Development of High Seismic Performance Pipe for Crossing Active Faults

JFE ENGINEERING CORPORATION

Introduction

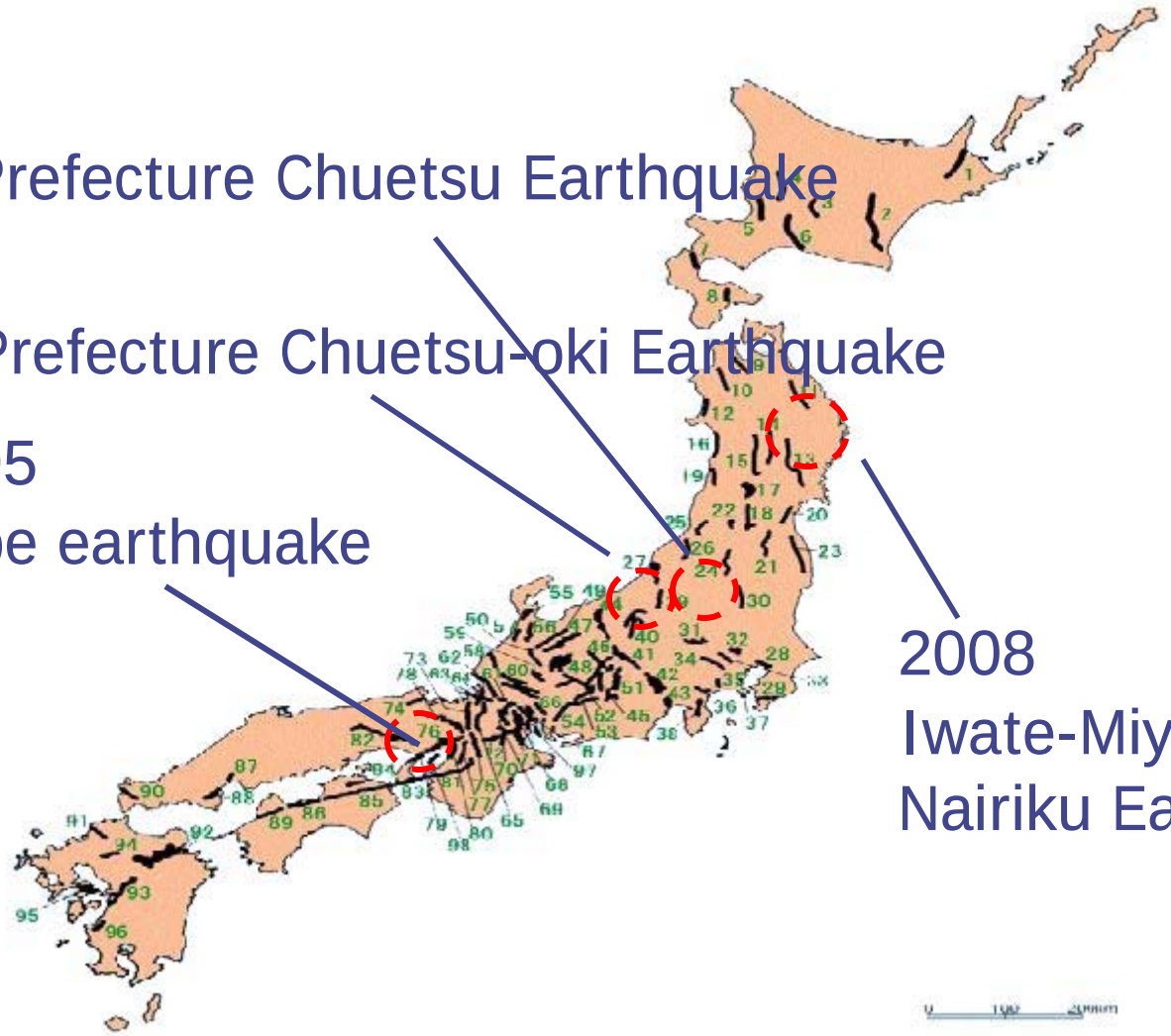
Main active faults in Japan

2004
Niigata Prefecture Chuetsu Earthquake

2007
Niigata Prefecture Chuetsu-oki Earthquake

1995
Kobe earthquake

2008
Iwate-Miyagi
Nairiku Earthquake



”A”class fault

Fault Displacement

Less than 1m	1m-3m	3m-5m	More than 5m
6	286	71	21

Fault Type

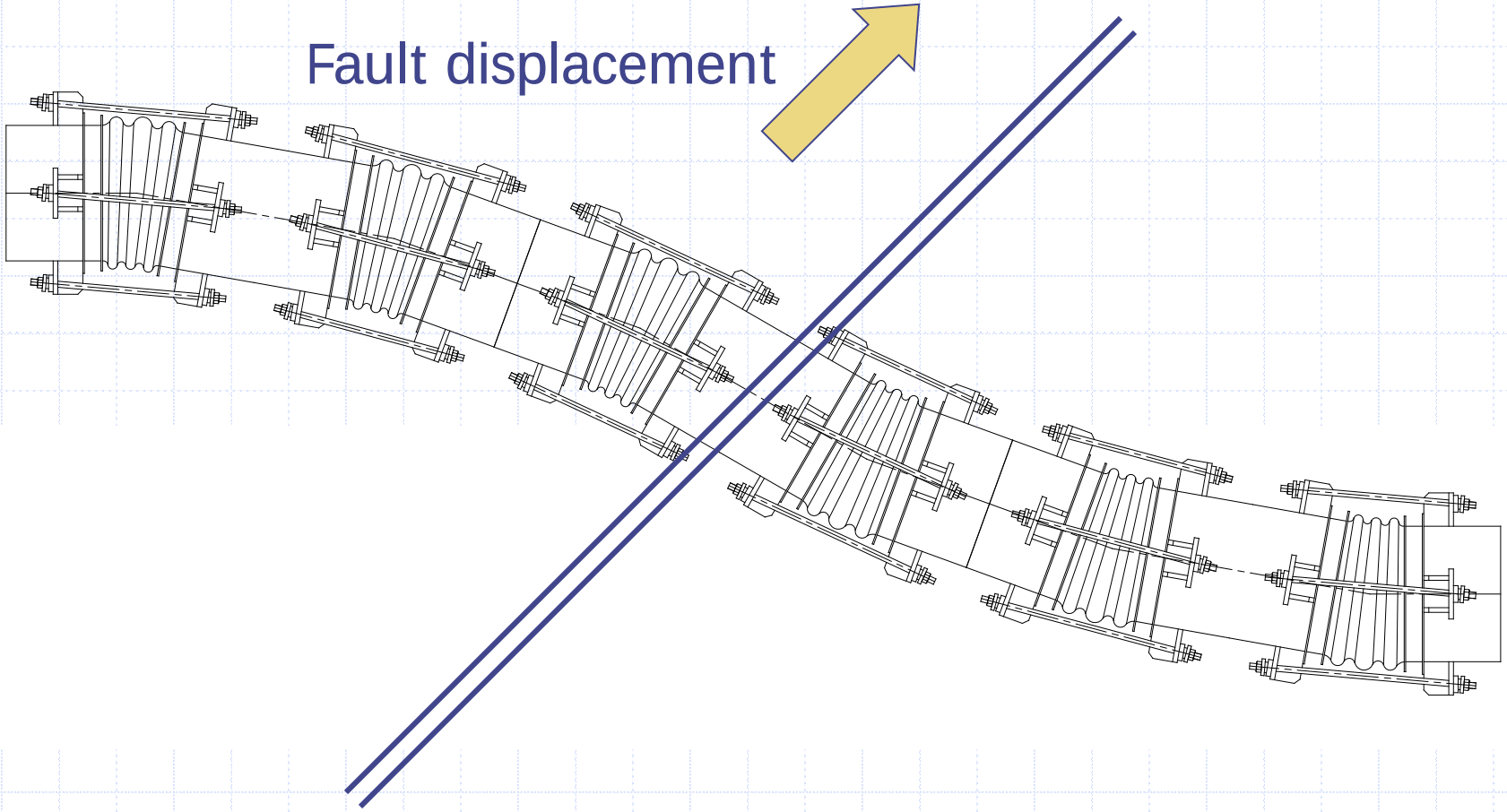
Nomal	Reverse	Dextral	Sinistral
31	219	103	65

Fault dip

