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Risk Assessment and Management for A Cable-Stayed Bridge in Japan

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Purpose of Research

To propose a risk assessment in Japan by using a cable-stayed bridge.

Risk assessment is to consider how many risks for targeted bridge before construction and determine quantitatively risks.

Risk assessment is often used abroad, but not famous in Japan.

So as an introduction, I studied the any results of risk assessment on actual bridge in Akita prefecture.

Why is Risk assessment important ?

Thinking about risks in advance can prevent serious accidents from occurring.

As a result, we can prevent new risks too.

Risk assessment

Any accidents

Prevent serious situation

Cause serious situation1

Cause serious situation2,3~

My research step

1st, To research about actual bridge's risks.

2nd, To determine quantitatively risks and consider its for actual one.

3rd, To propose a importance of risk assessment for bridge in Japan by using results.

About Akita and Targeted bridge



Area : 11,610 km² (no.6 in Japan)

Population : 896,225 people (worst in Japan)

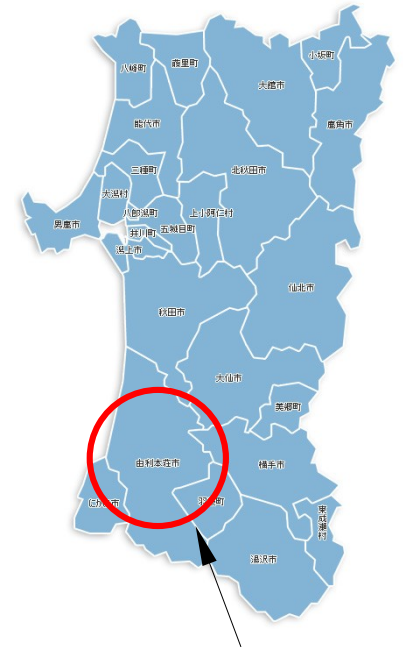
※ In Tokyo, 14,187,176 people

Total road length : approximately 24,700 km

Specific feature : rural area / snowing area /
aging population is no.1 /
rice-producing is famous

Targeted bridge is **YURI bridge**.

Akita



Yurihonjo

YURI bridge is built in Yurihonjo city in Akita.

There are prefectural roads around YURI bridge,
so not too much traffic.

For example, about traffic volume of prefectural roads.

Prefectural Road 32 : approximately 8000 vehicles / day

Prefectural Road 57 : approximately 6500 vehicles / day

Prefectural Road 241 : approximately 4200 vehicles / day

Proposal of Risk assessment

▶ How to calculate risks

Probability of risks depending on the situation \times Bridge's span
 \rightarrow Possible risks per year for that bridge (/ year)

Risk of traffic accident

Traffic accident rate in Akita : **0.38%**
Accident rate on prefectural roads : **0.27 / km \times year**
Akita's prefectural roads rate in Japan : **0.2%**
Traffic accident rate on a straight road : **88.4%**
Correction factor for a straight road : **0.1**
Traffic accident fatality rate : **0.0036%**
Accident rate on bridges : **15.0%**



Risk of vehicle fire

Vehicle fire rate in Akita : **7.9%**
Freight vehicle pass rate : **14.15%**

This rate is high
despite low traffic volume.

Quantification of risk

$1.09 \times 10^{-14} / \text{km} \times \text{year}$

Multiplied by span

$1.09 \times 10^{-14} / \text{km} \times \text{year}$

$\times 0.19\text{km}$ (bridge span of YURI bridge)

