Bridge Management System and Maintenance of Bridges

3. Fatigue of Steel Members

Organized by
Centre for Infrastructure Engineering and Management
&
School of Engineering
Griffith University Gold Coast Campus

Introduction

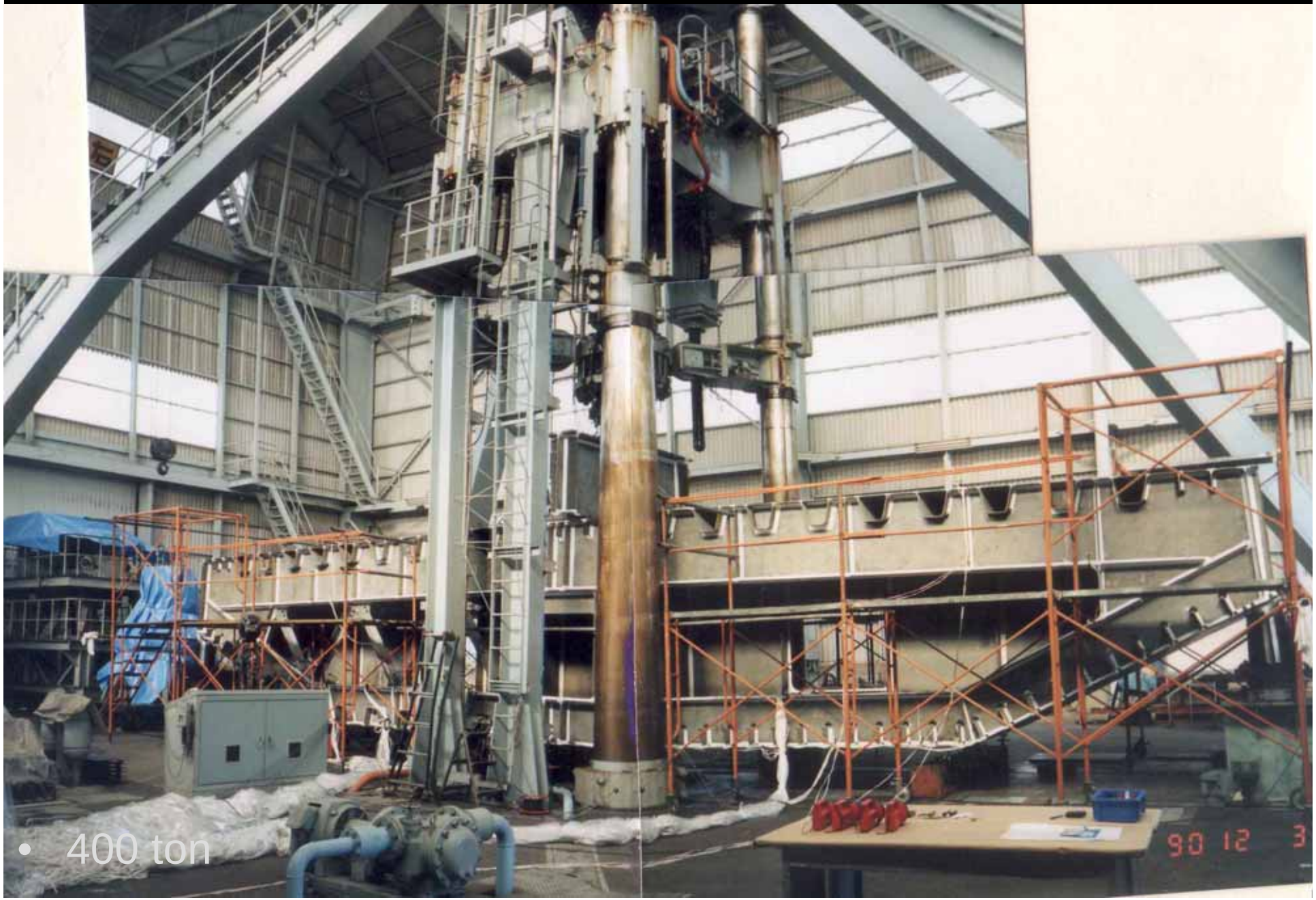
1. Bridge Management system
2. Inspection, evaluation and maintenance
3. **Fatigue of steel members**
4. Stress measurement and Bridge Weigh-in-Motion
5. Retrofitting, example of orthotropic steel deck
6. Corrosion and anti-corrosion measure

1. Fatigue cracks observed in steel bridges
2. Fatigue tests and physical behavior of fatigue crack propagation
3. Fatigue design
4. Evaluation of fatigue life
5. Fracture mechanics analysis of fatigue crack propagation

Fatigue tests

1. Large scale fatigue tests
2. Actual structural components
3. Model tests
4. Small scale fatigue tests
5. Fatigue tests in plate bending