Less than 30°	30° - 45°	45° - 60°	More than 60°
14	167	91	145

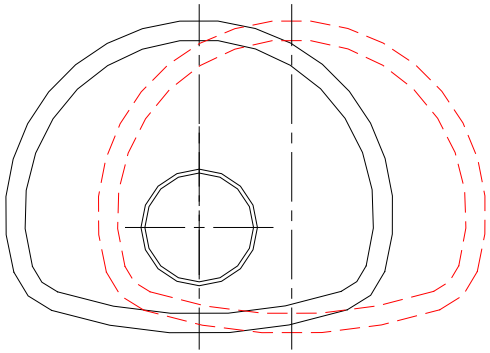
Existing measures

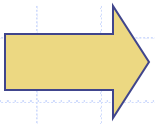
Piping with flexible joint-pipes method



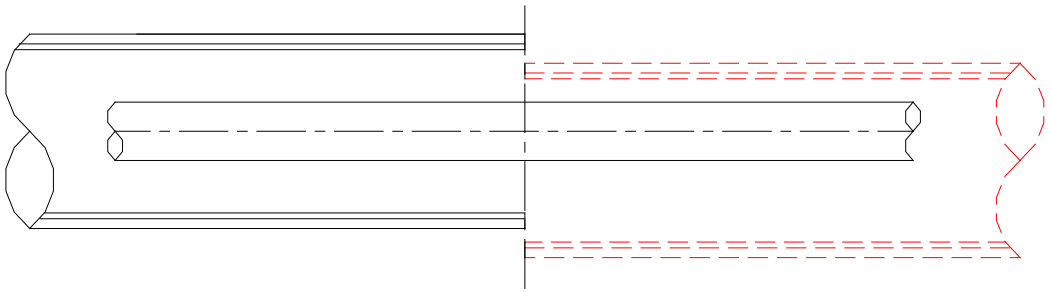
Existing measures

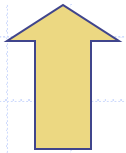
Piping in tunnel method





Fault displacement

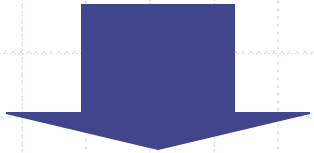




Fault displacement

Purpose of development

It is difficult for the local waterworks bureaus to adopt these methods, as they are both costly.



