Design of a Reinforced-Concrete Coaling Station

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DESIGN OF A REINFORCED-CONCRETE COALING STATION

BY

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I recommend that the thesis prepared under my supervision by HOMER WALSTON DAHRINGER entitled Design of a Reinforced-Concrete Coaling Station be approved as fulfilling this part of the requirements for the degree of Bachelor of Science in Civil Engineering.

Recommendation approved  

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Head of Department of  
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DESIGN OF A REINFORCED CONCRETE COALING STATION.

In this paper the following outline will be followed.

I. Definition of coaling station.

II. History of coaling stations.

A. Development.

1. Effort to reduce the waste and cost of handling coal.

2. Effort to save the time of coaling locomotives on the main line and in congested terminals.

B. Methods of coaling.

1. Shoveling from railroad cars to tenders.

2. Shoveling from cars to platforms then to tenders.

3. Crane and bucket system from storage platforms. Handfilled buckets.

4. Shoveling and dumping from cars to bins from elevated trestles (Gravity feed).

5. Hauling up steep incline by cable and dumping into bins (Gravity feed).

6. Dumping from railroad cars and elevating by conveyors and air hoists (Gravity feed).

7. Locomotive cranes from stock piles to tender.

8. Dumping through trestle and tramming into tenders.
C. Cost of coaling by different methods.
D. Discussion of types of coaling stations.
   1. Steel.
      a. Deterioration due to gases, rust, etc.
      b. Past experience proves them impractical.
   2. Wood.
      a. Cheaper first cost.
      b. Harder to insure.
      C. Not permanent.
      d. Up-keep expense.
      a. Permanent.
      b. Cheaper in the end.
      c. Greater strength.
      d. Practically no cost of maintenance.

III. Requirements of Ill. at Champaign.
   A. Present condition of Ill. R. R.
      1. Rolling stock.
      2. Earning capacity.
      3. Local conditions.
   B. Future growth of Ill. R. R.
      1. Based on increase in traffic.

IV. Design of Structure.

V. Conclusion.
I. DEFINITION

The term "Coaling Station" is given to the device or appliances which are adapted to supplying locomotives with coal.

II. HISTORY OF COALING STATIONS

The development of coaling stations has not kept pace with the growth of the railroads. Just a few years ago probably no part of the railroad was run with as little system and uniformity as was the coaling of the locomotives. The increased price of coal, together with the greater traffic and meagerness of yard room, has made necessary the adoption of some economical device for the coaling of locomotives.

METHODS OF COALING.

The following is a chronological list of a few of the methods of coaling locomotives used in the development of the American railroad.

A. Shoveling from railroad cars to tenders.
B. Shoveling from platforms to tender.
C. Storage platform with the crane and bucket fixtures.
D. Dumping through trestle and tramming into tenders.
E. Storage piles with locomotives cranes.
F. Storage bins with trestle approaches.
C. Storage bins with conveyors and air hoists.
A. Shoveling from railroad cars to tenders.

This method of coaling locomotives was to shovel the coal direct from the railroad cars to the locomotive tender. The only requirement for this was a short side track upon which the coal cars could be placed. This method is both slow and costly to operate and is no longer used except as a temporary expedient while a more complete station is being built.

B. Shoveling from platform to tenders.

This method is possible where the side track can be placed at a slight elevation above the main track. The platform is built high enough to make the work of shoveling into the tenders a minimum. This method has several advantages over the preceding one. It provides for the storage of a quantity of coal and does away with the labor of shoveling coal up over the sides of a car into the engine tender. This advantage offsets the disadvantage of having to handle the coal twice. The platform should of course be built high enough, also, to do away with the lift over the side of the tender.

C. Storage platform with crane and bucket fixtures.

The introduction of the crane and bucket was a step in advance of the elevated platforms. In this plant a platform is used for the storage of the coal. A jib crane is placed on the platform with about eight or ten
buckets or tubs. The buckets are fitted with wheels and are of about one to one and a half tons capacity. They are hand filled and can be rolled along the platform from any point to the crane. The crane is operated by hand power.

There are several modifications of this plant. In one case enough buckets are filled to last throughout the day. They are placed next to the air hoist so that the enginemen do their own coaling.