Section model of cable-stayed girder

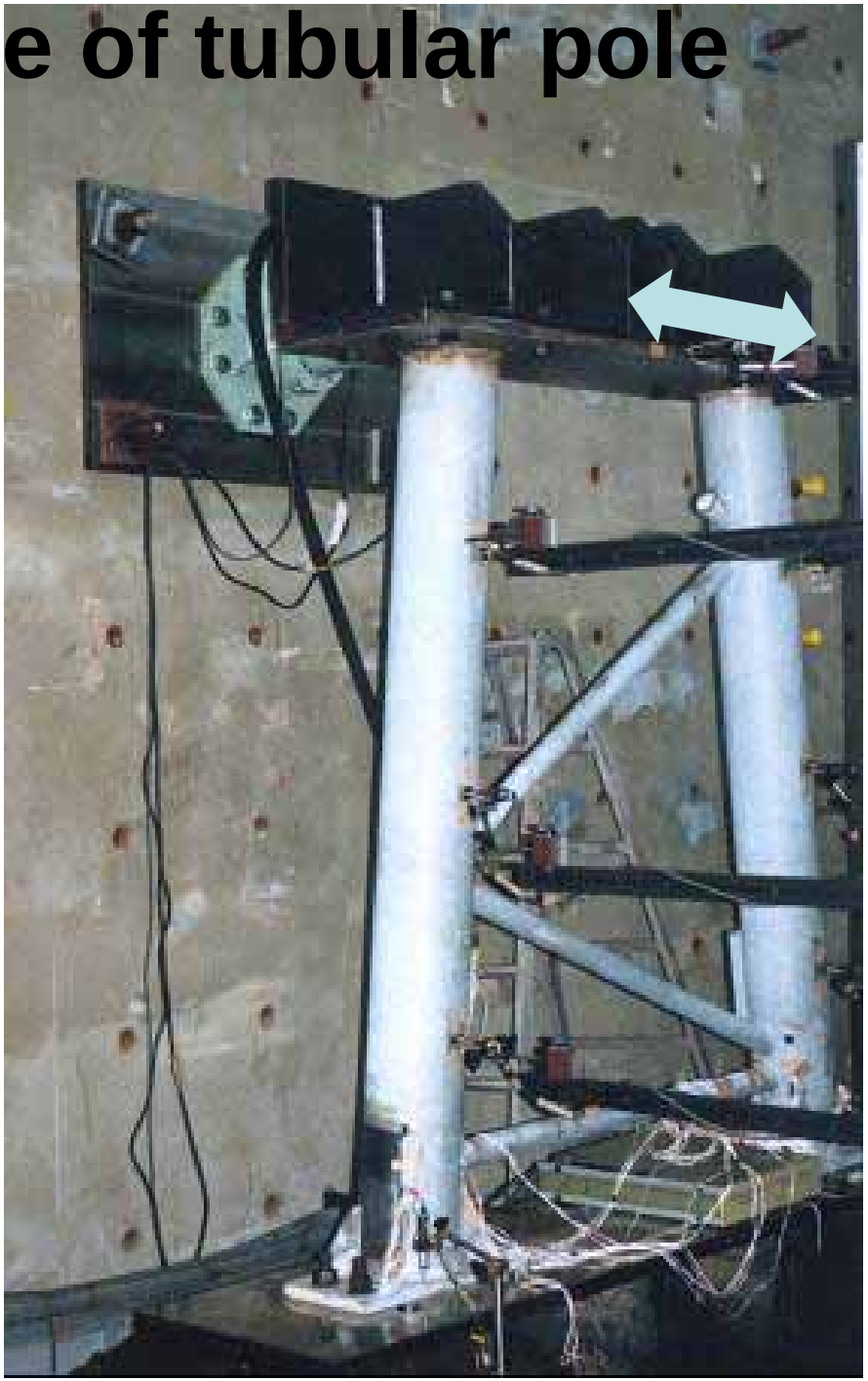


- 400 ton

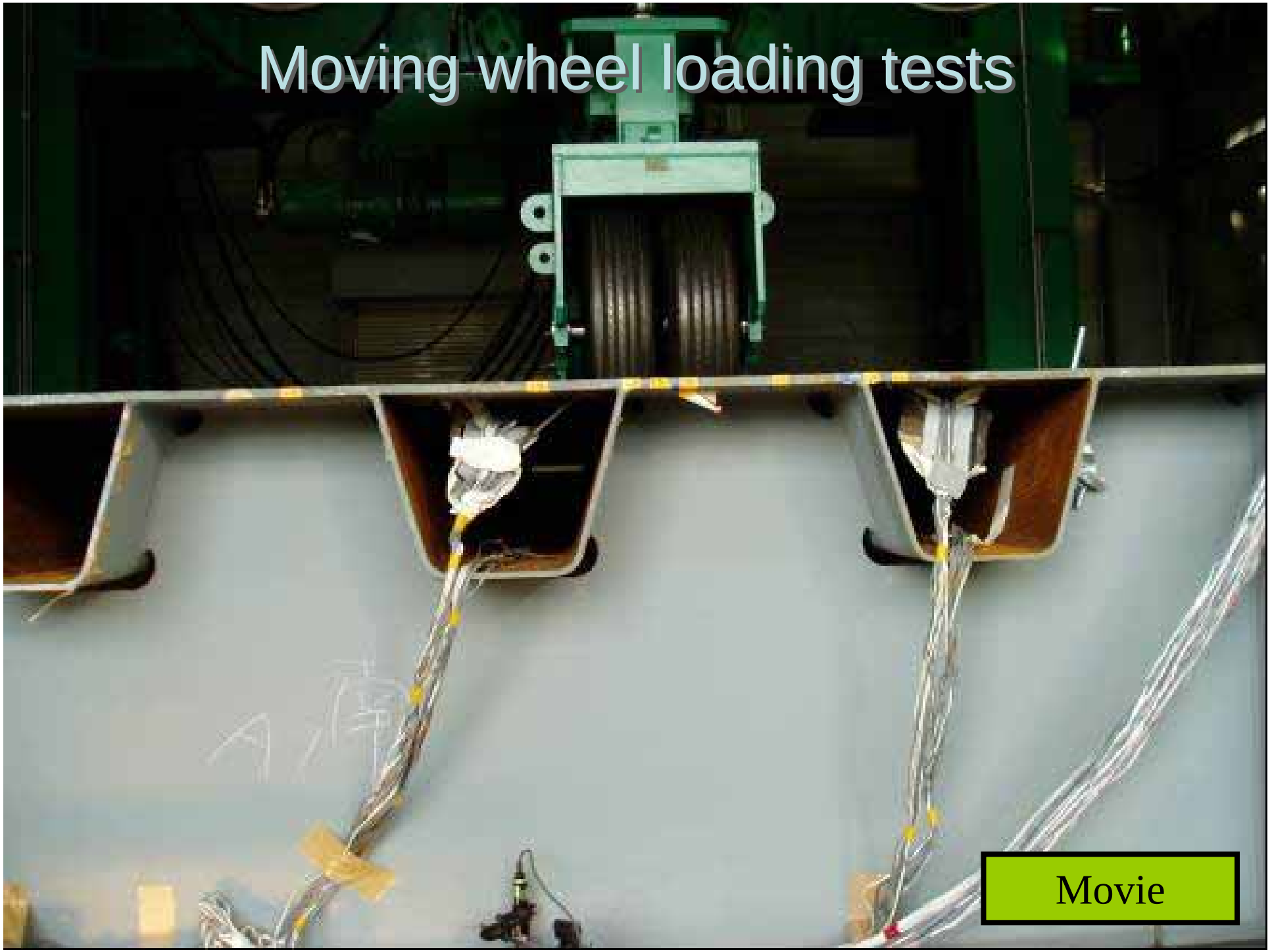

Fatigue tests on steel piers
2004, MEX

Fatigue tests of base of tubular pole