We need to develop a seismic-protected pipeline crossing a fault, which is optimal from the economical point of view .

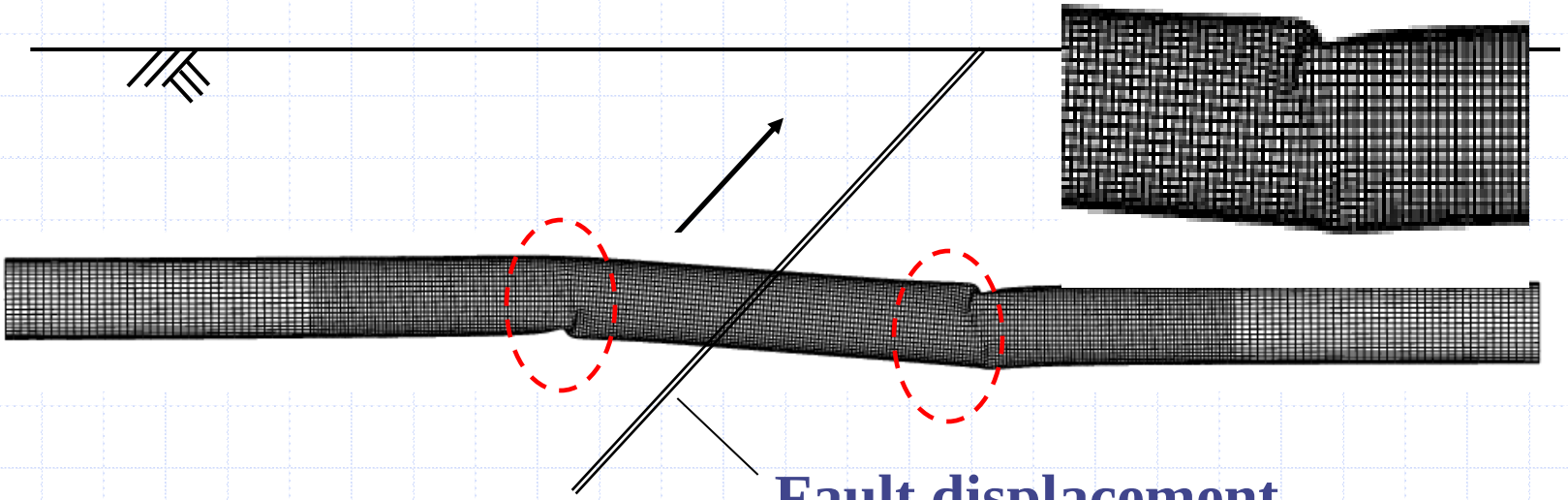
Development of High Seismic Performance Pipe

Design concept

- In order to reduce the cost, the wall thickness of the pipe module is same with the pipeline.
- Only one time deformation is considered, as the interval of earthquakes is long enough.
- The plastic deformation or bucking is allowable, but the crack initiation or leakage is not.