Fire risks of YURI bridge

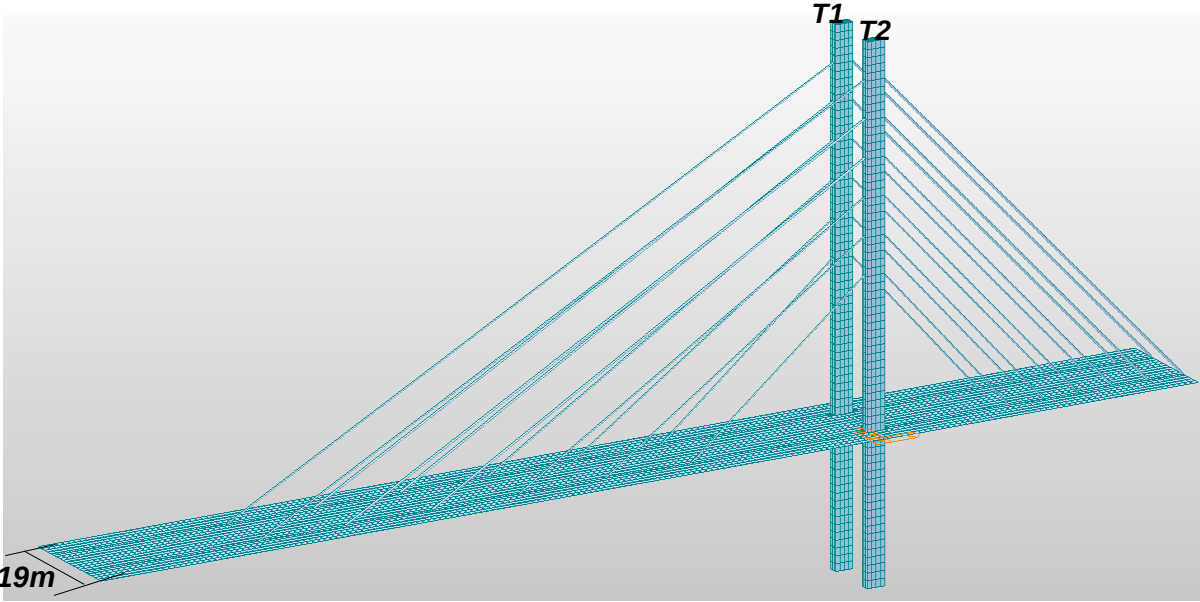
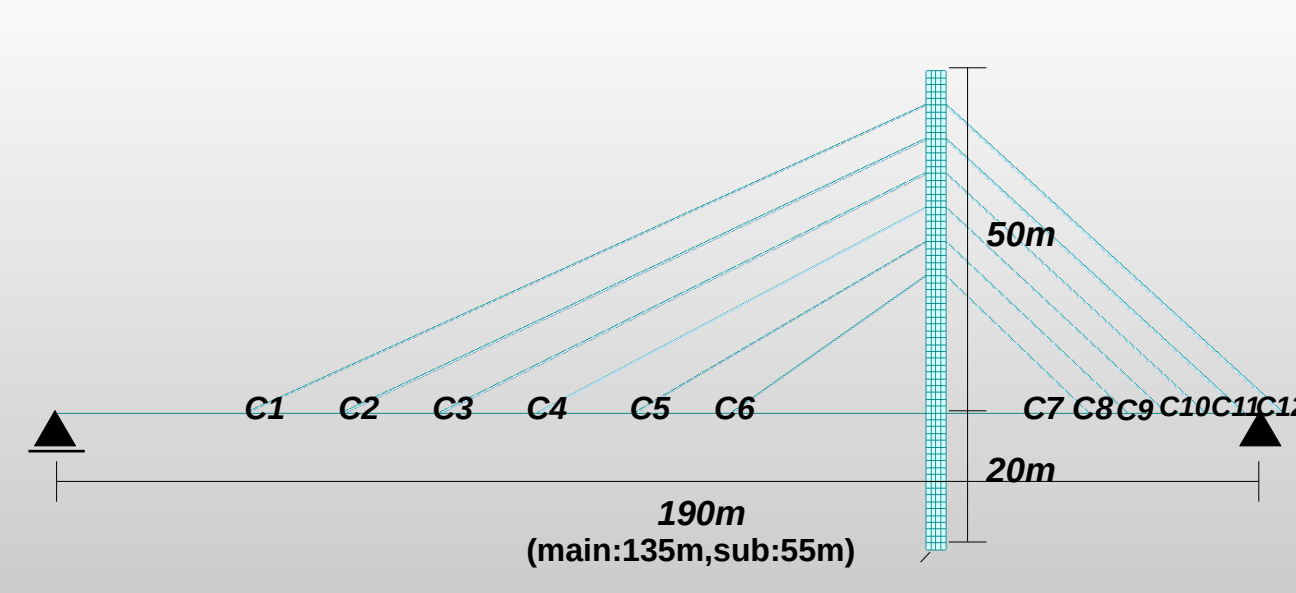
$2.07 \times 10^{-15} / \text{year}$

※ Supplementary information :
Risk of bridge (span : 1974m) in Romania is **$1.14 \times 10^{-6} / \text{year}$** .