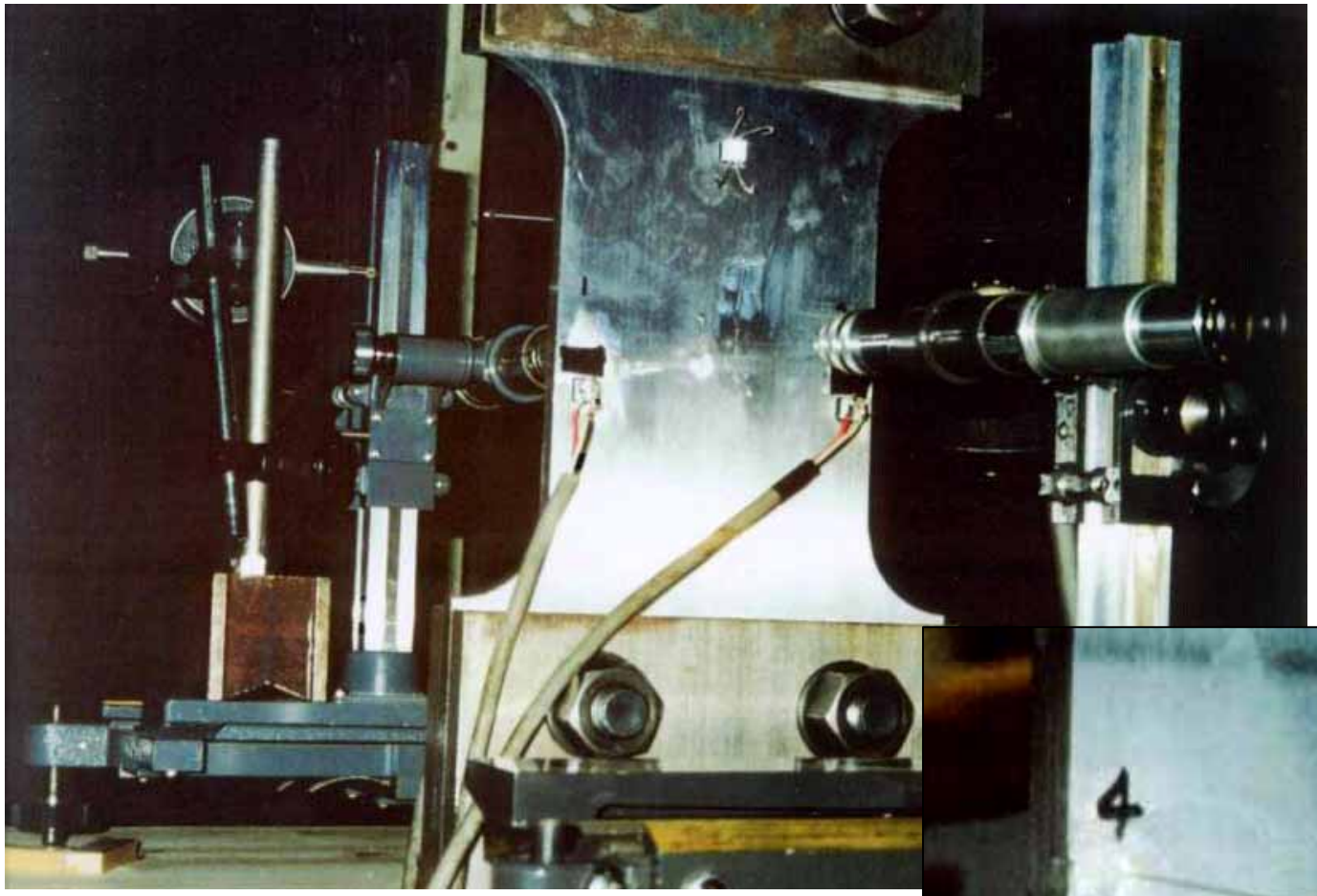
Removed from sign poles

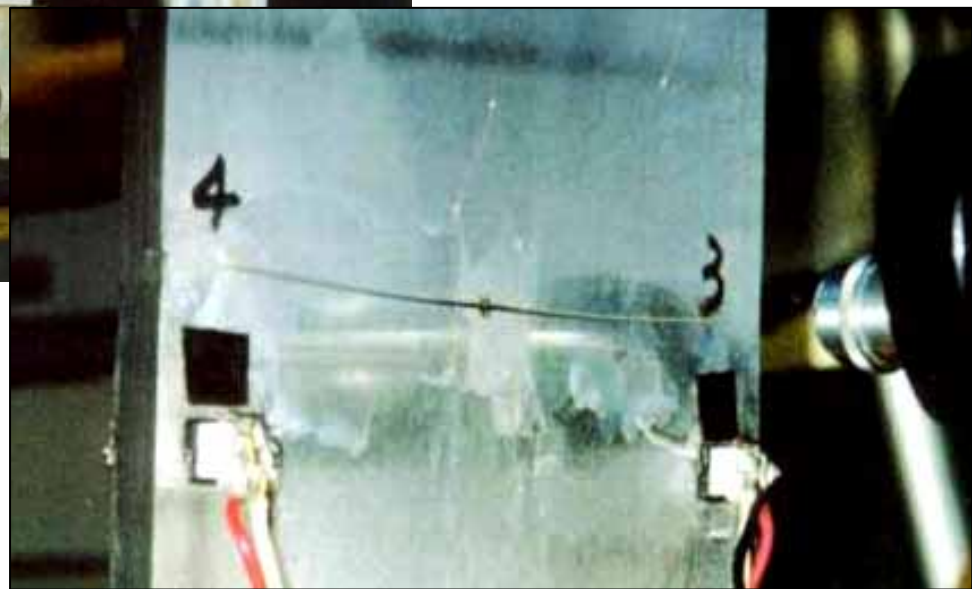


Moving wheel loading tests



Measurement of fatigue crack growth



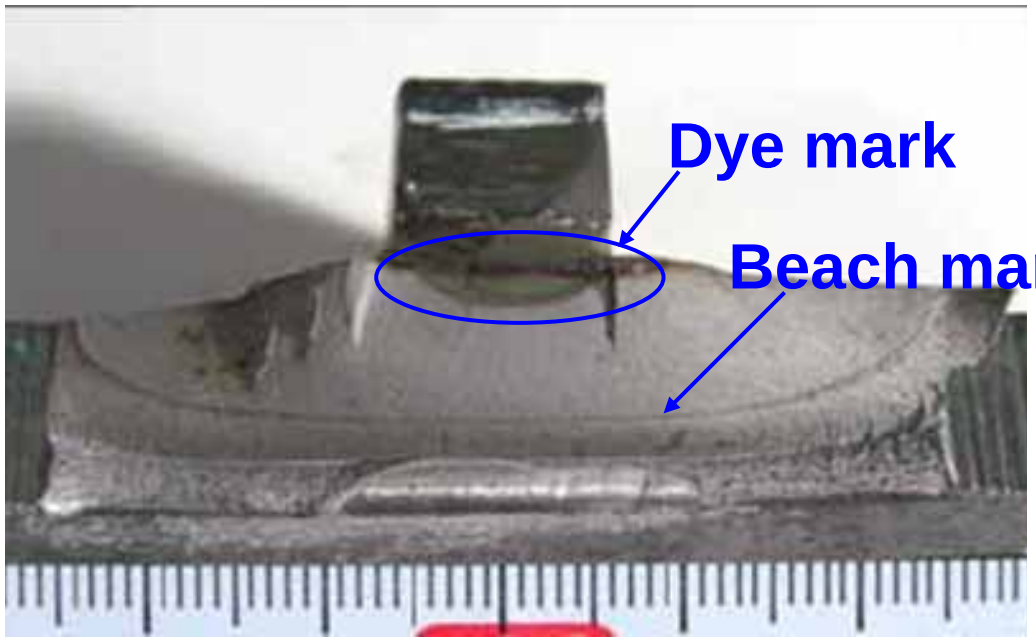


