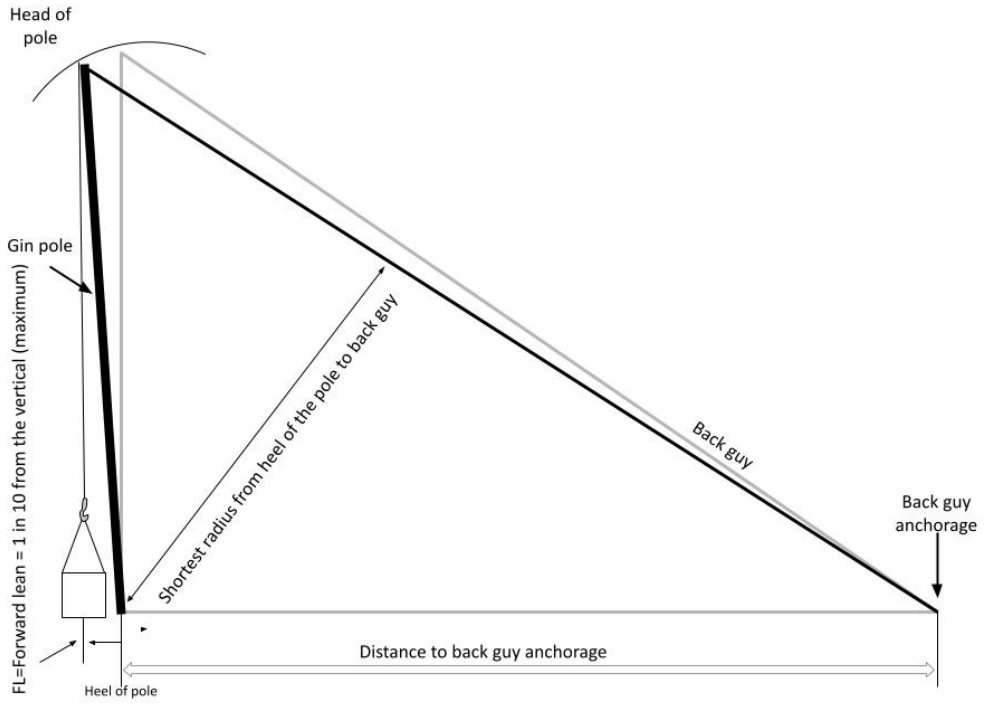
D. Name the identified parts of the span line system:



1. Counterweights
2. Suspension and Secondary Ropes
3. Electric Scaffold Hoist
4. Modular Swing Stage Scaffold (Cradle)
5. Power cable
6. Counterweight Needle

Section 10: Gin Pole Calculations

Scenario: You need to set up a gin pole at the recommended maximum lean to lift a load. The guys will be anchored at the minimum distances from the foot of the pole. The lead rope will run parallel to the pole as shown in the diagram.



The load specifics are as follows:

- Height of pole: 24 meters
- Weight of load: 25.5 tonnes
- Load on the lead rope: 3.5 tonnes
- Shortest radius from heel of pole to back guy: 19 meters

A. What is the recommended minimum distance between the pole heel and the back guy anchor? Show formula and all workings/calculations.

$$\begin{aligned}\text{Minimum Distance} &= \text{Pole Height} \times 1.5 \\ &= 24\text{m} \times 1.5 \\ &= 36\text{m}\end{aligned}$$

B. What is the recommended maximum forward lean on the pole? Show formula and all workings/calculations.

Option 1:

$$\begin{aligned}\text{Forward Lean} &= \text{Pole Height} \times 0.1 \\ &= 24\text{m} \times 0.1 \\ &= 2.4\text{m}\end{aligned}$$

Option 1:

$$\begin{aligned}\text{Forward Lean} &= \text{Pole Height} \div 10 \\ &= 24\text{m} \div 10 \\ &= 2.4\text{m}\end{aligned}$$

C. What is the Total Head Load (THL)? Show formula and all workings/calculations.

$$\text{Total Head Load} = \text{Total Load} + \text{Load in the Lead Rope}$$
$$= 25.5\text{T} + 3.5\text{T}$$
$$= 29\text{T}$$

