Span limitation of steel self-anchored cable-stayed bridges

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Introduction of long-span bridges related

Katsushika Harp Bridge (Tokyo)

Tatara Bridge (Hiroshima-Ehime)

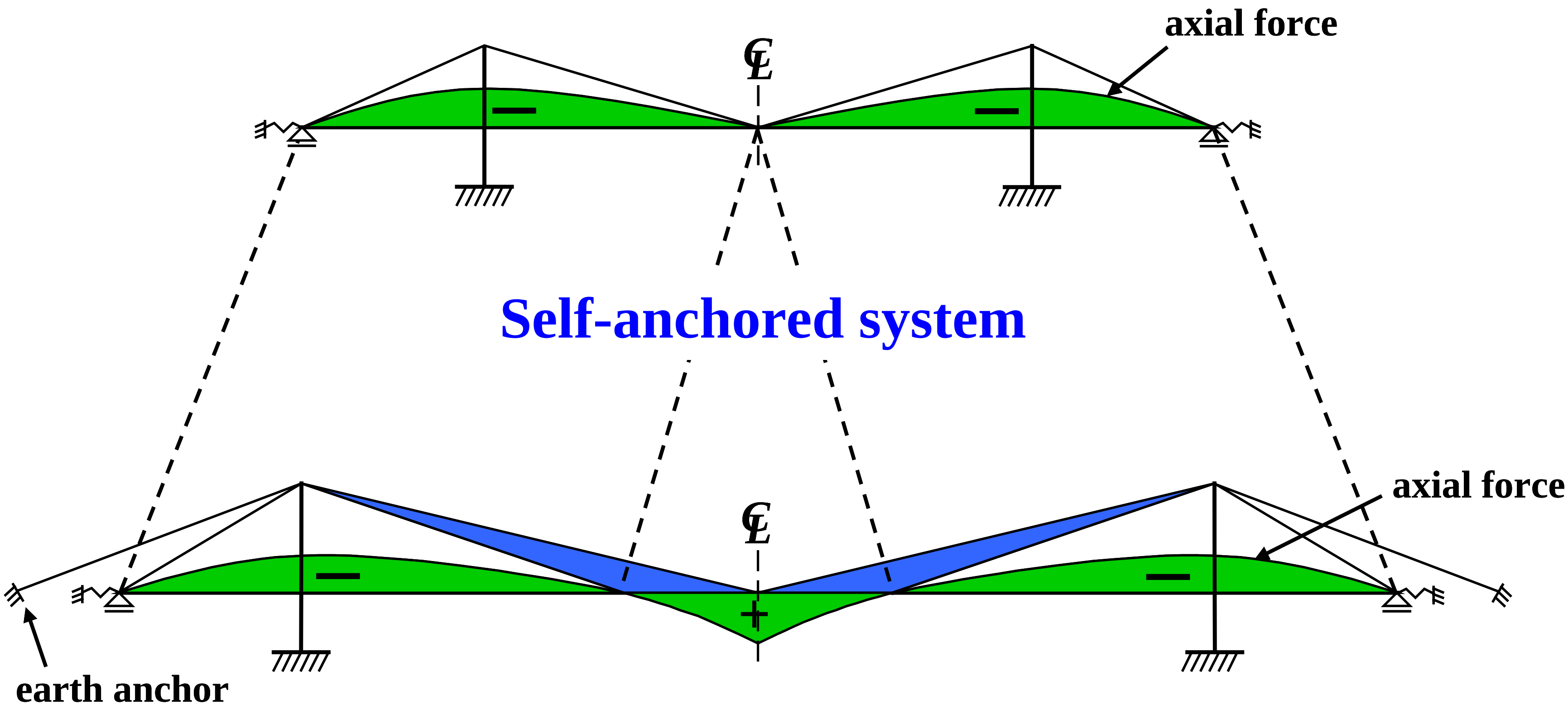
My topics today

1) Span Limitation of Steel (Self-anchored) Cable-stayed Bridges

2) Possibility of further span extension by Partially Earth-anchored System

3) Economical tower height is 1/5 of the span???

Cable-stayed System



Partially earth-anchored system

Objective (of my first topic)

How far

it can span?????

(identification)

We have to take into account two aspects

1) **Mechanical viewpoint**
2) **Economical viewpoint**

From economical viewpoint!!