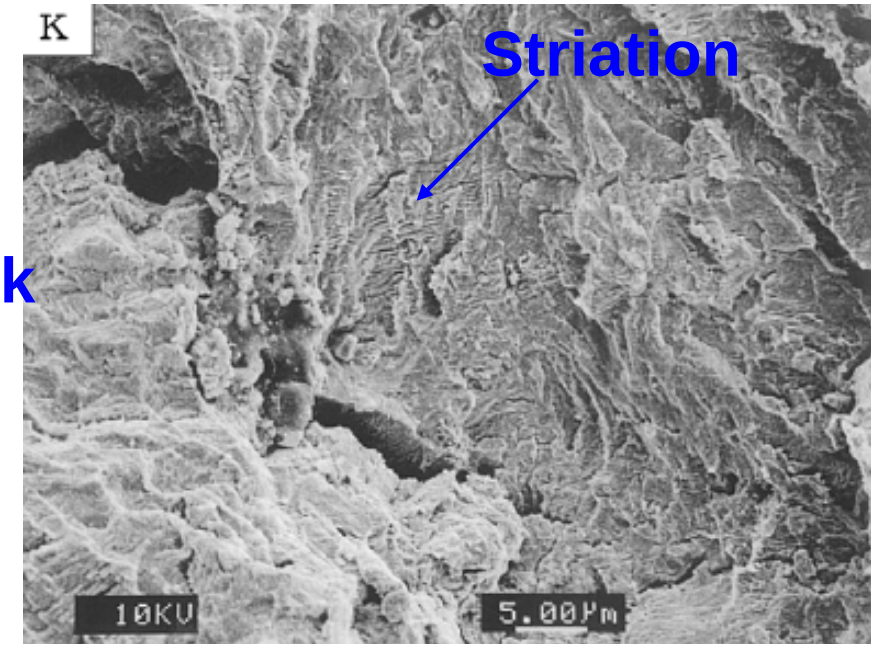
Fracture mechanics analysis

Fracture surface

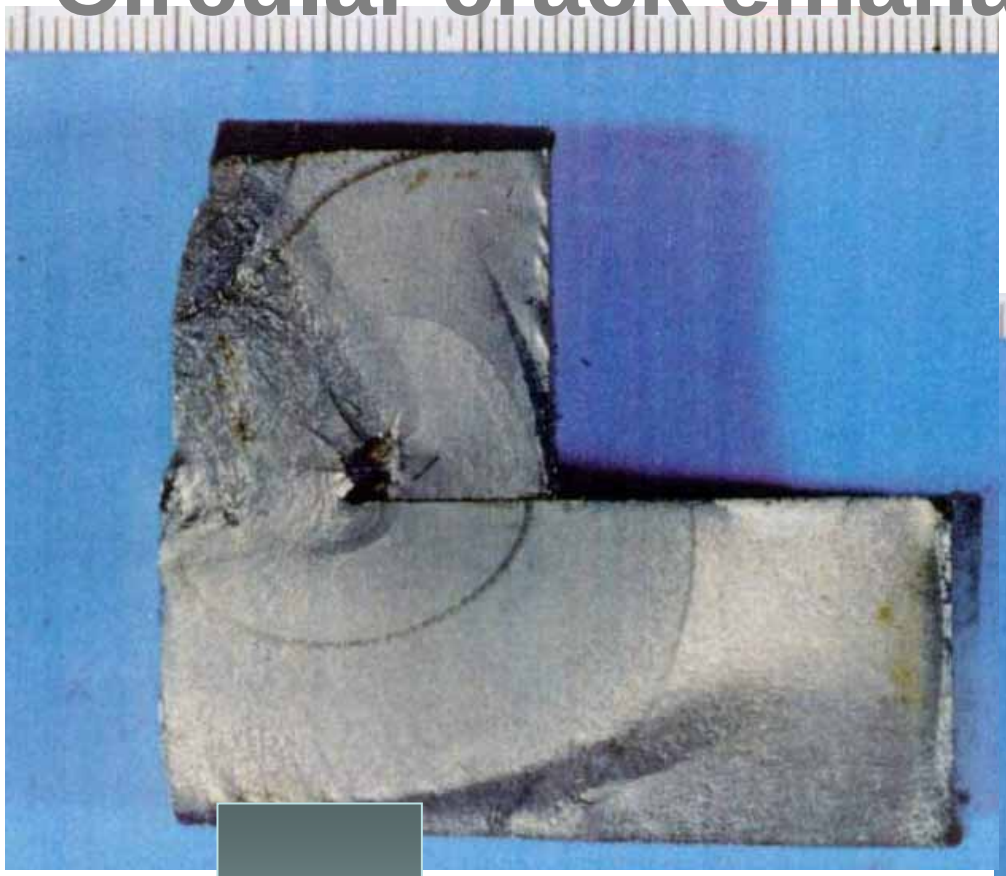
Trace of fatigue crack propagation

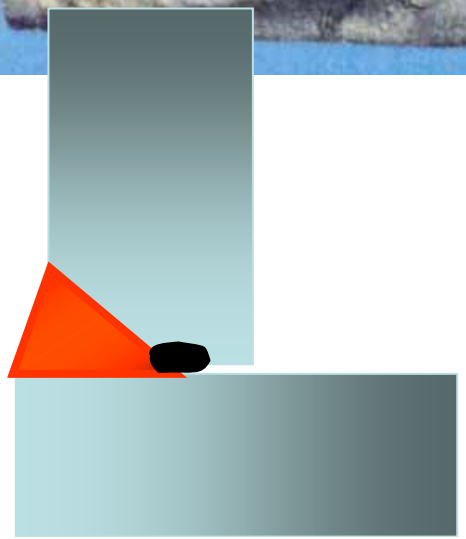
- Beach marks by visual inspection