Deformation of straight pipe

Complex deformation



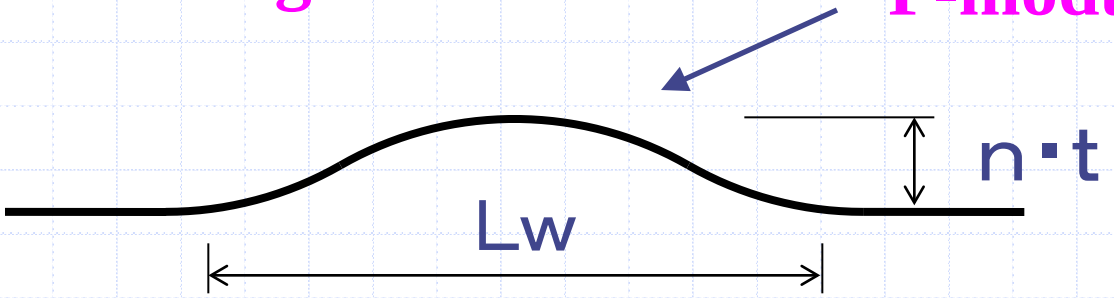
It may cause the cracks in the pipes

Shape of pipe module

Control the deformation by initial deformation

Adopt buckling wave

P-module



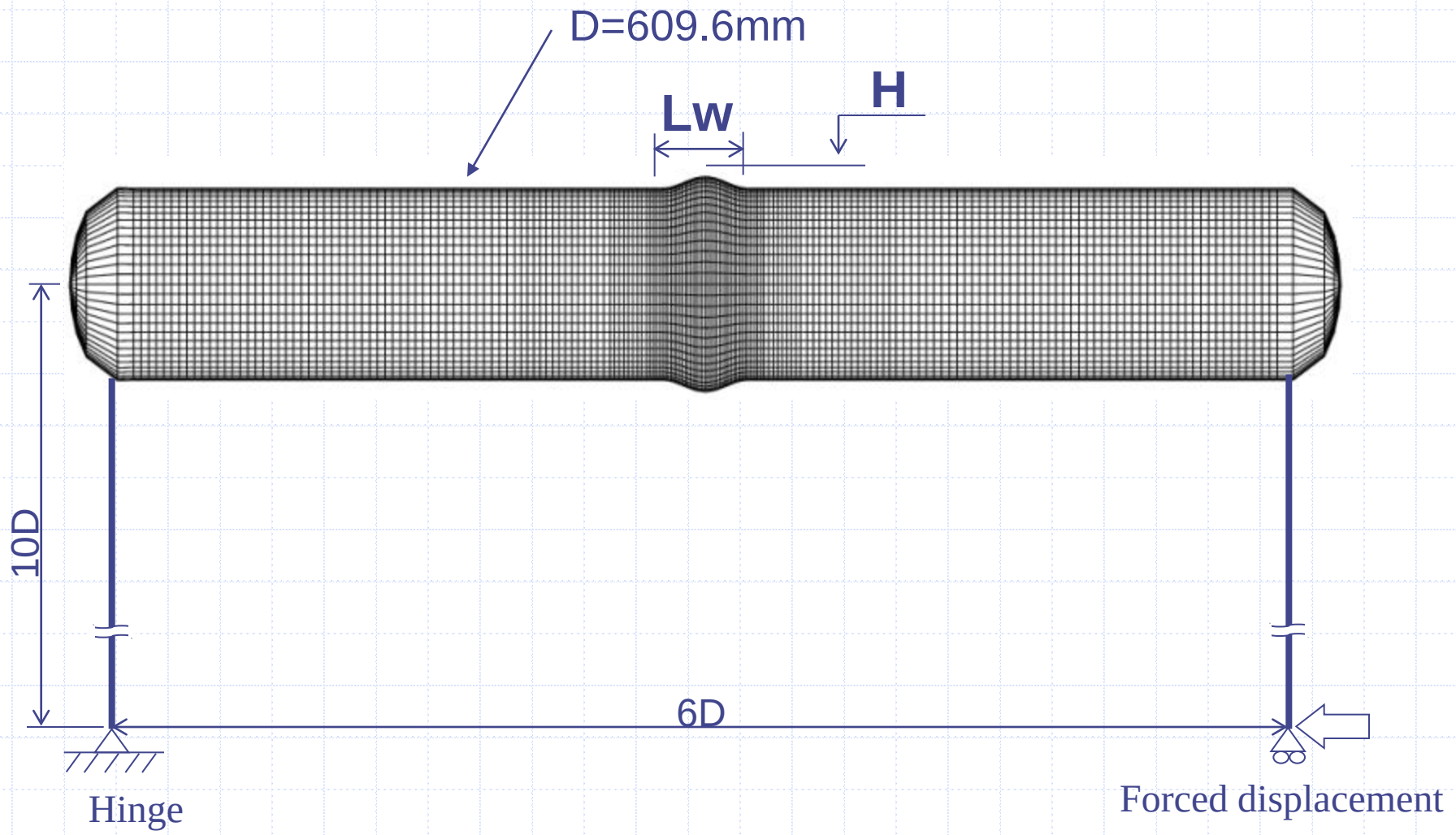
$$Lw = 1.72\sqrt{r \square t}$$

r : Radius of center pipe

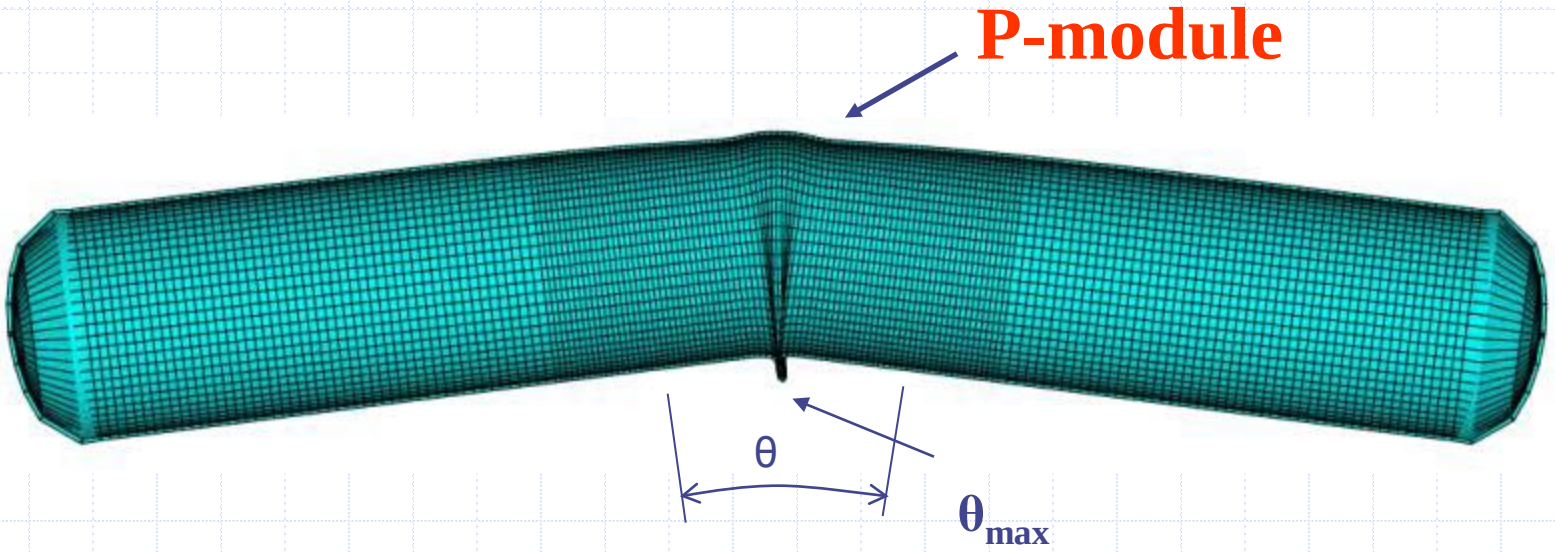
t : Pipe thickness