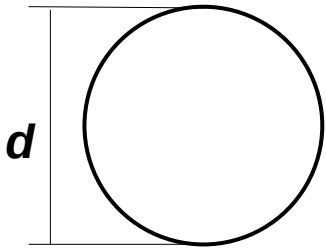
I try to confirm what would happen if bridge fire actually cause.

Analysis Model

Targeted bridge: YURI Bridge



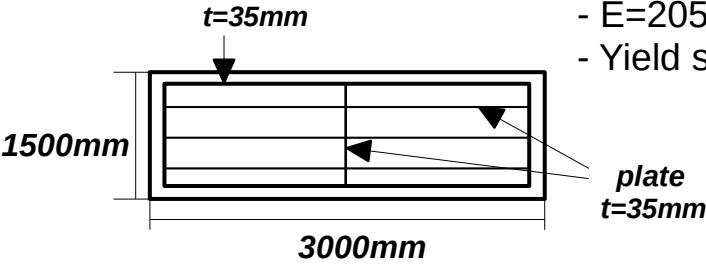
Cable diameter



C1,C4,C10 is $d=225\text{mm}$
C5~C9 is $d=200\text{mm}$
C2,C3,C11,C12 is $d=315\text{mm}$

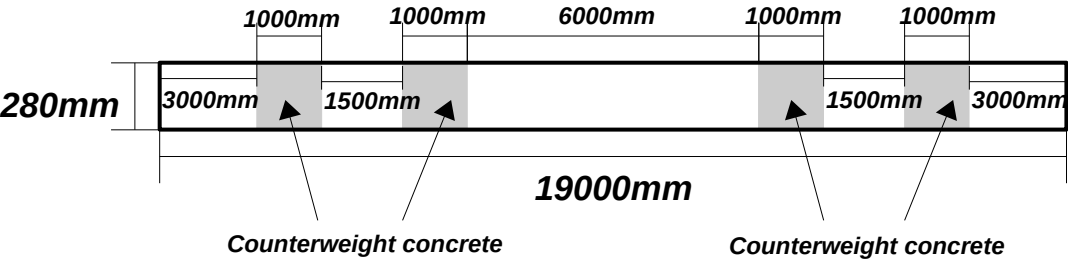
Cable material:ST1570
- $E=195\text{GPa}$
- Yield stress is 1570MPa

Main tower area



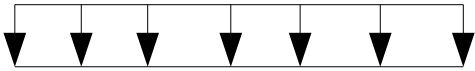
Steel material:SM490
- $E=205\text{GPa}$
- Yield stress is 335MPa

