Design of a Portable Headframe

Rodney C. Foster

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DESIGN OF A
PORTABLE HEADFRAME

By
Rodney C. Foster

May 10, 1957
Montana School of Mines
Mining 68
Spring Semester 1957
Mining Methods

Report
Submitted to
Professor K. S. Stout

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PORTABLE HEADFRAME

By
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May 10, 1957
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DESIGN OF A PORTABLE HEADFRAME

INTRODUCTION

Present day methods of ore exploration consists of surface geology, geophysical methods, and drilling datum. These methods have all produced results, but, the sure way of telling whether ore is present is to look at it in place, determine it's tonnage, grade, and ease of mining. This can only be done by the use of a headframe to sink a shaft. Therefore a low cost, well designed, and easily constructed headframe would be a great aid to underground exploration work. For this reason the report is devoted to the design of a portable headframe to be used in preliminary ore development.

DESIGN

The headframe was designed with emphasize on the following points:

1. Ease of transportation
2. Ease of setting up and dismantling
3. Working space
4. Construction
5. Strength
6. Cost
7. Flexibility

These points will be discussed on the following pages.

Ease of Transportation

Much of the terrain in mining country is highly irregular and a light portable headframe would be a great help to exploration. With this in mind the headframe was designed of 6 in. pipe with an overall weight of 7020 lb.
The structure consists of four welded panels, a sheave wheel
and block, and accessory members. The welded panels are designed
to a size that would easily facilitate their handling and trans-
portation on a small truck. The only restriction to their haulage
on the open highway would be that in some states a hauling permit
would be required, because their width slightly exceeds the
allowable limit. This however is not a serious objection.

Setting up and Dismantling

Setting up and dismantling the headframe is considered because
of the time factor involved. After a suitable area of about 20 X 30 ft
has been cleared and leveled, the foundation set, two men should
be able to set the headframe up in about two days; dismantling
should take less time. This would reduce the labor force considerably
and save days of valuable working time.

Assembling the structure would consist of placing the welded
panels in the correct position and bolting them and the additional
members securely. Installation of the hoisting motor would finish
the job and the headframe would be ready for operation.

Working Space

Ordinarily in the construction of headframes the smallest
fleet angle obtainable is desired. However in this design the
fleet angle was not considered, the object here was to conserve
on the area leveled and still give ample space. For this reason
the headframe was also designed to provide the foundation for the
hoisting drum and motor if necessary. The iron plate bolted to
the ground members in Figure 1, page 8, is the reserved space for installation. Ample head room is also provided by the location of the headframe members to allow easy access to the collar of the shaft and facilitate in the handling of supplies around the shaft opening.

**Construction**

As mentioned before the headframe would be constructed of standard 6 in., 20 lb/ft pipe utilizing welded joints on the A-frame. Figure 1, page 8 shows the details of construction. The members joining the front and back transverse are 6 X 2 1/2 in., 12 lb/ft angle iron and are fastened to a A-frame with 10 X 3/4 in. bolts. All the welded joints could be easily welded with an electric arc machine and all sizing of the individual members could be cut with an acetylene torch. Special care should, however, be exercised in prefabricating the joints connecting the welded panels. Design of the joint is shown on Figure 2, page 9.

**Strength**

The strength of the pipe in the headframe should be able to withstand the heaviest load that could be imposed upon it. Therefore the breaking load on the rope selected is the determining factor. Calculations for selection of the desired rope, page 11, shows this load to be about 82,000 lb, using the maximum elastic limit in tension and compression the pipe would easily withstand this load as the following calculations testify. The allowable working stresses for structural steel as given by The Chicago Building Laws also show favorable conditions as shown below.
1. Elastic limit

Maximum stress tension = 35,000 psi
Maximum stress compression = 35,000 psi

\[ P = SA \quad A = \frac{\pi d^2}{4} - \frac{\pi d^2}{4} = \]

\[ P = 35,000 \text{ psi} \times 5.4 \text{ in.}^2 \]

\[ = 189,000 \text{ lb} \]

Where:

\[ P = \text{Acting Force} \]
\[ S = \text{Elastic Limit} \]
\[ A = \text{Area} \]


Maximum stress = 18,000 psi

\[ P = SA \quad \text{Where:} \]

\[ = 18,000 \text{ psi} \times 5.4 \text{ in.}^2 \quad P = \text{Acting Force} \]

\[ = 97,000 \text{ lb} \quad S = \text{Maximum allowable stress} \]

\[ A = \text{Area} \]

As both these calculations show the maximum load is well within the desired limit.