Competition

Cable-stayed bridges

vs.

Suspension bridges

What is the key point (subject)

to identify???

⇒ design main girder

with minimum size

(min. steel volume)

(ensuring safety against

static and dynamic instabilities)

Analytical approach

1) Elaso-plastic finite displacement analysis under in-plane load

2) Finite displacement analysis under displacement-dependent wind loading

3) Flutter analysis using multi-modal coordinate (complex eigen value analysis)

—Competition (Key factor)—

to identify min. size of cross section

of girder ensuring safety

against static & dynamic instabilities

1) Minimum width of box girder

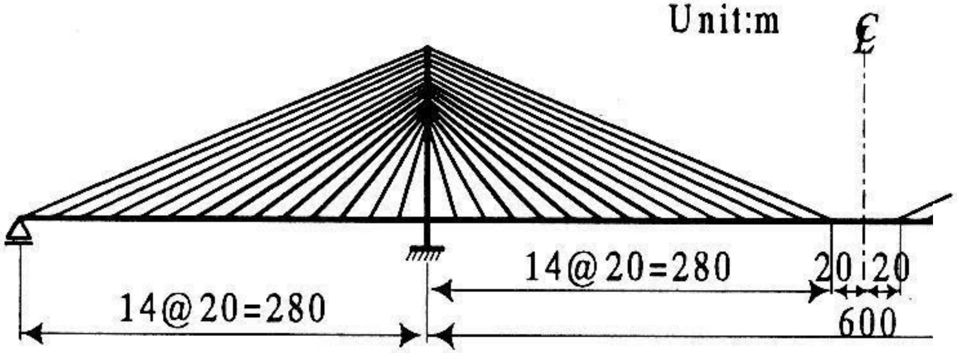
L_c(span)/B(girder width)

should be less than <u>40</u>

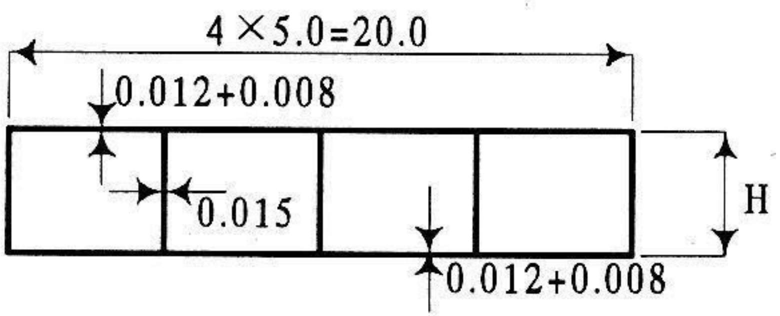
(Leonhardt's recommendation)