- Striation by SEM





Circular crack emanating from blowhole



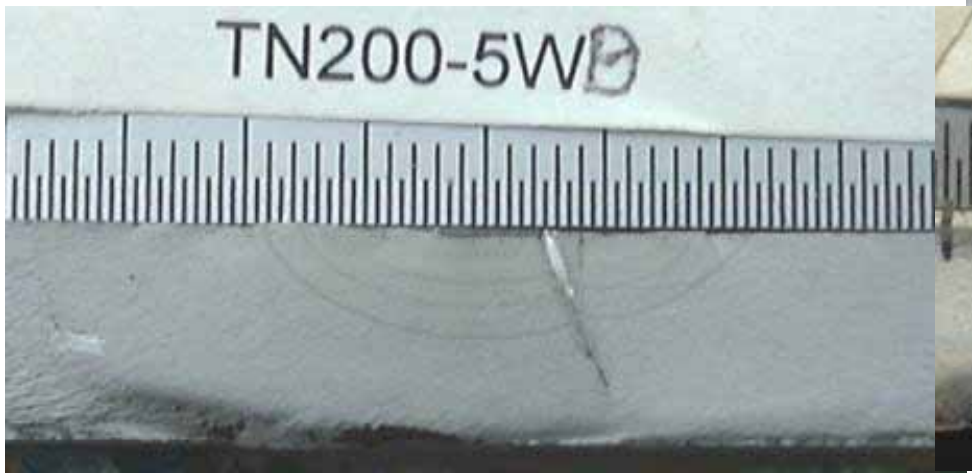


提供:トピー工業

Cracks emanating from combined attachment Out-of-plan gusset and fillet welded ribs