Welded joints were utilized on the A-frame because if properly applied their strength exceeds that of the pipe. The calculations below for the shearing stress will illustrate this point. The largest force acting on any point is a force in tension of 14,400 lb, therefore figures on the remaining welded points will be omitted.

\[ S_s = \frac{P}{A} \quad \text{Where:} \]

\[ S_s = \text{Shearing stress} \quad P = \text{Acting force} \]
\[ A = \text{Welded area} \]

\[ S_s = \frac{14,400}{3} \]

\[ = -4,800 \text{ lb/in.}^2 \]

Circumference around the weld = 16 in.

\[ A = 3 \text{ in.}^2 \]
The shearing stresses allowable for structural steel according to the New York Building Laws are 13,500 lb/in.², therefore the strength of the welded joints are well within the limit allowable.

Girders supporting the sheave wheel should be constructed of a strong structural steel which would give the strength necessary to withstand a breaking load. A 15 in. channel at 33.9 lb/ft and a 12 in. channel at 30 lb/ft were selected. Calculations supporting the selections are given below.

(1.) Front Posts

Moment on Post = 1,200,000 in.-lb

(2.) \( M = \frac{SI}{c} \)

Where:

- \( M \) = Bending Moment
- \( S \) = Allowable Unit Stress
- \( I \) = Moment of Inertia
- \( c \) = Distance from the neutral axis

\[
M = \frac{18,000 \times 312.6 \times 2}{7.5} = 1,500,000 \text{ in.-lb}
\]

The 1,500,000 in.-lb exceeds the amount calculated in step 1 above therefore the selection of the 15 in. channel for the front post is satisfactory and will be used.

(1.) Back Posts

Moment on Post = 96,000 in.-lb

(2.) \( M = \frac{SI}{c} \)

\[
M = \frac{18,000 \times 161.2 \times 2}{6} = 97,000 \text{ in.-lb}
\]

This figure exceeds the above figure of 96,000 in.-lb therefore the channel selected for the back post would be satisfactory. Bolts 10 X 3/4 in. would be used to fasten the girders to the headframe.
Pages 12 through 23 show the dead-load, live-load, and the wind-load stress the headframe is subjected to. Page 22 is a summation of these stresses.

**Cost**

Costs for construction materials for the headframe were obtained from The Butte Steel and Iron Works, and are as follows:

- Standard 6 in. pipe = $1.95/ft
- 6 X 2 1/2 in. Angle Iron = $1.10/ft
- 6 X 3 in. Angle Iron = $1.25/ft
- Lincoln Welding Rod = $0.20/lb
- Bolts 10 X 3/4 in. = $0.60/Bolt
- Bolts 3 X 3/4 in. = $0.25/Bolt
- Labor = $16.00/day

Total cost for the materials to build the headframe would be approximately $2,000.00.

The savings in the construction is not in savings of material to any extent but to the saving obtained with labor. This savings results from the use of welded joints and acetylene cutting torches which greatly speed up the time of prefabication.

**Flexibility**

Some operators will use the portable headframe as a permanent installation. It will adapt easily to a sinking operation where two or perhaps a three compartment shaft is desired. An extension could be added to the front of the headframe and other sheave wheels added. Another possibility is to widen the apex and place an additional sheave along side: this method would be limited to 2 1/2 compartment shaft. Either possibility should be examined, however, before making the addition.
CONCLUSION

The portable headframe in this report was designed primarily for the use in ore exploration work where surface, geophysical, and drilling results have indicated a favorable ore deposit. If ore is discovered it is intended that the operator will install a larger permanent headframe. However if the ore bodies size does not warrant further capitalization or if additional capital cannot be obtained the portable headframe can be adapted to a permanent installation.

It should be noted that some of the members are constructed from 6 X 2 1/2 in. angle iron, and the shaft guides are 6 X 3 in. angle iron. Angle Iron with these dimensions are no longer manufactured. The nearest size angle iron available at the present time is 6 X 3 1/2 in. and could be readily adapted to the structure with no apparent change in strength.