D. Dumping through trestle and tramming into tenders.

This method which was used to quite an extent a few years ago is practically obsolete now. It consists of a trestle leading up to a platform about 20' high. The coal is shoveled from the cars out upon the platform and then shoveled into small push cars which operate on a tramway spanning the track. The small cars are run out over the tenders and dumped. This method is both costly and slow. It is used on some roads, however, that burn a mixture of bituminous and anthracite coal, the coal being mixed on the platform.

E. Storage piles with locomotives cranes.

Several roads have used this method of coaling to great advantage. The locomotive cranes work either from a storage pile or from cars direct to the tenders. They are of the usual locomotive type and
are filled with grab buckets. They can be used for handling the coal, ashes and cinders, and even for light wrecking work, so that at no time need they be idle. They are very efficient and are quite rapid. Each bucket holds about one ton of coal.

F. Storage bins with trestle approaches.

This type is perhaps the most common of all coaling stations. The cars are drawn up on elevated trestles and unloaded into pockets or bins. The coal is loaded into the tenders by gravity. These stations differ from each other only in the ways in which the cars are elevated and unloaded. In some stations the incline of the trestle is so steep as to make it necessary to pull the cars up by means of a steam winch and cable, while others have a grade small enough to permit the cars to be pushed up by locomotives. The former method permits of a 20% grade being used and is much safer and convenient than the latter method. A grade of 5% is about the maximum to be used when a switch engine must push the cars up the incline. This grade makes necessary a long trestle which is both expensive and dangerous. Besides this disadvantage a switch engine is not always available, and this might cause delay. With the winch and cable a trestle of only one fourth the length is necessary. It may also be made lighter as it must bear the weight
of only the one slowly moving car instead of three or four rapidly moving cars and a locomotive.

The storage track for loaded cars should have sufficient down grade toward the foot of the trestle to allow loaded cars to roll to a position where they can be picked up by the cable.

There are two methods of unloading the cars into the pockets. One is by shoveling out the coal, the other by dumping the cars. Of the two methods the latter is of course the cheaper and more rapid, although it has the disadvantage of not distributing the load.

The coal is taken from the bins through chutes of different designs. It is in the improvement of these chutes that most of the progress in design is now being made.

G. Storage bins with conveyors and air hoists.

This type of coaling station is the most modern of all and the best design. The working principle is as follows: The coal is dumped into a pit under the coal-car tracks from which it is elevated to the storage bins by some form of conveying machinery. The canvas belt conveyor, and chain and bucket conveyor are perhaps the most common of the conveying machinery, although the air hoist is used to a considerable extent.

These plants have two decided advantages over all others, viz: They have better storage facilities
and occupy less ground space. The storage bins are closed bins having sloping bottoms with the chutes placed at the lowest part of the bin. The coal is protected from the weather. The greatest objection to this type of coaling station is its high first cost of construction. It is a station of this type which the writer is to design, so more will be said of it in a subsequent discussion.

Cost of Coaling by Different Methods.

The cost of handling coal at various coaling stations is made up largely of the following items:

1. Operation.
3. Depreciation.
4. Car rental.
5. Interest on the investment.

Due to the fact that all data cannot be gathered from one station, it is very difficult to make an accurate comparison of the cost of operating the different types of stations.

Since the type A stations are only make-shift affairs and not in any way permanent, no careful authentic records can be had. The writer estimates the probable cost of coaling from 30¢ to 60¢ per ton.

The cost per ton of coaling the type B station varies between wide limits. This type depends mostly on the cost of manual labor; and manual labor varies in
different parts of the country. In the South the negro labor can be secured much cheaper than can the labor in
the North. Likewise in the North the labor is made harder by weather conditions, such as sleet and ice storms.
This is an important item at stations where the coal is not kept under cover. The cost also varies with the
amount of coal handled daily by the station. It ranges from 19¢ to 50¢ per ton. The upper limit was taken
from a station which operated under very adverse conditions.

With the type C station the price is more uniform. As shown by various plants it ranges from 15¢ to 30¢ per ton. This variation is due mainly to the
difference in the capacity of the coaling station.

Types D and F vary in their cost of operation according to the way in which the coal is elevated and unloaded, and according to the arrangements made for storing the coal. In the type where the car is run up the trestle and unloaded by hand shoveling, the cost per ton will run up as high as 20¢; whereas with the self dumping or unloading cars the price will run as low as 2¢ per ton, and seldom cost more than 15¢ per ton. The reason for
this is of course perfectly obvious. Some stations are built large enough to store coal sufficient for a forty-eight hour "drag," while others are of such a capacity that coal must be kept on hand stored in coal cars. This makes an added expense to the total cost of coaling per ton. The average car will hold 40 tons of coal. The demurrage
for the car for each day it is held in the yard is one dollar. This amounts to 2.5 cents per ton added expense. If a forty-eight hour supply is to be kept on hand, the extra cost will be 5¢ per ton. This expense alone is larger than the total coaling expense of some of the stations. This shows the advisability of designing the station large enough to provide for the future growth.