Out-of-plane gusset

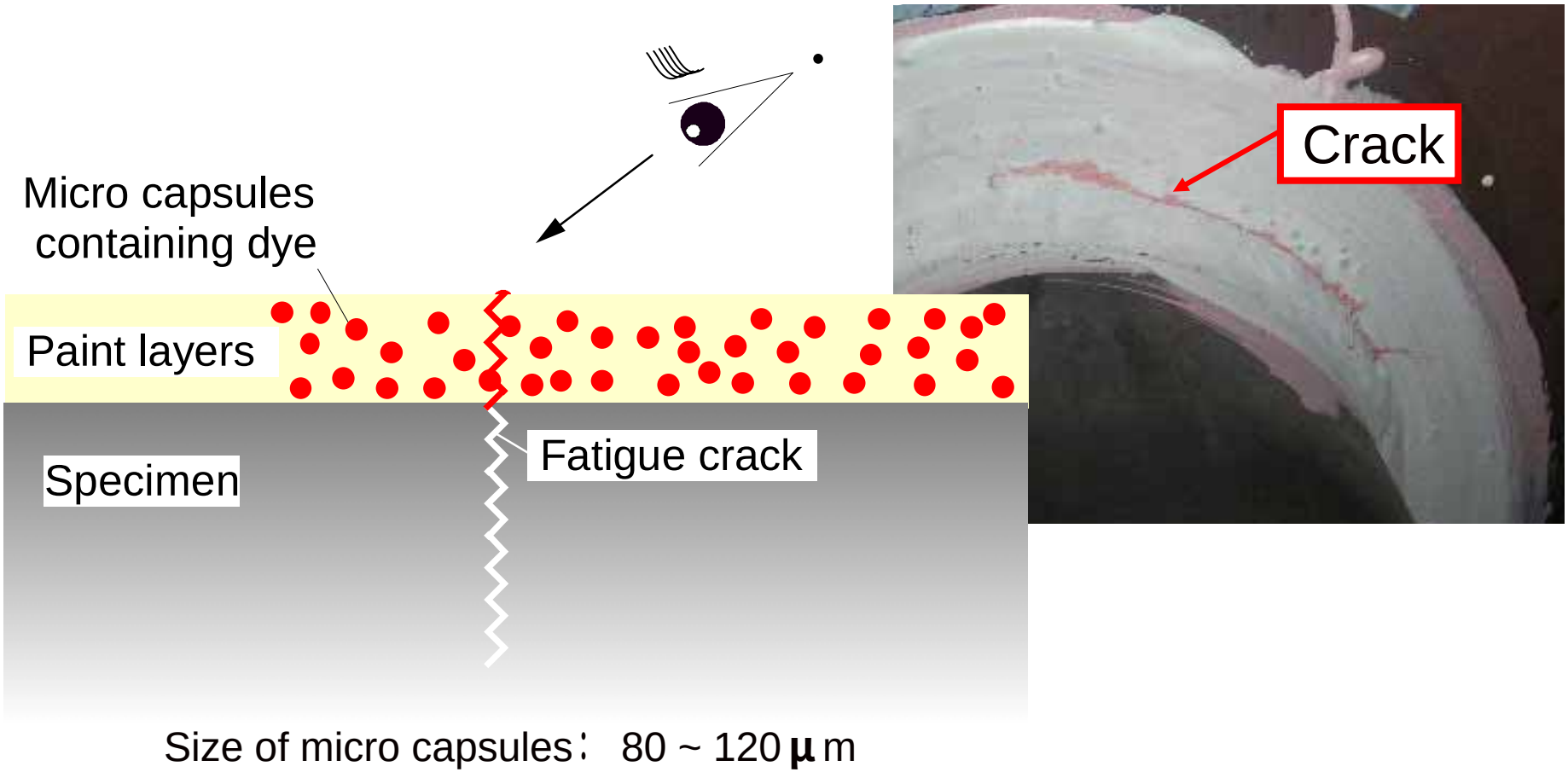
Fillet welded ribs



Tensile fatigue testing machine (1971～2005)