D. What is the tension in the back guy? Show formula and all workings/calculations.

$$\text{Tension} = \text{Total Head Load} \times \text{Forward Lean} \div \text{Shortest Radius}$$
$$= 29\text{T} \times 2.4\text{m} \div 19\text{m}$$
$$= 3.663\text{T rounded up to } 3.664\text{T or } 3664\text{kg}$$

E. What is the diameter of the FSWR in the back guy? Show formula and all workings/calculations.

$$\text{Diameter} = \sqrt{\text{Tension in the Back Guy} \div 8}$$
$$= \sqrt{3664\text{kg} \div 8}$$
$$= \sqrt{458}$$
$$= 21.5 \text{ rounded up to } 22\text{mm}$$

F. What is the compression load on the gin pole? Show formula and all workings/calculations.

$$\text{Compression Load} = \text{Total Head Load} \times 1.125$$
$$= 29\text{T} \times 1.125$$
$$= 32.625\text{T}$$

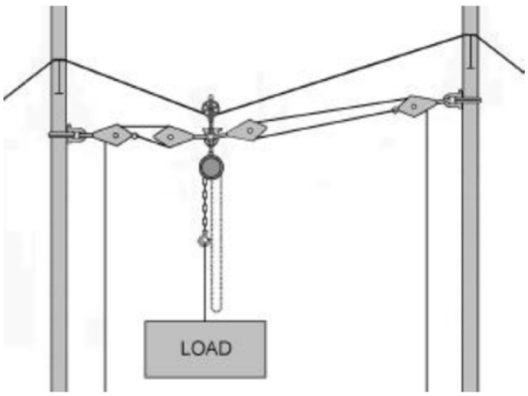
G. Determine the minimum pole size from the table below? (Circle your answer on the table below)

Oregon size in mmm	SAFE TOTAL LOAD AT POLE HEAD IN TONNES Length of pole in metres											Oregon size in mmm
	4.5	6	7.5	9	11	12	13.5	15	18	21	24	
	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	
100 x 100	1.05	0.75	-	-	-	-	-	-	-	-	-	100 x 100
150 x 150	3.0	2.6	2.0	1.7	-	-	-	-	-	-	-	150 x 150
200 x 200	6.5	6.0	5.25	4.5	3.75	3.2	-	-	-	-	-	200 x 200
250 x 250	12.0	11.0	10.0	9.0	8.0	6.5	6.0	5.0	-	-	-	250 x 250
300 x 300	18.5	17.0	16.0	15.0	14.0	12.0	11.0	9.0	7.0	-	-	300 x 300
350 x 350	26.5	26.0	24.0	23.0	22.0	20.0	18.0	17.0	13.0	11.0	-	350 x 350
400 x 400	-	-	-	-	-	30.0	28.0	26.0	21.0	17.0	14.0	400 x 400
450 x 450	-	-	-	-	-	-	-	-	30.0	26.0	27.0	450 x 450

Off chart – refer to engineer or identify legitimate ways to reduce load on gin pole to bring it back on chart.

Section 11: Span Line Calculations

Scenario: You need to install a span rope fixed between two beams.



As shown in the diagram, a chain block or other lifting device will be supported from an inverted snatch block on the span rope to lift a load.

The load specifics are:

- Span between beams: 32 meters
- Weight of load: 200 kgs
- Weight of lifting gear and load in the hauling part: 25 kg

A. What is the tension in the span rope when the sag is at its recommended minimum? Show formula and all workings/calculations.

Option 1:	Option 2:
$\text{Minimum Sag} = \text{Span} \times 0.05$ $= 32\text{m} \times 0.05$ $= 1.6\text{m}$ Then: $\text{Tension in Span Rope} = \frac{225\text{kg} \times 32\text{m}}{4 \times 1.6\text{m}}$ $= \frac{225\text{kg} \times 8\text{m}}{4 \times 1.6\text{m}}$ $= \frac{7200\text{kgm}}{6.4\text{m}}$ $= 1125\text{kg}$	$\text{Tension in Span Rope} = \text{Total Head Load} \times 5$ $= 225\text{kg} \times 5$ $= 1125\text{kg}$

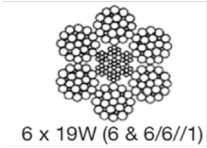
B. Based on your answer to the previous question, determine from the following wire rope chart below:

Part A: Minimum diameter of the main span rope? 13mm (red circle)

Part B: Minimum breaking force of the main span rope? 74.3kN (green circle)