With the type E stations it is harder to determine the cost per ton of coal handled. From various data obtained from working plants the writer estimates it at from 5¢ to 15¢ per ton. The fact that the locomotive crane can be put to other uses when it is not being used for coaling locomotives is a great argument in favor of this type of station. This fact enables work to be done under the most economical conditions.

The type G plants average about the same for cost of operation per ton as do the trestle and storage bin stations. They have, however, so many advantages over the other types that they are coming into general use.

Coaling stations may be built either of steel, wood, or concrete. A little investigation shows conclusively that a concrete structure will prove cheaper in the end. Steel structures have never been very much used for coaling stations. They are more expensive as to first cost than the wooden structures, and are not
as permanent as either the wooden or concrete structures. The gases from the locomotive, and other causes, make the steel structure deteriorate very rapidly. They therefore need not be considered. This narrows the choice down to concrete or wooden structures. The best method of determining the cost of these structures is by the use of a formula. (See Turneaure and Russel's Public Water Supplies)

\[ S = C + \frac{c}{r} + \frac{c'}{(r+1)^n - 1} \]

- \( s \) = Total capitalized sum.
- \( c \) = First cost of structure.
- \( o \) = Operating and maintenance expenses.
- \( r \) = Rate of interest.
- \( c' \) = Cost of renewal.
- \( n \) = Life of structure in years.

From the tables given it is shown that the operating and maintenance expense of a coaling station for a year will average about $2000.00. This is, however, for timber structures. For a concrete structure the operating and maintenance expenses will not amount to more than $1500.00 per year. It has been assumed by prominent engineers that a concrete structure will cost fifty per cent more to build than a wooden structure. Assuming then that the wooden structure of 120 tons capacity cost $10,000.00, the concrete structure of the same capacity will cost $15,000.00 to build. The rate of interest will
of course be the same in both cases and will be taken as 4%. The life of the concrete structure will be taken as 25 years and the timber structure as 15 years. Substituting those values in the formula we get the following results for the total capitalized cost of the two structures.

Timber \[ s = 10000 + \frac{2000}{0.04} + \frac{10000}{(1+0.04)^{15}} - 1 \]

\[ = \$74,000 \]

Concrete \[ s = 15000 + \frac{1500.0}{0.04} + \frac{15000}{(1+0.04)^{25}} - 1 \]

\[ = \$62,100 \]

These results show that although the concrete structure is higher in first cost it is more economical to operate and maintain.

This lower capitalized cost is not the only argument in favor of a concrete station. Coal stations are in an unusually dangerous position so far as fire is concerned. The fireman in cleaning his fires near the structure may be careless, and the sparks from the engine are very likely to set fire to the structure. Besides, the spontaneous combustion of the coal itself is a source of danger. All these things tend to make the fire insurance rate upon a timber structure much higher than that upon a concrete structure, it being practically four times as great for wooden structures as for concrete
ones. This amounts to over 10 per cent of the first cost of the structure. Reinforced concrete coaling stations are permanent and require little maintenance, while wooden structures have an average life of 15 years.

All these facts have led to the construction of many reinforced concrete coaling stations within the past few years; and all that have been built have proved to be entirely satisfactory.

The coaling station to be designed will be of the reinforced concrete type.
THE DESIGN.

The problem is the design of a reinforced concrete coaling station to replace the present station. The present station is of wood and has been just recently built. It has a capacity of 600 tons and is of the modern type using an "alternate lift" arrangement for hoisting the coal. Since bituminous coal only is used, the problem is much simplified. The new station is to be designed for the maximum run and to this is to be added a certain percent for future growth. The amount of coal used per day at present is approximately 300 to 350 tons. Champaign is a division point and is located on the main line from Chicago to New Orleans. Therefore, any conditions that apply to the Ill. Cent. R.R. as a whole will apply to the Champaign Division. It is on this assumption that the future growth of this division point is based.