Concentrate deformation on P-module

Design of the optimal form of the pipe module

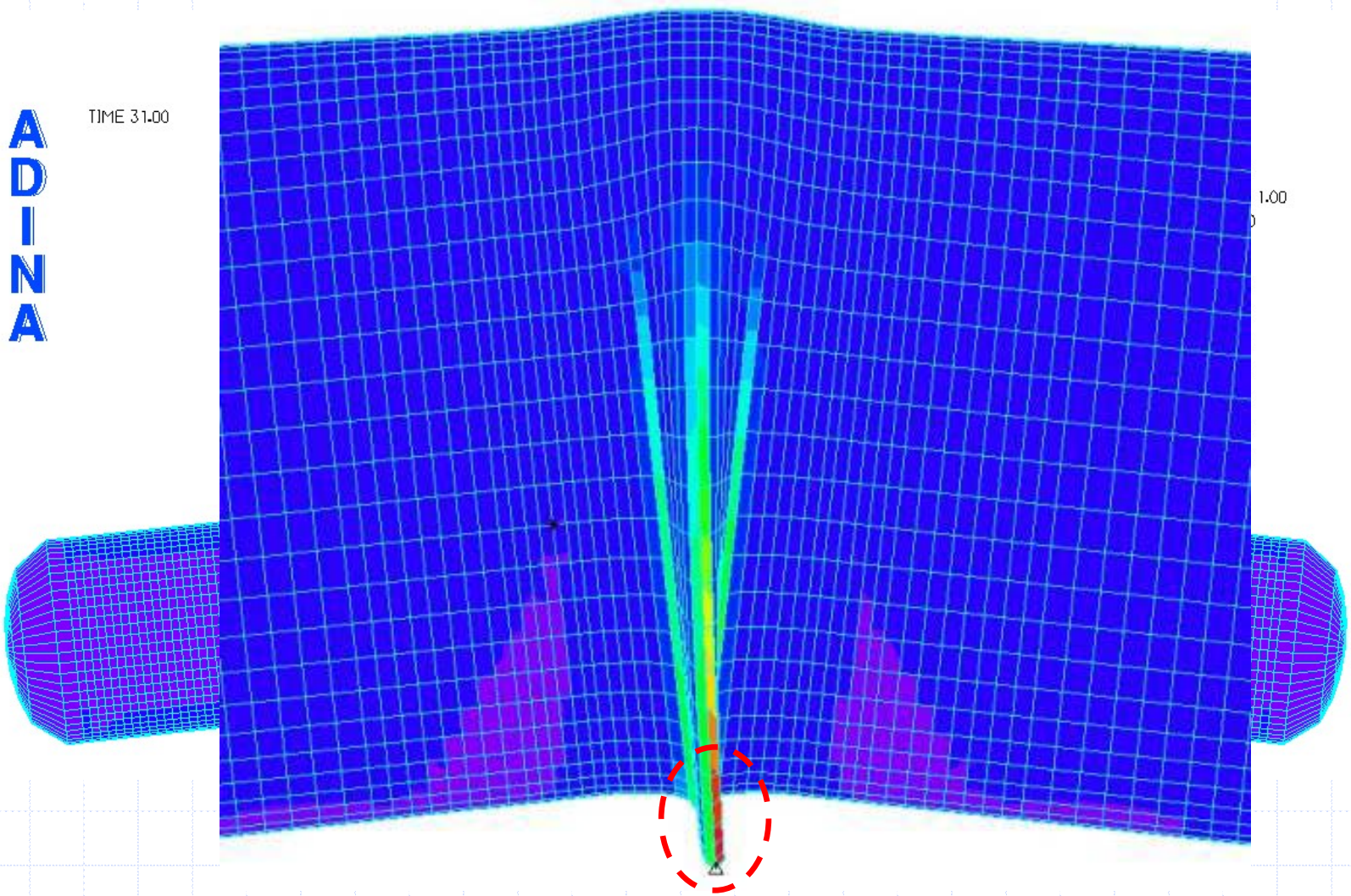


Definition of the ultimate bending angle



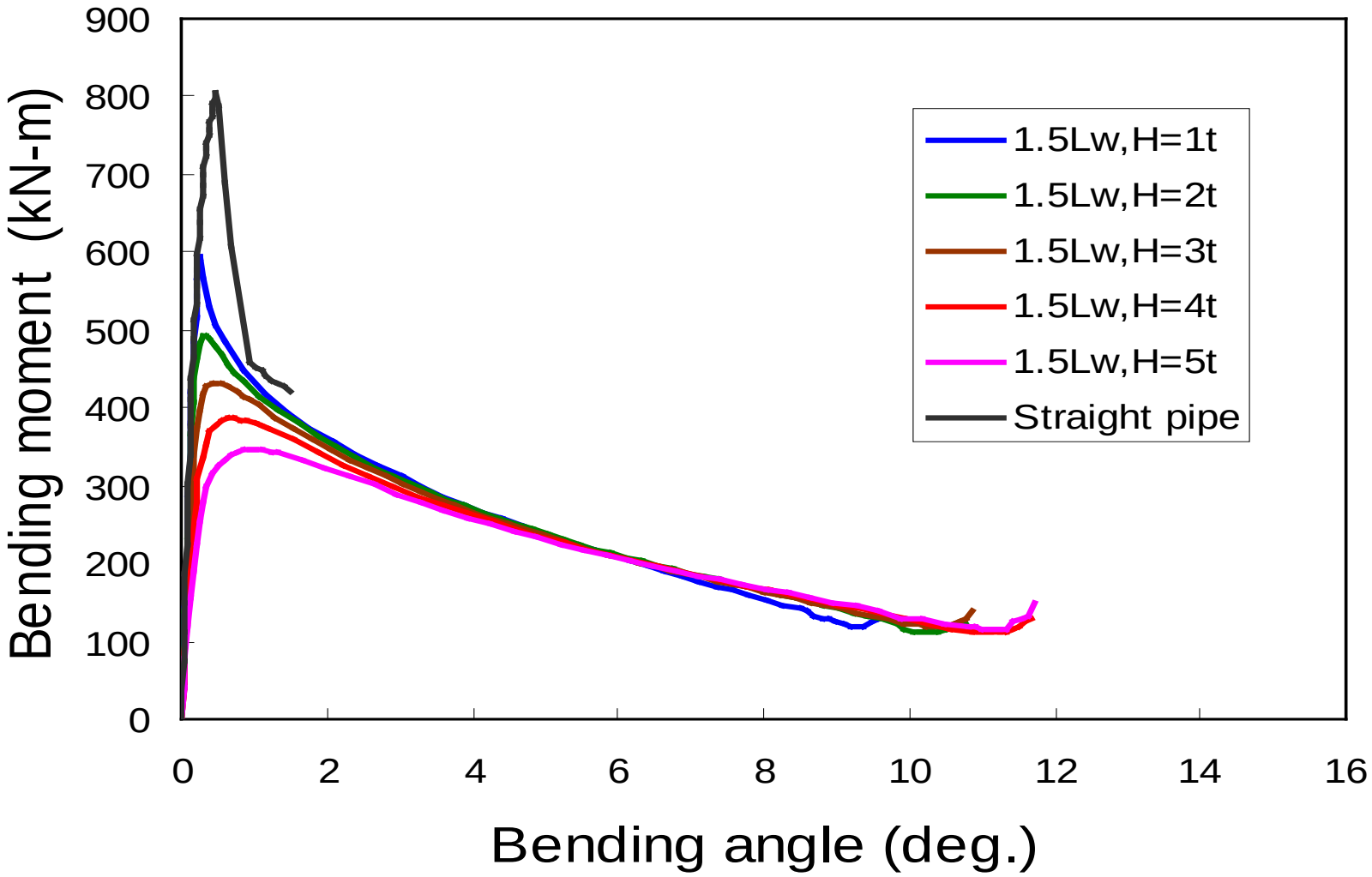