<u>Is it valid???</u>

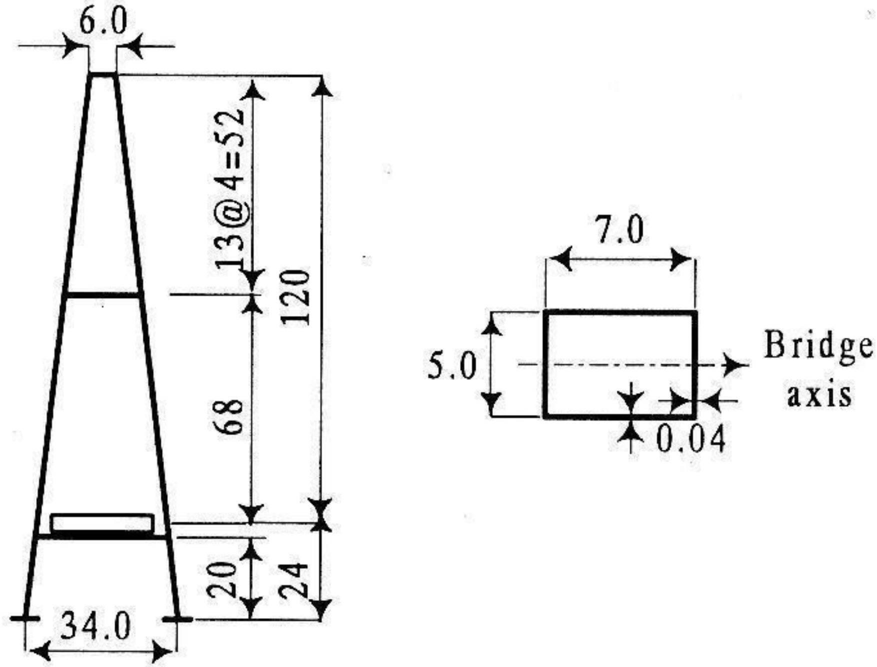
Cable-stayed bridge model



(a) side view

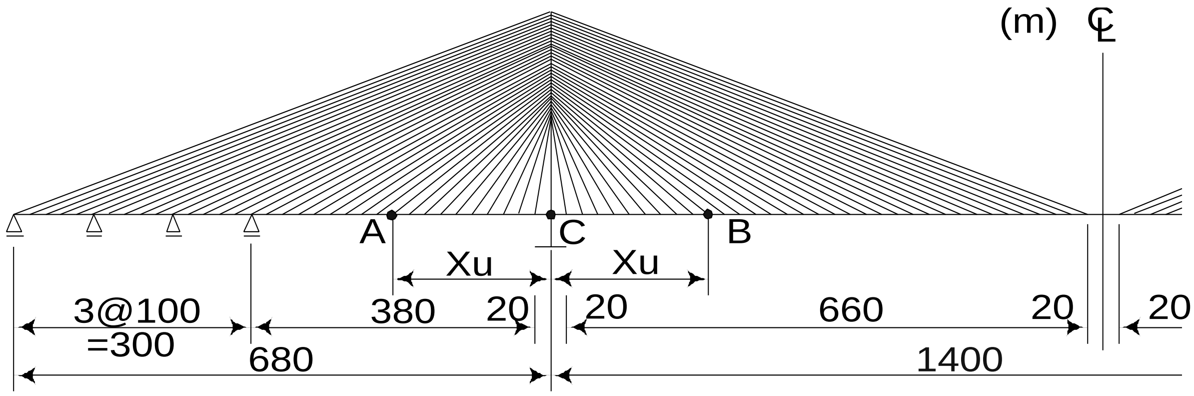


(b) girder section

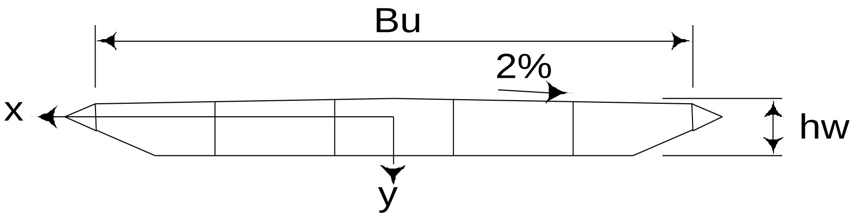


(c) tower

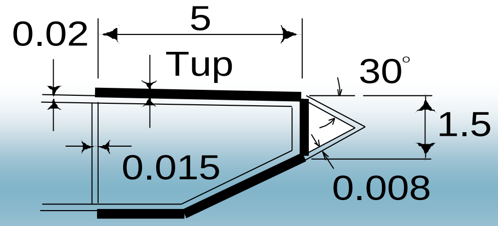
1,400-m Cable-stayed Bridge Model