Tensile plate with fillet welded pipes

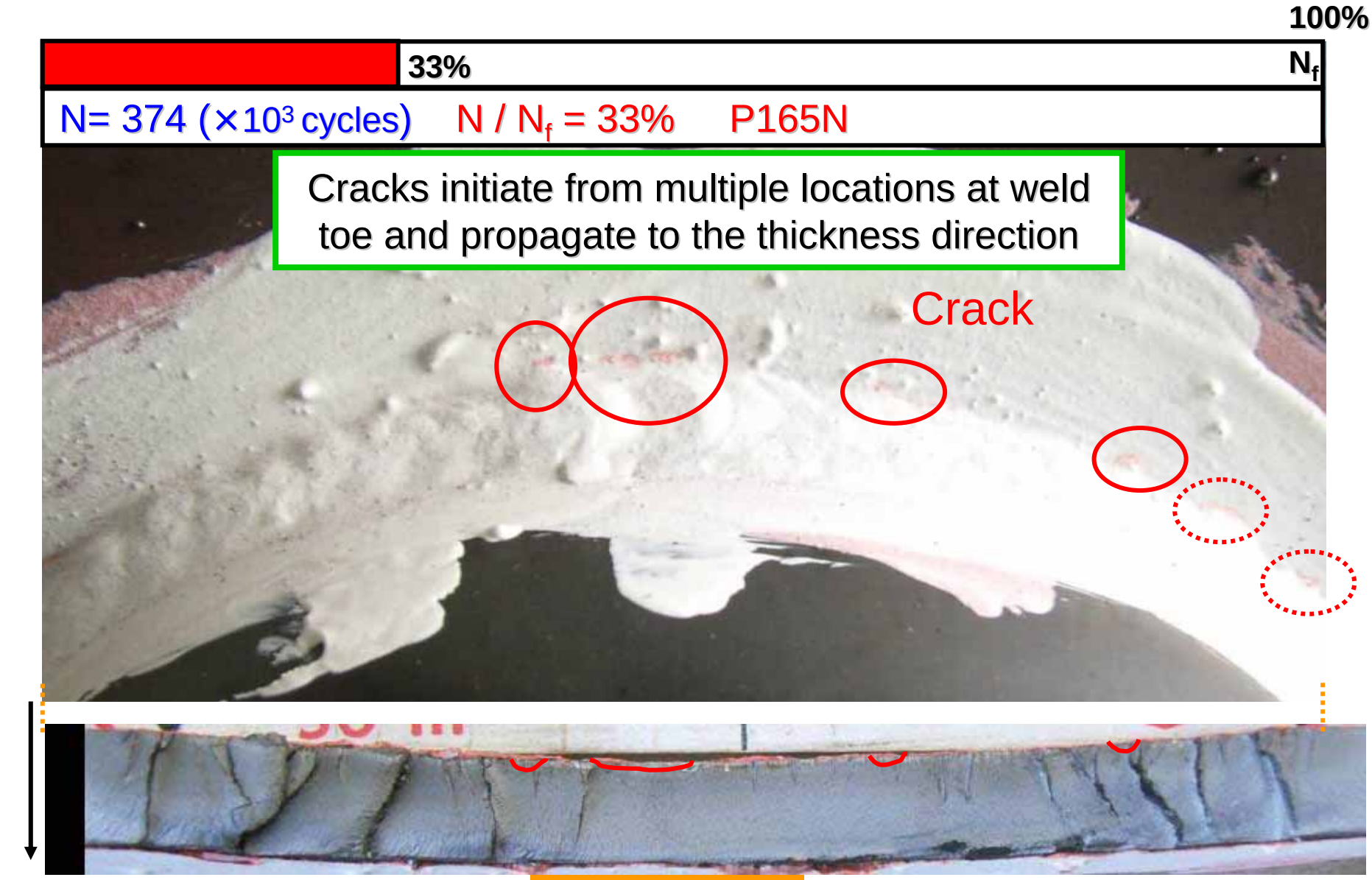
Mechanism of Crack Detection Paint



Size of micro capsules： 80 ~ 120 μm

Micro capsules are broken when cracks initiate and propagate.
Dye in micro capsules make cracks visible.