Wave shape comes in contact → θmax

Results of analysis- Distribution of strain

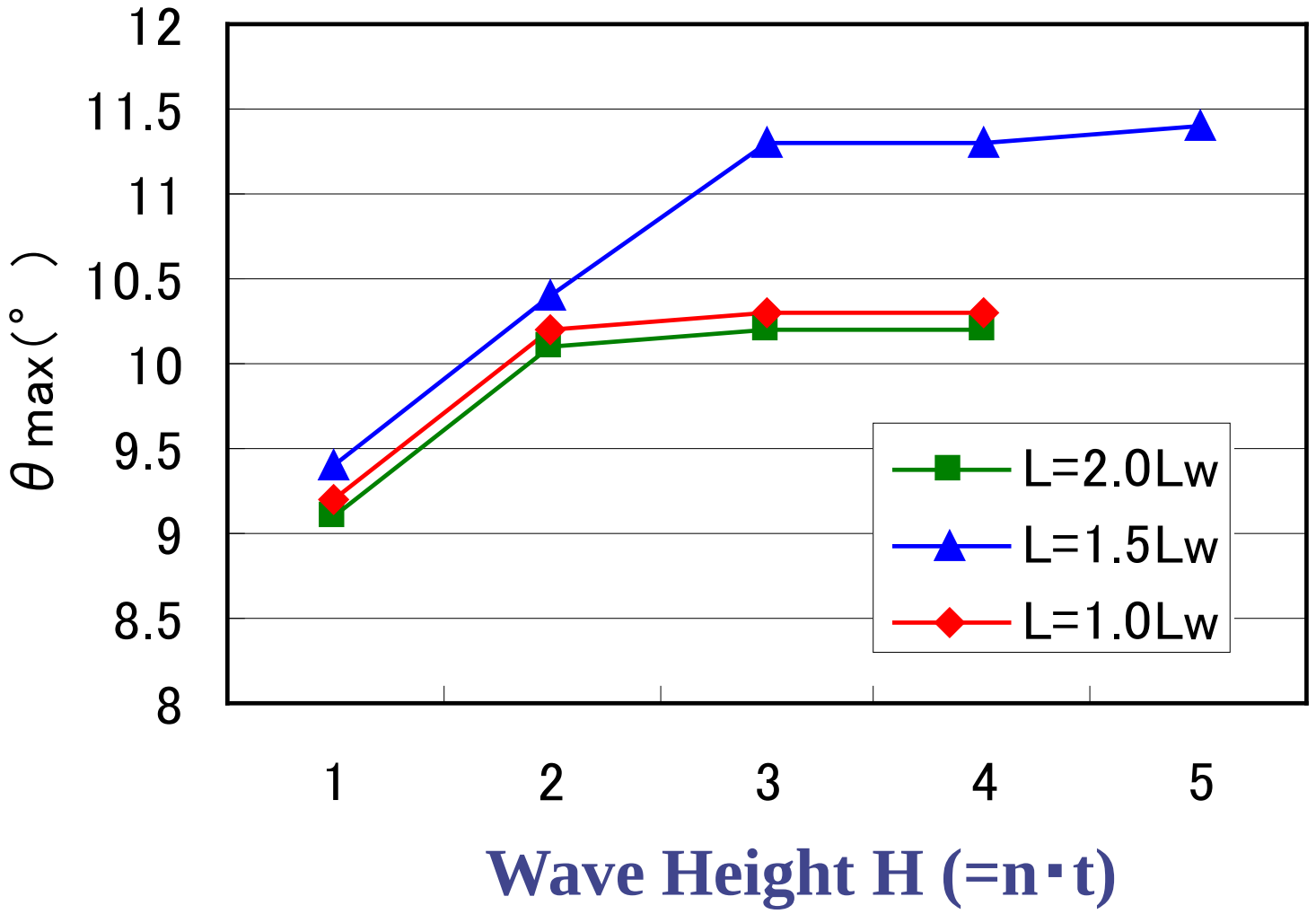


Max 28.17%

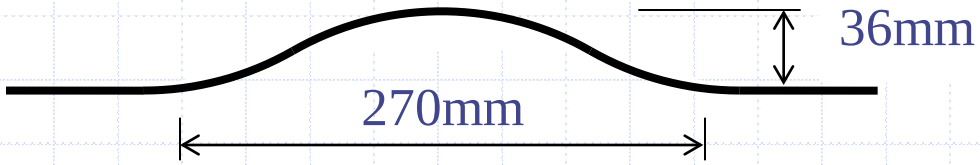
M-θ (L=1.5Lw,t=6mm)