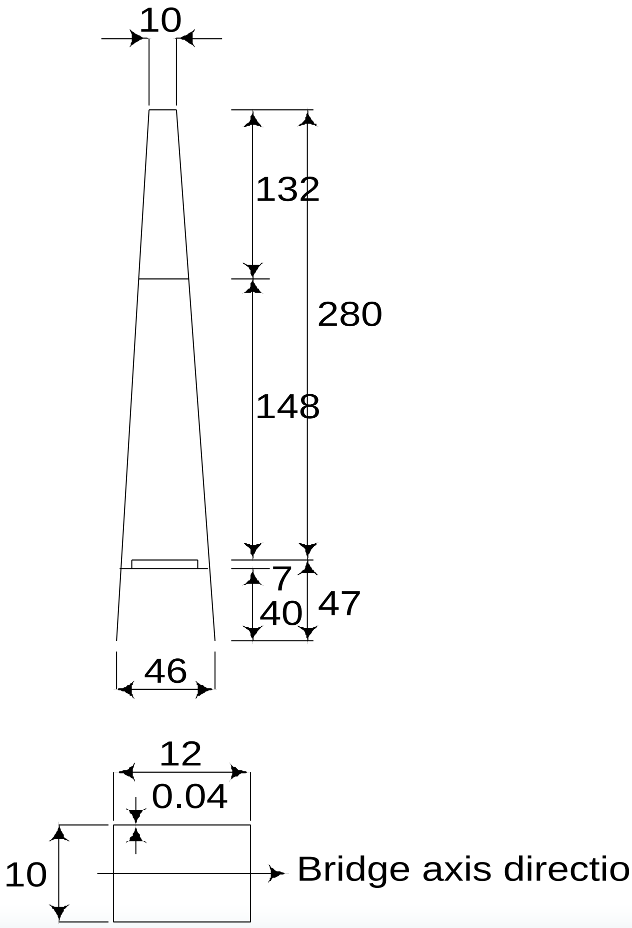
(a) Side-view (plan)



(b) Cross section of girder



(c) Increase of plate thickness



(d) Tower

since $V_{(divergence)} < V_{(flutter)}$

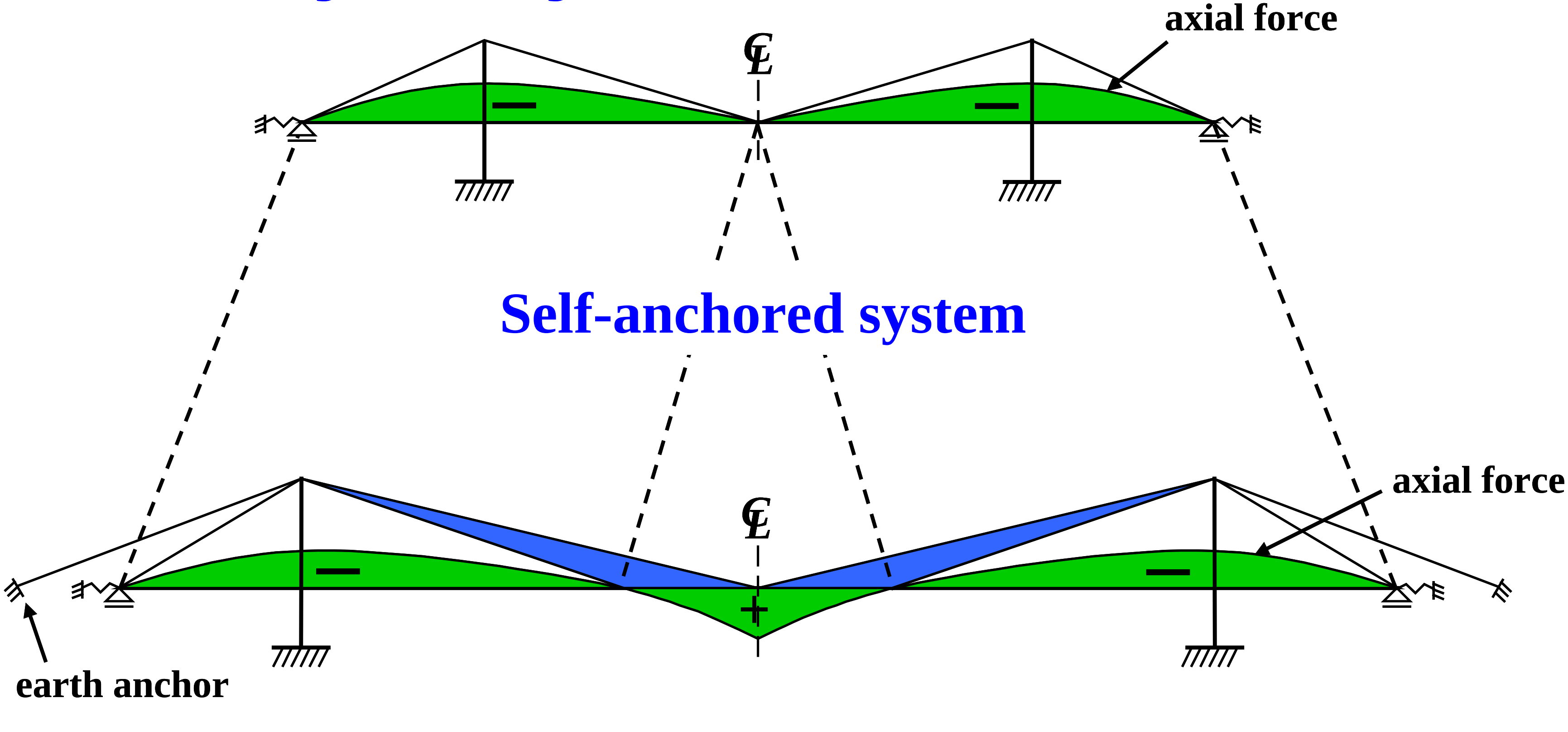
Important parameters to enhance $V_{(divergence)}$ under wind load are