In the construction of the stress diagrams some members were assumed to facilitate the drawing of the diagrams. Since the resulting stresses were very low a small error was introduced. This error should not have any serious effect on the results obtained.
PORTABLE HEADFRAME
ALL STRUCTURE UNLESS SPECIFIED IS 6" PIPE
6" PIPE AT 20 LB/FT = 238 FT = 4800 LB
6 X 2 1/2" I R O N AT 12 LB/FT = 80 FT = 960 LB
6 X 3" I R O N AT 15 LB/FT = 31 FT = 465 LB
30'-10X3/4" B. 15-3X3/4" BOLTS = 42 LB
3' S H E A V E = 500 LB 1 R O N P L A T E = 250 LB
SCALE 1" = 5', TOTAL WEIGHT = 7020 LB
APRIL 7, 1957, RODNEY C. FOSTER
WEIGHTS FOR DEAD LOAD STRESS

Total Load = \( \frac{6520 + 250}{2} + 3260 + 250 = 3510 \text{ lb} \)

There are 10 panel points. (Two at the apex)

\( \frac{3510}{10} = 350 \text{ lb at each panel point} \)

At the apex

\( 2 \times 350 + 250 = 950 \text{ lb} \)
MAXIMUM WEIGHT FOR LIVE LOAD STRESS

Size of Rope

Depth = 1500 ft
Maximum velocity = 1500 ft 1 min
Maximum weight to hoist = 10,000 lb
Acceleration = 5 ft/sec.\(^2\)
Safety factor = 6
Time = 5 sec.

\[
F = \frac{W}{g} \cdot \frac{Vt - Vo}{t}
\]
\[
= \frac{10,000 \times 5}{32.2}
\]
\[
= 1,550 \text{ lb}
\]

10,000 + 1,550 lb = 11,550 lb

11,550 \times 6 = \frac{69,300}{2000}

= 34.65 tons

Try 1.0" rope weighs 1.60 lb/ft

1500 \times 1.60 = 2,400 lb

\[
F = \frac{2,400}{32.2} \times 5
\]
\[
= 375 \text{ lb}
\]

2,400 + 375 = 2775 lb

2,775 \times 6 = 16,650 lb

69,300 + 16,650 = 85,950 lb

= 42.98 tons

Use 1.0" special steel rope, 6 strands, 19 wires to the strand, 1 hemp core. Weight = 1.60 lb/ft

Safety Factor

\[
\frac{42 \times 2000}{14,325} = 84,000 = 5.86 \text{ Safety factor}
\]

The 1" rope would be satisfactory
Fig. 4

Moments about P.

\[ P_1 = P \]
\[ 2P = 2P \]
\[ 1P = 2P \]
\[ 15600 = 2P \]
\[ P = 7800\,\text{Lb.} \]

P & P are vertical forces and must be resolved into the plane of the A-frame. These forces are E & E.

\[ P = \tan \phi \]
\[ \phi = \frac{8.5}{20} \]
\[ \theta = 18^\circ \]
\[ \cos \theta = 0.951 \]

\[ E = \frac{P}{78000} \]
\[ E = \frac{900}{78000} \]
\[ E = 8200\,\text{Lb.} \]

Determination of resultant from breaking stress acting on the rope.

Breaking load 84000

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<tr>
<th>Load</th>
<th>F, Lb</th>
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<tr>
<td>S, Lb</td>
<td>186000</td>
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\[ \text{Stress in rope} = S \]
\[ \text{Resultant stress} = F = 1.86S \]
Figure 6

Stress in front & rear transverse frame

\[ P_1 = P = 78000 \text{ LB.} \]
\[ G_1 = G = 40000 \text{ LB.} \]
\[ H_1 = H = 46000 \text{ LB.} \]

Scale 1" = 24000
Fig. 8

G = G = 40000 Lb.

Stress Diagram
Scale 1" = 24000 Lb.

Live Load Stress in the Back Transverse Frame

Space Diagram
Scale 1" = 5 Ft.
Fig. 9

STRESS DIAGRAM
SCALE = 1200Lb.

WINDLOAD STRESS IN FRONT TRANSVERSE
CASE!

SPACE DIAGRAM
SCALE = 5 Ft.

Professor K. S. Stout
May 10, 1957
Fig. 10

STRESS DIAGRAM
SCALE 1" = 1200 lb.

CASE II
WINDLOAD STRESS IN BACK TRANSVERSE

SPACE DIAGRAM
SCALE 1" = 5 ft.

R_1 = 2520
V_y

R_1 = 2500

A
B
C
D
E
F
G
H
K

90°

90°

90°

90°

90°
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<th>MEMBERS</th>
<th>A - FRAME</th>
<th>FRONT POST</th>
<th>BACK POST</th>
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<th>FRONT TRANSVERSE BRACING</th>
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