Girder area

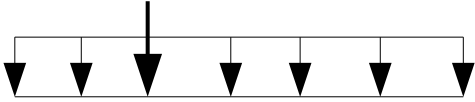


Design Load

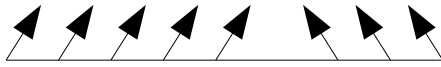
Dead load



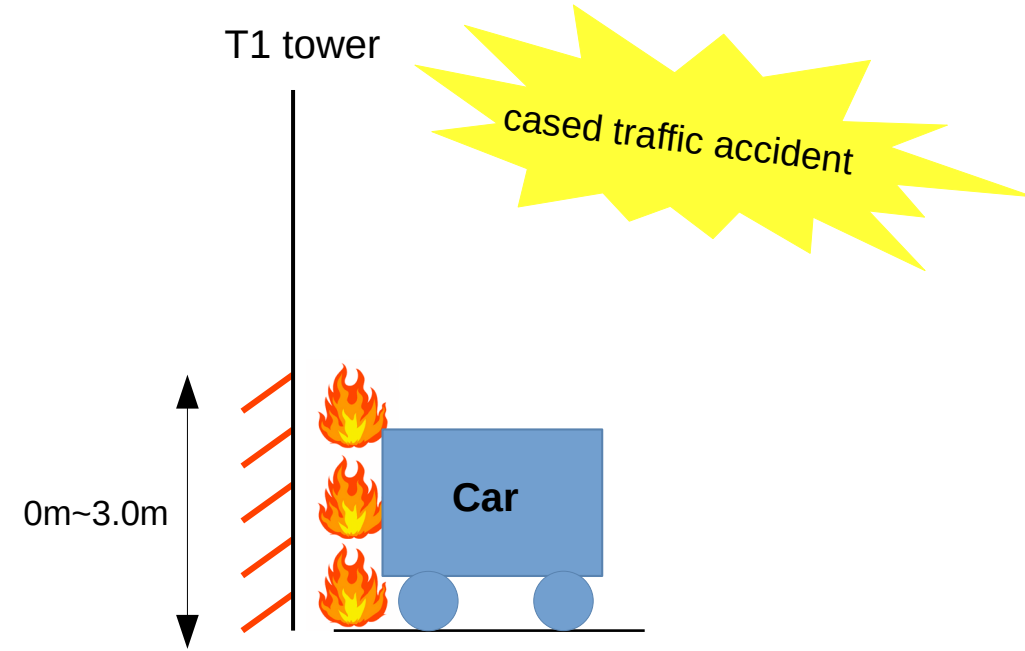
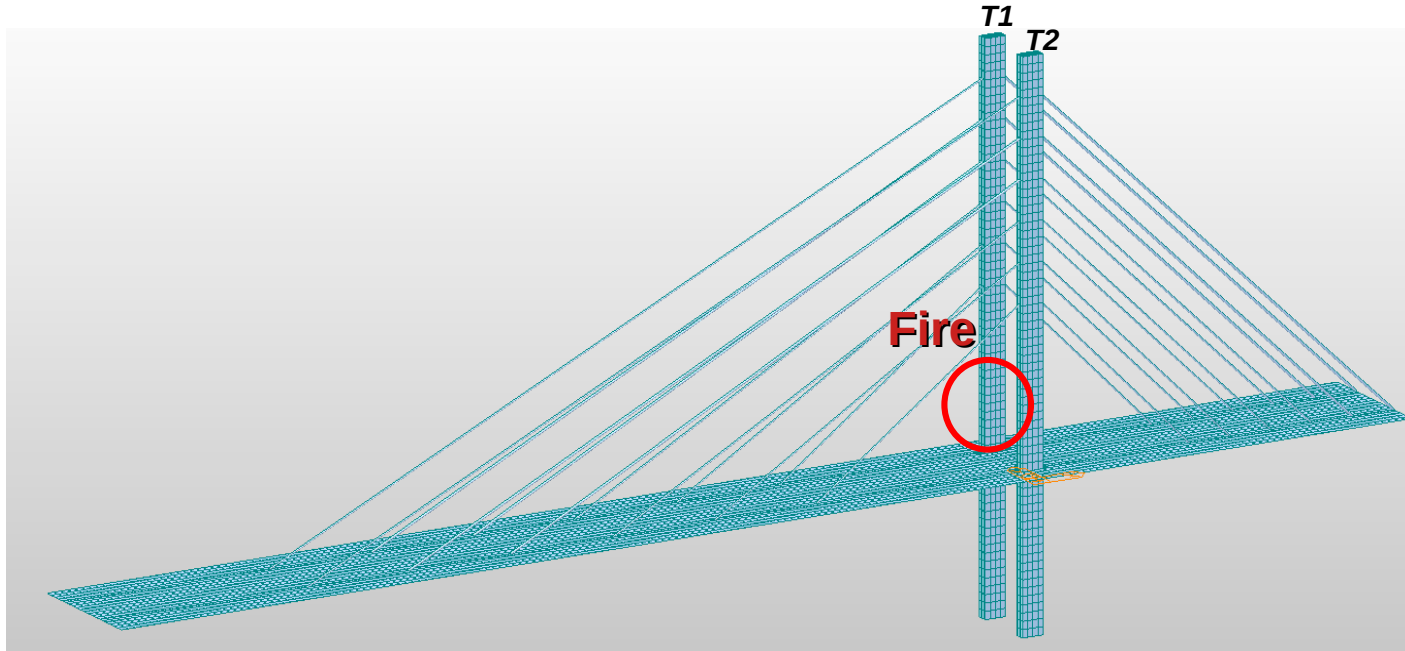
Live load



Pretension



Analysis Method



There is fire on the T1 main tower.
Temperature was applied at 0m~3m on the T1.
This position means "car height" .
The analyzed temperature are 250, 270, 300, 400
and 800 degrees.