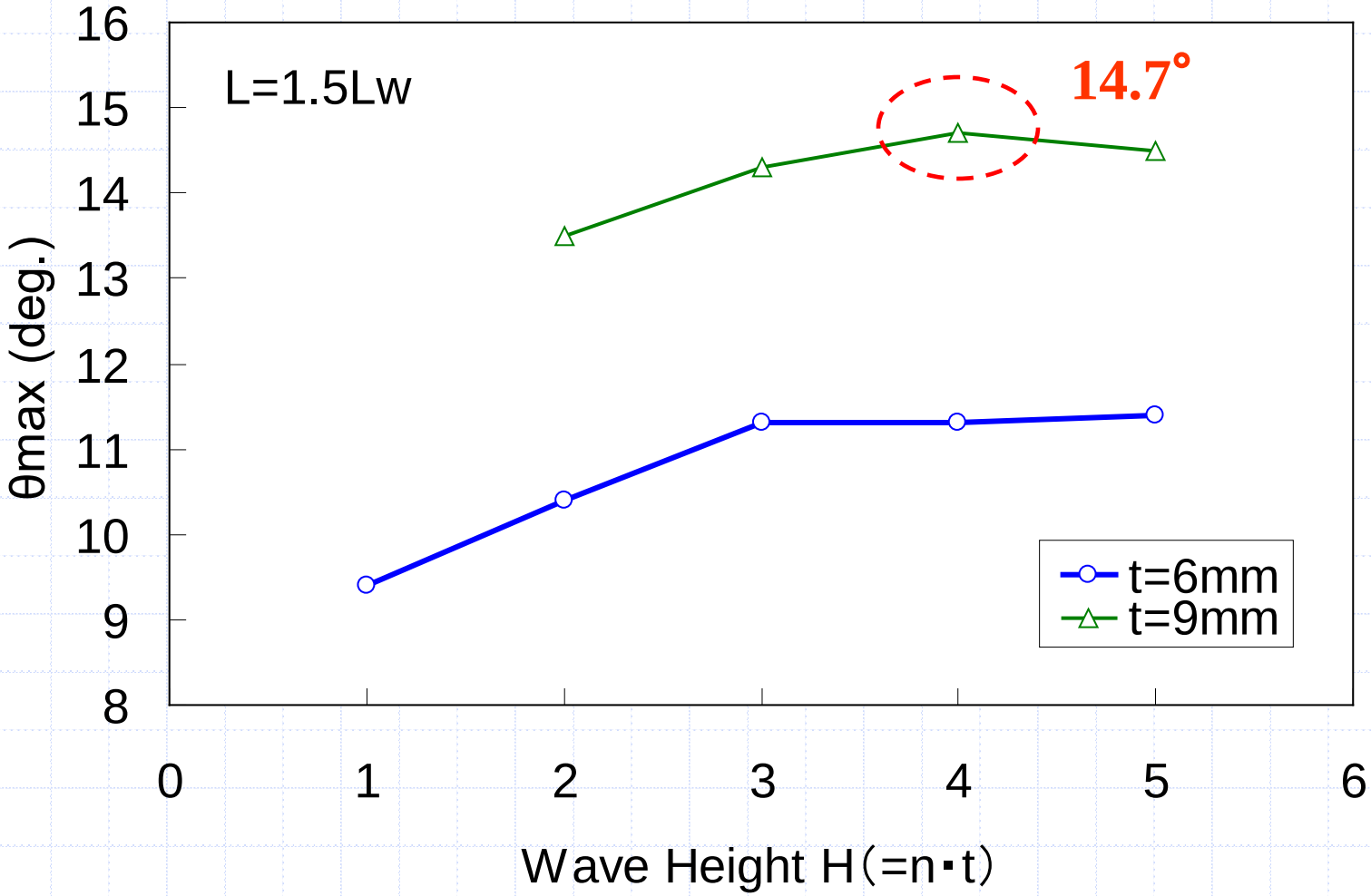


θ_{max}～H (t=6mm)

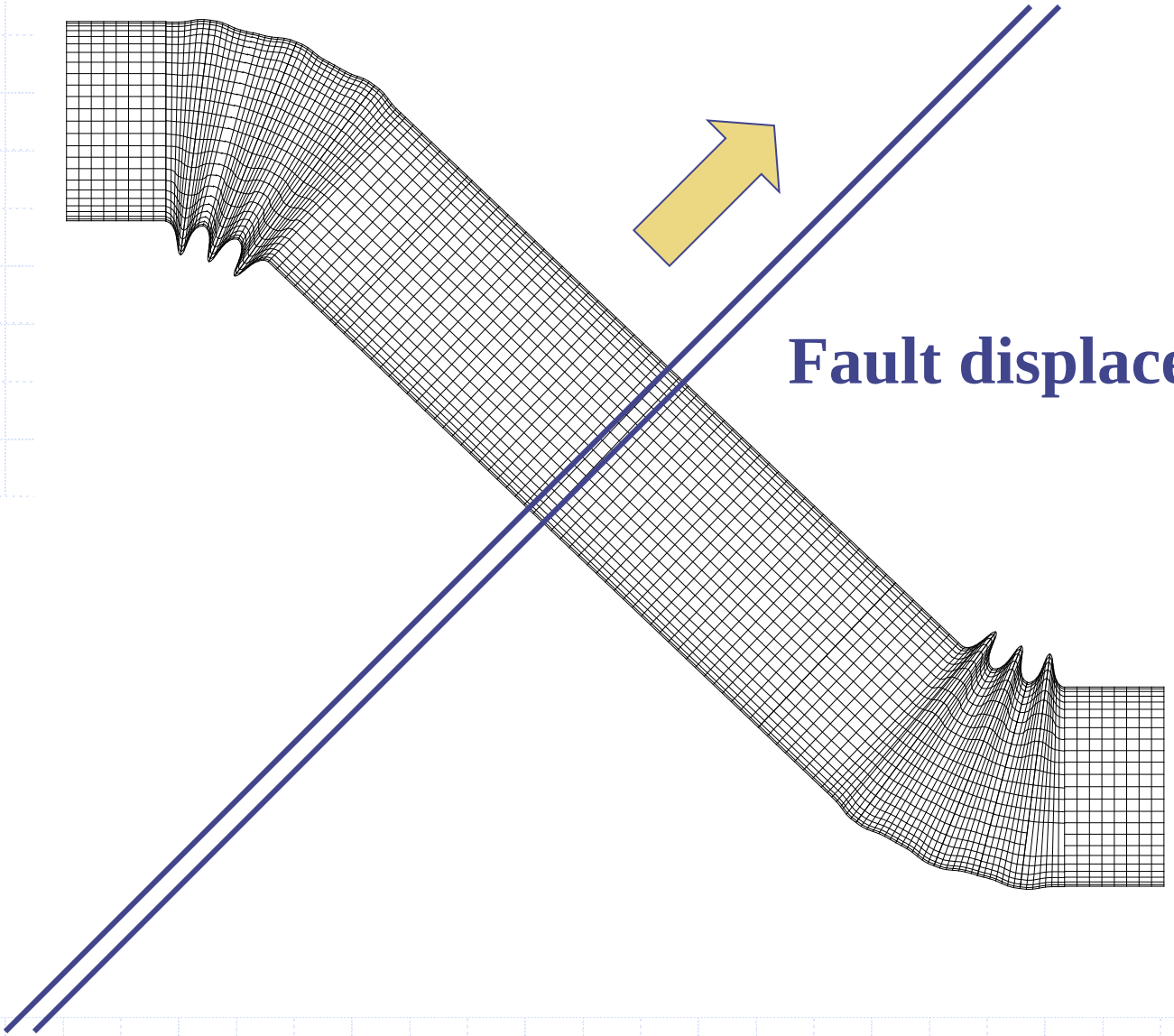


θ_{max}～H (L=1.5Lw)





Seismic behavior of the pipeline system



Experimental Study

Experimental Device

Result of Experiment

More than 30° but no crack

Conclusion

Conclusion

P-module can

- **absorb fault displacement by controling deformation**
- **ensure plastic deformation of the pipe without crack initiation or leakage**
- **secure the minimum water supply after a large earthquake**

Thank you for your attention.