1) In-pane flexural rigidity of the system

2) Torsional rigidity of the system

Effect of increase out-of-plane flexural rigidity will be minor

Cable-stayed System



Partially earth-anchored system

N(+) = N(-)

⇒ L_c (Partially earth-anchored) = $\sqrt{2}L_c$(Self-anchored)

From 1,200 to 1,400m cable-stayed bridges

will be possible!!

(through economical comparison with suspension bridges)

↓

Partially earth-anchored system

with a span of 1600m will be possible!!

(taking into account of feasibility of erection)

Concluding remarks

1) Ultimate strength is not affected by box girder depth

(3,4 & 5m dealt with in this paper)

【 ex. $L_c/H_w = 470$ (in case $H_w = 3.0$m) 】

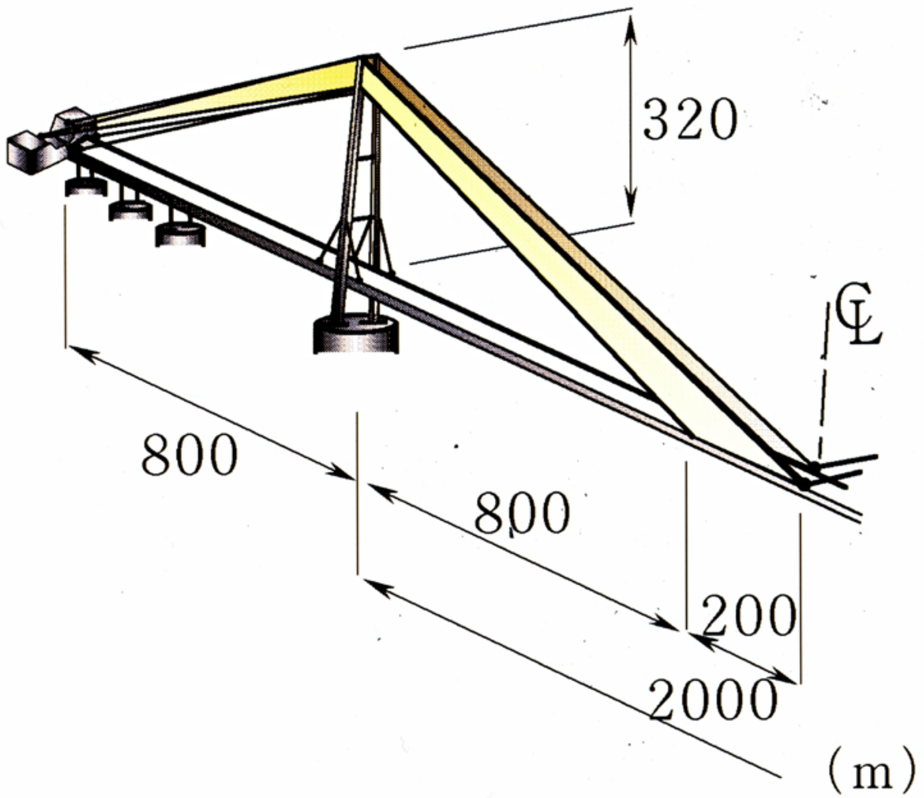
2) Plastic behavior governs failure of the girder.

