PHOENIXVILLE BRIDGE-WORKS.

loaded tender is 125,000 pounds, occupying with pilot
fifty feet of track, \(\frac{125,000}{50} = 2500\) pounds per foot;
distance occupied by wheel base of engine and tender
alone is 41\(\frac{3}{4}\) feet, \(\frac{125,000}{41.5} = 3000\) pounds per foot;
distance occupied on track by the concentrated weight
over drivers, say 17 feet, and weight 60,000 pounds,
\(\frac{60,000}{17} = 3530\) pounds per foot; if the driving-wheel
base is 15, \(\frac{60,000}{15} = 4000\) pounds per foot; if the driving-wheel
base is 12 feet, \(\frac{60,000}{12} = 5000\) pounds per foot. This will give us the following loads:

<table>
<thead>
<tr>
<th>Spans</th>
<th>Footage</th>
<th>Weight per foot</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>17 feet</td>
<td>4000</td>
</tr>
<tr>
<td>17</td>
<td>17 feet</td>
<td>3500</td>
</tr>
<tr>
<td>25</td>
<td>83</td>
<td>3000</td>
</tr>
<tr>
<td>83</td>
<td>110</td>
<td>2500</td>
</tr>
</tbody>
</table>

Floor beams under 12 feet apart, and track stringers
less than 12 feet long, will carry 5000 pounds per foot.
Floor beams 12 to 15 feet apart, and track stringers
12 to 15 feet long, will carry 4000 pounds per foot.

Inasmuch as the weight per foot of cars is considerably
less than that of engines, in spans of over 100 feet,
the actual load per foot will diminish with the length of
span.

These results have been arranged in Table No. 2,
showing, for different spans, the weights caused by—

1. All locomotives.
2. Reading coal cars, drawn by two Reading standard
coal engines.
3. Same cars by one similar engine.
4. Pennsylvania box freight cars, drawn by two standard
freight engines.
5. Same cars by one similar engine.
6. Pullman palace cars, drawn by one New York
Central passenger engine.

These are the maximum loads which can come upon
the chord systems of any of the forms of girder truss,
upon the primary system of a Fink truss, or upon the
arch and chord of a bowstring. Owing to the excess
of weight of the locomotive above that of cars, the loads
upon the panel systems of girder, trusses, and bow-
strings, and the subsidiary systems of the Fink truss
will be in excess, and should be taken for all spans at
not less than 3500 pounds per foot.

II. It has been stated that it is not customary to make
any distinction between the effects of the dead load of
the bridge and the live load of trains. This varies
very much in ratio, according to the length of span.
Table No. 3 shows what the ratio of dead to live
loads is for different spans.

There can be no doubt but that the short spans, where
nine-tenths is live load, accompanied by vibration, are
more severely strained than the long bridges where half
the load is quiescent. It would appear that the margin
of safety ought to be greater upon short than upon long
spans, in order to give uniform strength.

It is difficult to say what the exact difference is be-
tween the effects of dead and live loads. Professor
Macquorn Rankine, a very high authority, states in his
"Applied Mechanics," "a suddenly applied force is
equivalent in strain to twice the same force gradually
applied."

This conclusion is confirmed both by the experiments
made by order of the English Commissioners upon the
application of iron to railway structures so far back as
1849, and by the later experiments of Fairbairn, which
will not be quoted here in detail, as they are to be found
in all the books.

From them it appeared that a tensile strain of six
tons per square inch, applied to the bottom flange of a
riveted plate girder, and accompanied by vibrations
made to resemble, as much as possible, those caused
by a passing train, did not break the girder, although
repeated over three millions of times. But when the
strain was increased to eight tons per square inch, it
broke after 300,000 further applications. As the break-
ing strength of average English plate ranges from twenty
to twenty-two tons, it would appear that the effect of
live load was more than twice as severe as dead load.
It is to be regretted that Dr. Fairbairn did not have
the girders made of exactly the same dimensions, and
of the same iron; ascertain the breaking static weight
of one, and then apply one-half of this as live weight,
and see how many applications it would bear before
breaking.

If we agree with Rankine and Fairbairn, that the
destructive effect of a live load is double that of a dead
load, our course is clear. A suggestion, originally
made it is believed by Unwin, in his treatise upon iron
bridges, points the way to a simple solution of the
problem. Multiply the live load by two, and add it to
the dead load. Their sum will be a load which may
safely be treated as an all dead load, and a strain per
square inch and margin of safety used such as is proper
for dead loads.

Table No. 4 shows the equivalent dead loads applic-
able to all spans. If these loads, or rather this
principle of fixing loads, be adopted by engineers, one
uncertain element will be eliminated from the problem,
and the only point left open will be what limit of strain
to put upon the iron.

III. It has been stated that the value of the factor or
margin of safety is commonly over-estimated. It is not
uncommon to read in specifications that the factor of