Round Strand 6 x 19 IWRC

Safety Factor 6:1

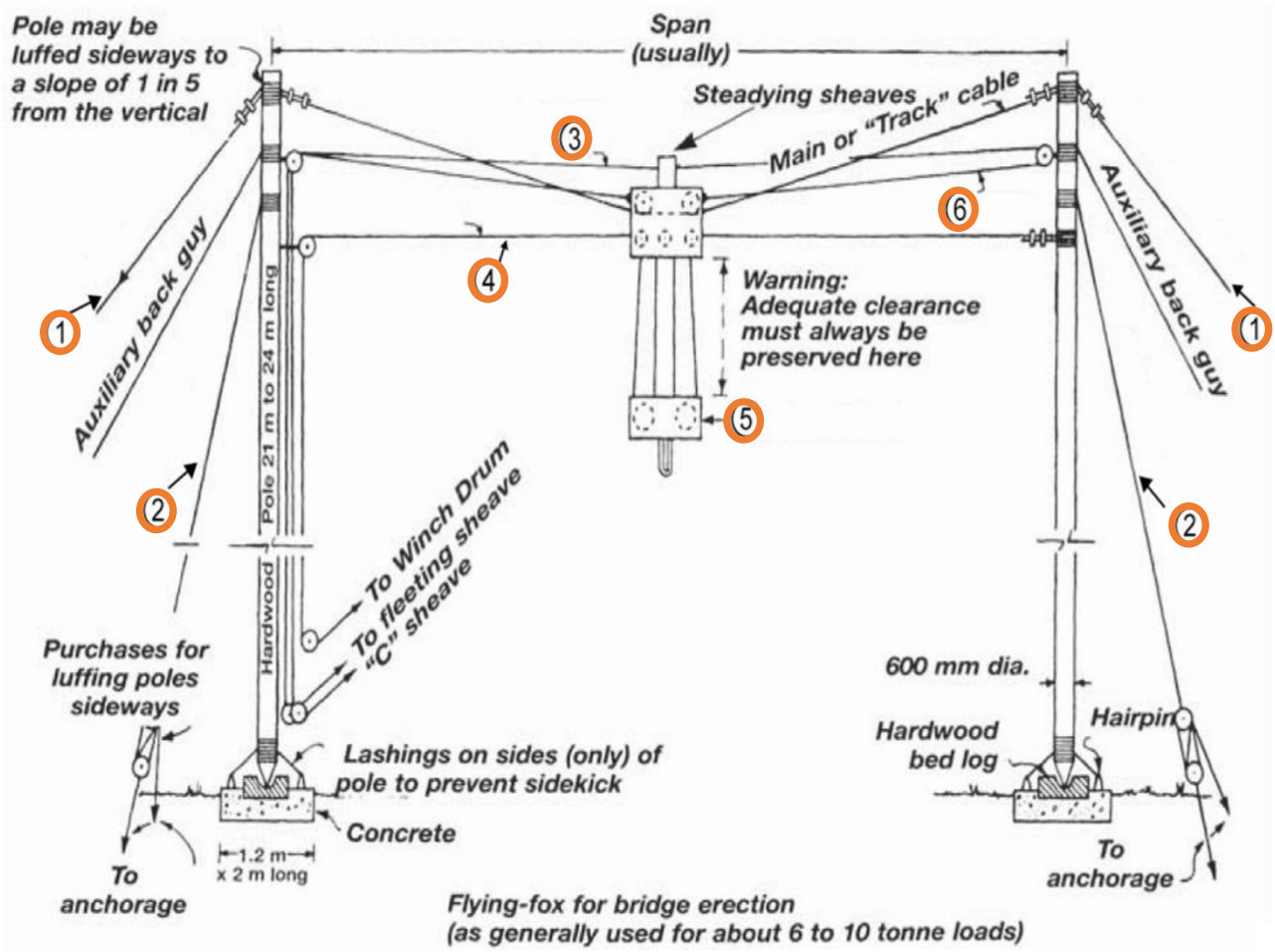


6 x 19W (6 & 6/6//1)