To determine the growth of the railroad it is best to consider the growth for the last few years. For this purpose the curve shown on the following page showing the earnings of the road for the past fourteen years. One curve gives the total passenger earnings, another gives the total freight earnings, and a third gives the grand total of earnings of the railroad. The data from which these curves were plotted were taken from the United
States Interstate Commerce Statistical Reports.

It is assumed that the coal consumption is proportional to the earnings of the railroad. This assumption is permissible. It is best to design the station for a life of 10 years for many reasons. In ten years conditions are likely to be so different as to make a new structure desirable. At the present time many railroads are taking up the project of oil-burning locomotives. The adoption of these would of course cause the abandonment of coaling stations. In the past fourteen years the earnings of the railroads have increased very nearly $2\frac{1}{2}$ times. This means that in 10 years the earnings have very nearly doubled. The capacity of the station should then be twice as great as at present, or 600 hundred tons. The coaling station then will be designed for 600 tons.

The references used in the design of the different parts of the structure are: - Turneaure and Maurer's "Principles of Reinforced Concrete Construction"; Ketchum's "Walls, Bins and Grain Elevators", and Taylor and Tompsoon's "Concrete, Plain and Reinforced".

In the following design the tensile strength of steel will be taken as 16,000 pounds per square inch, and the compressive strength of concrete as 500 pounds per square inch. The ratio will be taken as 15.
DESIGN OF TOP SECTION OF STRUCTURE.

**Roof Slab.**

A section 12" wide will be considered acting as a beam.

Span = 5' 0".

Wind load $P_n = 20\#/$sq. ft.

Snow load = $20 \times 0.86 = 17\#/sq.ft.$

Dead load = $50\#/sq.ft.$

Total load = $67\#/sq.ft.$

$M = \frac{1}{8} \times 67 \times 5 \times 5 \times 12 = 2400\"$

$M = f_s \rho_j b d^2 \quad R = f_s \rho_j$

From tables, $R = 71 \quad d = \sqrt{\frac{M}{R \rho}}$

$d = \sqrt{\frac{2400}{71 \times 12}} = 1.75\"$

3.5" is, however, the minimum practicable thickness for slab design.

$p = \text{percentage of steel} = 0.005$

Area of steel = $12 \times 3.5 \times 0.005 = 0.21\text{sq.in.}$

The reinforcement used will be $\frac{1}{2}\text{-square rods}$ spaced 6 inches center to center.

---

**Roof Beam.**

Span = 10' 0"

Dead load = $320\#/\text{lineal foot.}$

$M = \frac{1}{8} \times 320 \times 10 \times 10 \times 12 = 48,000\"$
Assume $b = 6''$

\[
d = \sqrt{\frac{48000}{71 \times 6}} = 10.5''
\]

The beam dimensions then are $6' \times 12'' \times 10' 0''$

$p = 0.005 \text{ Area} = .27 \text{ sq. in.}$

The reinforcement used will be two $\frac{1}{2}$-inch square rods spaced 3 inches center to center.

**Side Wall Slab.**

Span = 5' - 0''

Assume the wind load at 30#/sq.ft.

\[
M = \frac{1}{8} \times 30 \times 5 \times 5 \times 12 = 1,120 \frac{ft}{lb}
\]

\[
d = \sqrt{\frac{1120}{71 \times 12}} = 1.15''. \text{ We will use a 3.5'' slab.}
\]

The reinforcement will be $\frac{1}{2}$-inch square rods spaced 6 inches center to center.

**Side Wall Beam.**

Span = 10' 0'' spaced 5' apart.

Wind load = 330 #/ lineal ft.

\[
M = \frac{1}{8} \times 330 \times 10 \times 10 \times 12 = 49,500.
\]

Assume $b = 6'' \quad d = \sqrt{\frac{49500}{71 \times 6}} = 10.8''$

The beam dimensions are $6'' \times 12'' \times 10' 0''$

$p = 0.005 \text{ A} = .36 \text{ sq.in.}$

The reinforcement will be two $\frac{1}{2}$-inch square rods 3 inches center to center.
End Wall Slab.

Span = 10' 0"

The wind load is assumed at 30 #/sq.ft.

\[ M = \frac{1}{8} \times 30 \times 10 \times 10 \times 12 = 45000 \#" \]

\[ d = \sqrt[71 \times 12]{} = 2.3" \]

A thickness of 3.5 inches will be used. The reinforcement will be 1/2-inch square rods spaced 12 inches center to center, both horizontally and vertically.

Girder Beam.