【 geometrical nonlinear effect is minor 】

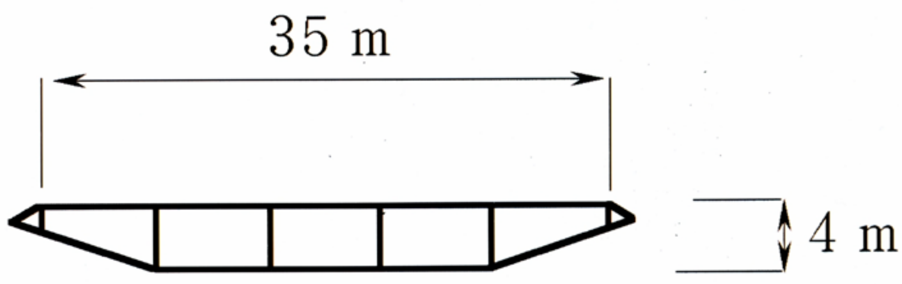
3) Residual stress affect load level occurring initial yielding, however, it does not affect the strength.

4) Except for loading case-1, intermediate piers do not affect the strength.

2000 - meter



My dream!!



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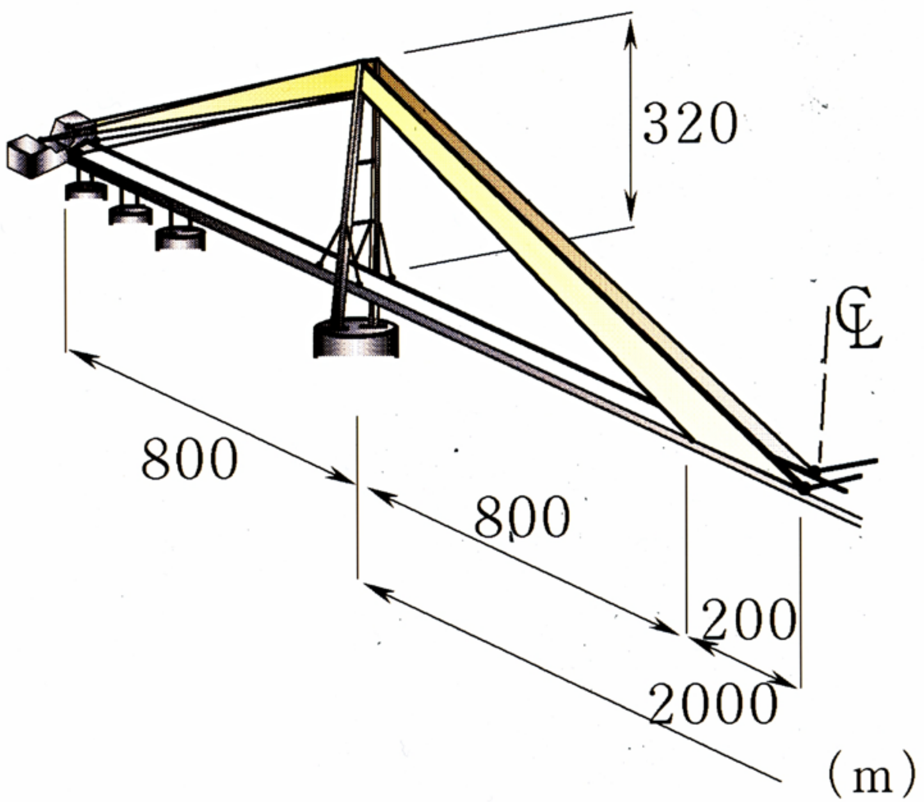

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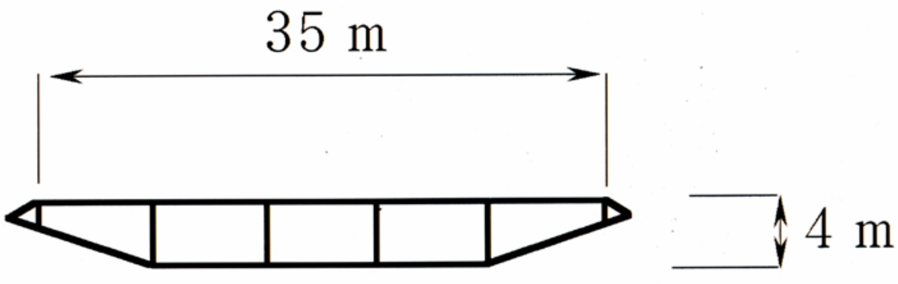

Thank you for your kind attention