Note: Working Load Limit (WLL) is based on 1/6th of Minimum Breaking Force

Nominal Diameter (mm)	Working Load Limit (WLL) tonnes	Min.Breaking Force at 1570MPa kN	Average Mass kg/100m
6	0.26	15.8	11.4
7	0.36	21.5	15.6
8	0.48	28.2	20.4
9	0.61	35.6	25.8
10	0.75	44.0	31.8
11	0.90	53.2	38.5
12	1.07	63.3	45.8
13	1.26	74.3	53.8
14	1.47	86.2	62.4
16	1.92	113.0	81.5
18	2.43	143.0	103.0
20	2.99	176.0	127.0
22	3.62	213.0	154.0
24	4.30	253.0	183.0
26	5.05	297.0	215.0
28	5.86	345.0	250.0
32	7.65	450.0	326.0

C. Name the identified parts of the span line system:



1. Anchorage Rope
2. Side Guy
3. Transverse Rope
4. Hoist Rope
5. Bottom Block
6. Transverse Rope

Section 12: Swing Stage Calculations

Scenario: You need to erect a suspended scaffold from a counterweighted cantilevered suspension rig.

The scaffold is an individual cradle supported from two needles with one suspension rope and one scaffolding hoist per needle. The specifics are as follows:

- The needles have an outboard of 0.9 meters and an inboard of 4.9 meters
- The counterweights weigh 14 kgs each
- The rope is 100 meters long and weighs 34 kg per 100 meters
- The hoist's rated capacity: 700 kg
- Each secondary line is tensioned by ratchet to the equivalent of 28kg

A. What is the maximum rope tension? Show formula and all workings/calculations.

$$\begin{aligned}\text{MRT} &= (\text{WLL Hoist} \times 1.25) + \text{Total Rope Used Weight} + \text{Total Stabilising Weights} \\ &= (700\text{kg} \times 1.25) + 68\text{kg} + 56\text{kg} \\ &= 875\text{kg} + 124\text{kg} \\ &= 999\text{kg}\end{aligned}$$

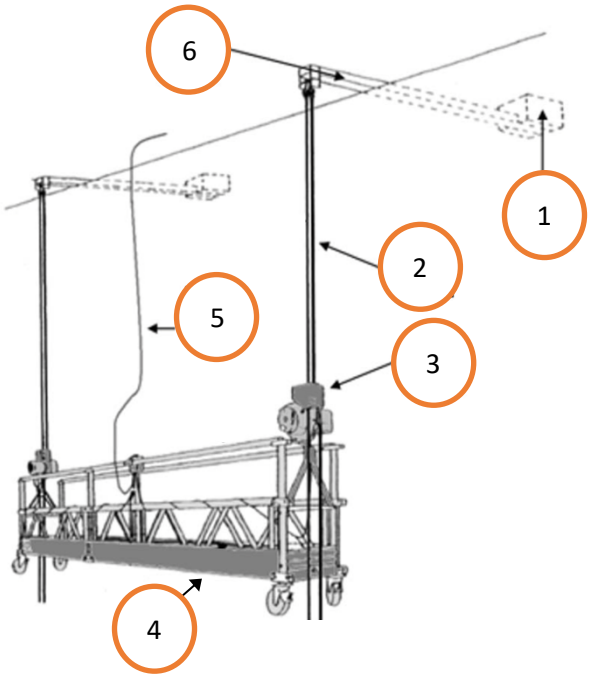
B. Using a safety factor of 3, how many counterweights are needed at the inboard end of the needle? Show formula and all workings/calculations. Answer must be shown as a whole number.

$$\begin{aligned}&\#\ \text{Counterweights Required} = \text{MRT} \times \text{Outboard} \div \text{Inboard} \times 3 \div \text{Weight of single Counterweight} \\ &= 999\text{kg} \times 0.9\text{m} \div 4.9\text{m} \times 3 \div 14\text{kg} \\ &= 39.3 \text{ rounded up to } 40 \text{ counterweights.}\end{aligned}$$

C. Using a safety factor of 10, what is the minimum guaranteed breaking load of the suspension rope? Show formula and all workings/calculations.

$$\begin{aligned}\text{MGB} &= \text{WLL Hoist} \times 10 \\ &= 700\text{kg} \times 10 \\ &= 7000\text{kg}\end{aligned}$$

D. Name the identified parts of the span line system:



1. Counterweights
2. Suspension and Secondary Ropes
3. Electric Scaffold Hoist
4. Modular Swing Stage Scaffold (Cradle)
5. Power cable
6. Counterweight Needle