Span = 32' 0"

Total load = 42,600 #

\[ M = \frac{1}{8} \times 42,600 \times 32 \times 12 = 2,044,000\#" \]

Assume \( b = 20" \)

\[ d = \sqrt[71 \times 20]{} = 38" \]

The beam dimensions then are 20" x 40" x 32' 0".

The reinforcement will be ten 3/4-inch square rods. Two sets of two rods each will be bent up 3 feet and 5 feet, respectively, from each end. (See Figure II) Stirrups 1/2 inch square will be used, spaced 12 inches center to center.

DESIGN OF LOWER SECTION OF STRUCTURE.

Roof Slab.

Span = 11'-9" = 11.75'

Dead load = 30 #/sq.ft.
M = \frac{30}{8} \times 11.75 \times 11.75 \times 12 = 6,200 \#" \\
d = \sqrt{\frac{6200}{71 \times 12}} = 2.75" A thickness of 3.5 will be used. The reinforcement will be \(\frac{1}{4}\)-inch square rods spaced 6 inches center to center.

**Roof Beams.**

Span = 11' 9"

Load = 255 \# / lineal ft.

\[ M = \frac{1}{3} \times 255 \times 11.75 \times 11.75 \times 12 = 52,500 \#" \]

Assume \( b = 6" \)

\[ d = \sqrt{\frac{52500}{71 \times 6}} = 11" \]

The beam dimensions are 6" x 12" x 11' 9"

The reinforcement will be two 3/8-inch rods spaced 3 inches center to center.

**Side Walls.**

Slab A. Span = 8' 0"

Load = 400 \# / sq.ft.*

\[ M = \frac{1}{8} \times 400 \times 8 \times 8 \times 12 = 35,400" \]

\[ d = \sqrt{\frac{35400}{71 \times 12}} = 6.7" \] The thickness used will be **eight** inches. The reinforcement will be \(\frac{1}{4}\)-inch square rods spaced 6 inches center to center.

Slab B. Span 8' 0"

Load = 300 \#/ sq.ft.

\[ M = \frac{1}{3} \times 300 \times 8 \times 8 \times 12 = 28,800 \#" \]

*Ketchum's "Bins, Walls and Grain Elevators".*
\[ d = \sqrt{\frac{28800}{71 \times 12}} = 5.8" \] The thickness used will be 7 inches. The reinforcement will be \( \frac{1}{2} \)-inch square rods spaced 6 inches center to center.

**Slab C. Span = 8' 0"**

Load = 200 \( \# \)/sq. ft.

\[ M = \frac{1}{8} \times 200 \times 8 \times 8 \times 12 = 19200 \#" \]

\[ d = \sqrt{\frac{19200}{71 \times 12}} = 4.75" \] The thickness used will be 6 inches. The reinforcement will be \( \frac{1}{2} \)-inch square rods spaced 6 inches center to center.

**Slab D. Span = 8' 0"**

Load = 100 \( \# \)/sq. ft.

\[ M = \frac{1}{8} \times 100 \times 8 \times 8 \times 12 = 9,600 \#" \]

\[ d = \sqrt{\frac{9600}{71 \times 12}} = 3.34" \] The thickness used will be 4\( \frac{1}{2} \) inches. The reinforcement will be \( \frac{1}{2} \)-inch rods spaced 6 inches center to center.

**Beam A. Span = 8' 0"**

Load = \( \frac{400 + 300}{2} = 350 \# / \) lineal ft.

\[ M = \frac{1}{8} \times 350 \times 8 \times 8 \times 12 = 33,600 \#" \]

Assume \( b = 6" \)

\[ d = \sqrt{\frac{33,600}{71 \times 6}} = 9" \]

The beam dimensions then are 6" x 10" x 8' 0"

The reinforcement used will be two \( \frac{1}{3} \)-inch square rods spaced 3 inches center to center.
Beam B. Span = 8' 0"

Load = 250 # / lineal ft.

\[ M = \frac{1}{8} \times 250 \times 8 \times 8 \times 12 = 24,000 \, \#' \]

Assume \( b = 6'' \)

\[ d = \sqrt{\frac{2400}{71 \times 6}} = 7.8'' \]

The beam dimensions then are 6" x 9" x 8' 0"

The reinforcement used will be the same as Beam A.