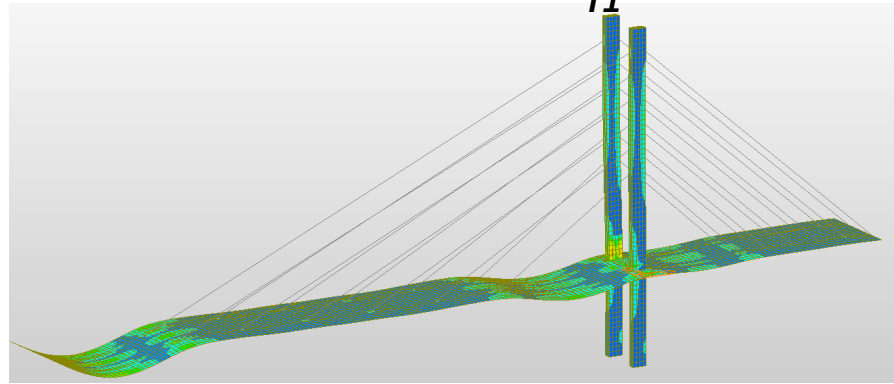
In this case, assuming a collision between
vehicles near the T1 main tower.
After that, it developed into a fire there.



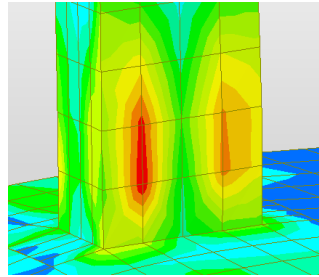
Look at the results of **main tower stress** and **displacement** at that temperature.

Analysis Results

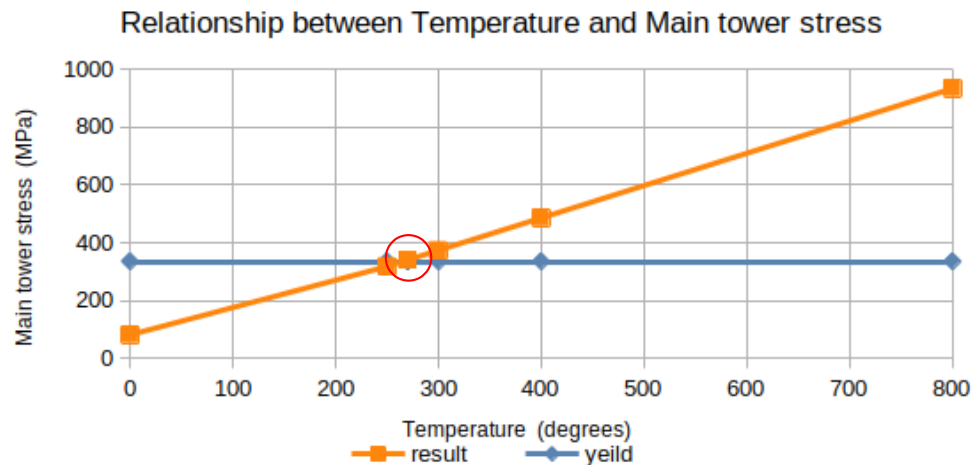
T1 Stress distribution



Enlarged view : T1

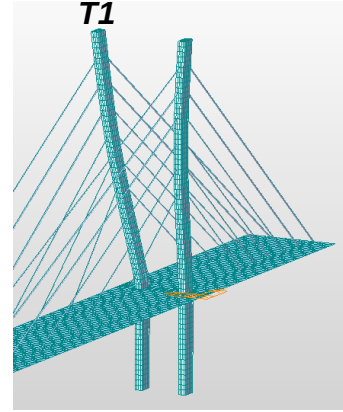
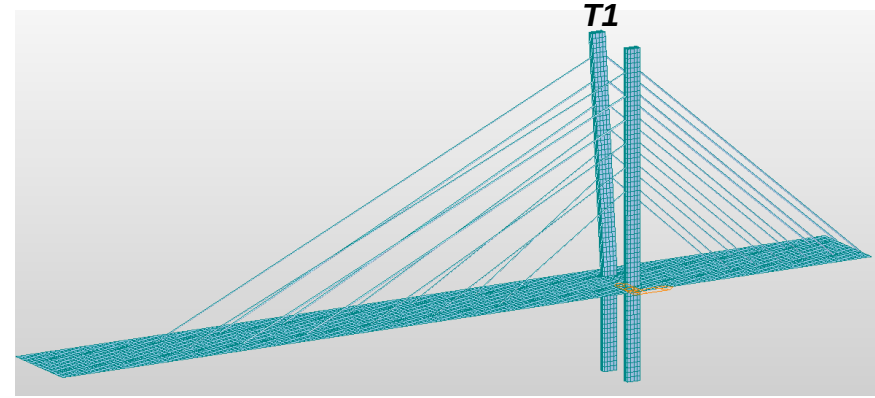


Stress concentrated in the heated area.