Beam C. Span = 8' 0"

Load = 150 # / lineal ft.

\[ M = \frac{1}{8} \times 150 \times 8 \times 8 \times 12 = 14,500 \, \#' \]

Assume \( b = 6'' \)

\[ d = \sqrt{\frac{14500}{71 \times 6}} = 6'' \]

The dimensions then are 6" x 8" x 8' 0"

The reinforcement will be the same as Beam A.

Beam D. Max. Mom. = 3400 x 16 - 2800 x 6

\[ = 48,000 \, \#' \]

Assume \( b = 8'' \)

\[ d = \sqrt{\frac{48000}{71 \times 8}} = 10'' \]

The dimensions of the beam then are 8" x 12" x 8' 0"

The reinforcement used will be three \( \frac{1}{2} \)-inch square rods spaced 1 3/4" center to center.

Beams A, B, and C are horizontal, and beam D is vertical.
Floor Slabs:

The angle of friction of coal on concrete $\phi' = 350$

The coefficient of friction $= \tan \phi' = .7002$

The weight of coal carried by the side walls equals the total lateral pressure times the tangent of $\phi'$ or $798,900 \times .7002$, or 559,230 pounds.

The vertical pressure equals the total weight of coal minus the weight of coal carried by the side walls or $1,200,000 - 559,000 = 640,000$ pounds. Assume this to act as a uniform load of 655 $\#$/sq.ft.

Span = 8' 0"

$$M = \frac{1}{8} \times 655 \times 8 \times 8 \times 12 = 60000 \#"$$

$$d = \sqrt{\frac{60000}{71 \times 12}} = 9"$$

A 10 inch slab will be used.

The reinforcement will be 3/4"-square rods spaced 6 inches center to center.

Floor Beam.

Span 16' 0"

Total load = $5,000 \times 16 + 20000 = 100000 \#$

$$M = \frac{1}{3} \times 100,000 \times 16 \times 12 = 2,400,000 \#"$$

Assume $b = 20"$

$$d = \sqrt{\frac{2,400,000}{71 \times 20}} = 42"$$

The beam dimensions are 20" x 43" x 16' 0"

The reinforcement will be the same as for the girder beam (See FigureII)

*Ketchum's "Bins, Walls, and Grain Elevators"
DESIGN OF COLUMNS.

Total weight of structure including machinery is 1,956,700#. This is obtained by calculating total volume of concrete used, assuming its weight as 150 #/cu. ft., steel as 490 # cu.ft., and estimating the weight of the machinery at 50,000 #. There are 15 columns. (See Figure IV-7)

\[
\frac{1,956,700}{15} = 130,000 \text{ # Load per column.}
\]

Let \( A \) = cross section of column.

\( p = \) ratio steel area to total area = .01

\( f_c = \) stress in concrete = 500 #/sq.in.

\[
\frac{E_s}{E_c} = 15
\]

\( P' = \) Total strength of a reinforced column for

\[
t_c P' = f_c A + (n - 1) p
\]

\[
130,000 = 500 (1 + (15 \times -1)) \times 0.1
\]

\[
A = \frac{130000}{500 \times 1.14} = 228 \text{sq}''or 16'' \text{ square.}
\]

Use columns 18'' square.

Area of steel reinforcement = 2.56 sq.in.

See Fig. for arrangement of steel.

Design of I-Beam for Supporting Cars Across the Hopper.

The maximum moment for span of 27' 0'' and E-50 Loading is 519,000 #/ft.

Try a 24'', 100 I beam

\[
S = \frac{Mc}{I}
\]

\[
c = 3.627 \quad I = 48.56 \quad A = 29.41 \text{ sq.in.}
\]

\[
s = \frac{519,000 \times 12 \times 3.627}{48.56} = 465,000 #
\]
Required area = \( \frac{465000}{16000} \) = 29.03 sq. in.

Use 24" 100# I beams.

**DESIGN OF FOUNDATION.**

Load on each column = 130,000# = 65 tons. Assume a safe bearing power of soil of 3 1/2 tons per square foot. Area of footing of column required = \( \frac{65}{3.5} \) = 18 1/2 sq. ft. A foundation of concrete 4 1/2 feet square will be used for each column, giving 20.25 sq. ft. or a foundation pressure of 3.21 tons per square foot.
FOUNDATION OF COLUMNS

Scale 1" : 2'

FIGURE I
FLOOR BEAM.

CROSS SECTION OF COLUMN

FIGURE-II
Plan Showing Conveyor.

FIGURE III
Figure 3Z

Transverse Section

Figure V

Scale 1" = 8'