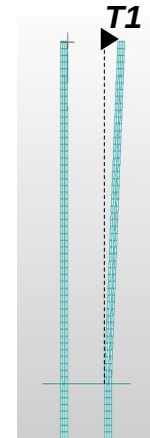


- Main tower yielded at 270 degrees.
- **Stress at 270 degrees is 340 MPa over than yielded.**
- All cables stress didn't change much.

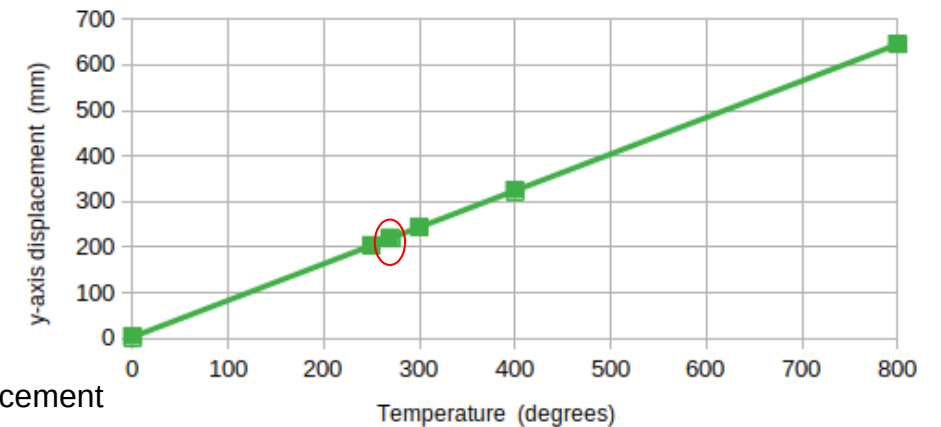
Deformation diagram



T1 main tower downed on outside the girder.



Relationship between Temperature and y-axis displacement



→ : y-axis displacement

- Before bridge fire, displacement is 0mm.
- When 270 degrees, displacement is 220mm
- Significant affect wasn't seen on the cables.

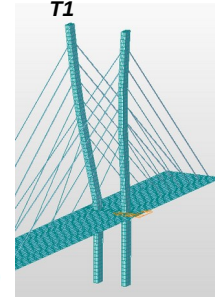
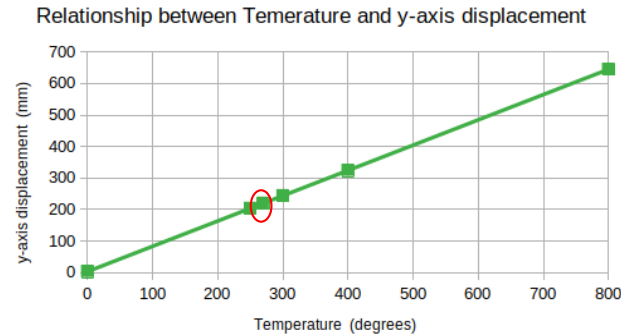
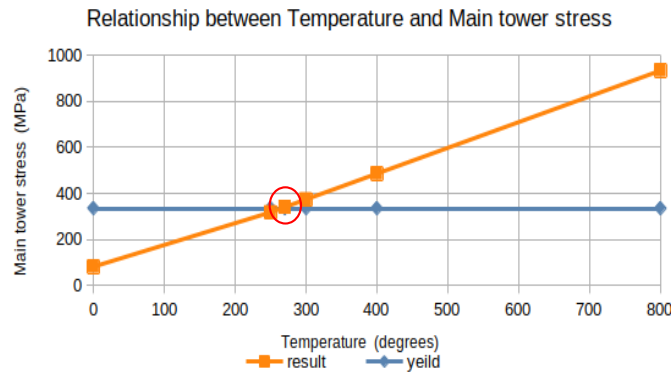
Conclusion

Risk assessment is to consider any risks and calculate possible one.

Risks of YURI bridge : **2.07×10^{-15} / year**

This risk level can not to be ignore.

if bridge fire cause...



Main tower yielded at 270 degrees and downed on outside.

New risks may be created

- To establish blockade period
- To increase travel time around people
- Traffic jam in another road
- To need repair costs



These will disadvantage to the around people and the city.

► Regardless of high or low risk,
It is important to consider risk assessment for bridges.

Future tasks

- To study what happens when there is fire on the cable.
- To consider more kind of risks in the future.



Thank you for your attention