Crack detection paint and beach marking

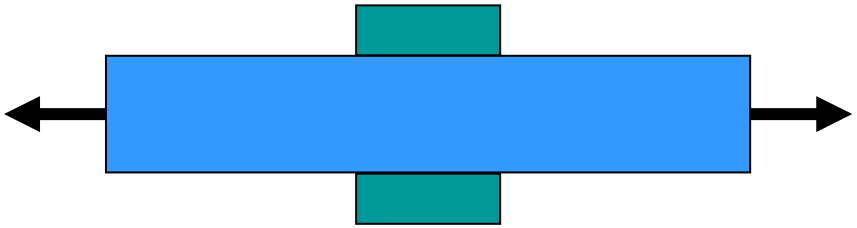


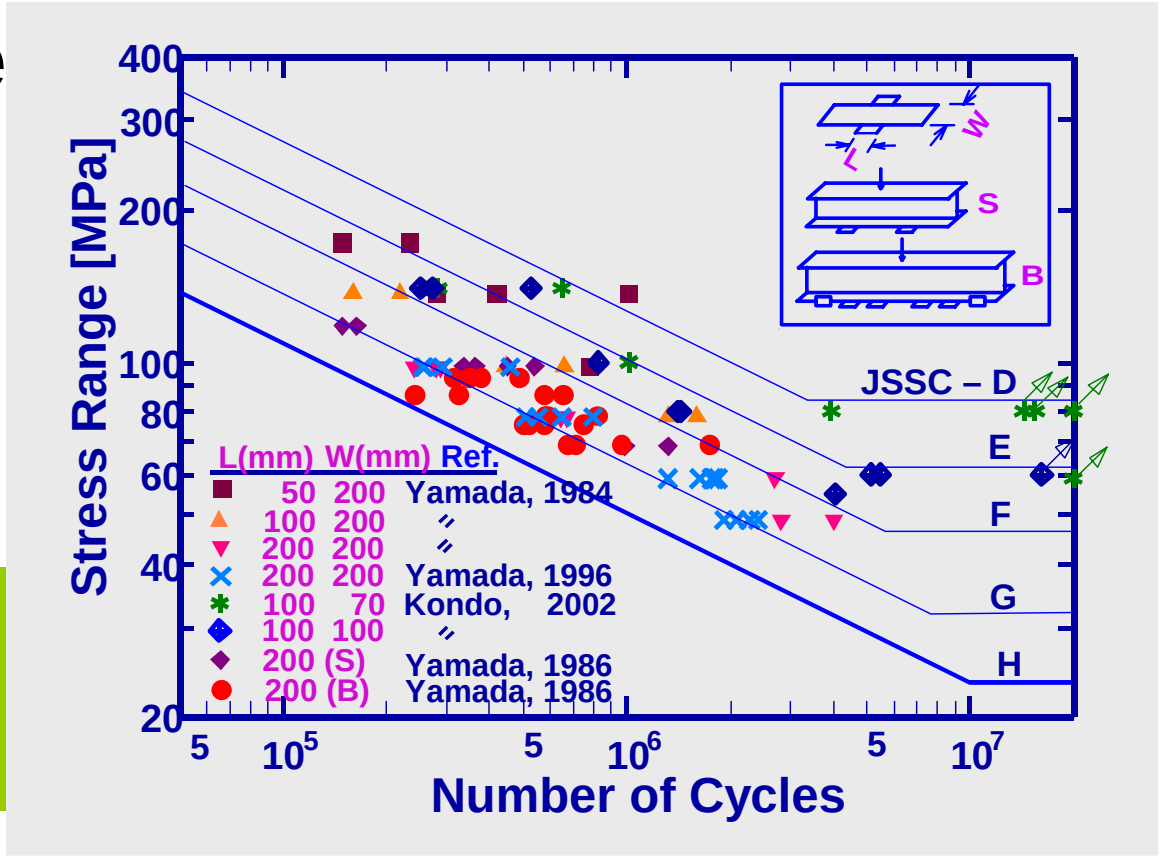
Yamada and Nakano, 2005

Base of fatigue of weldments

Three factors in fatigue of weldments

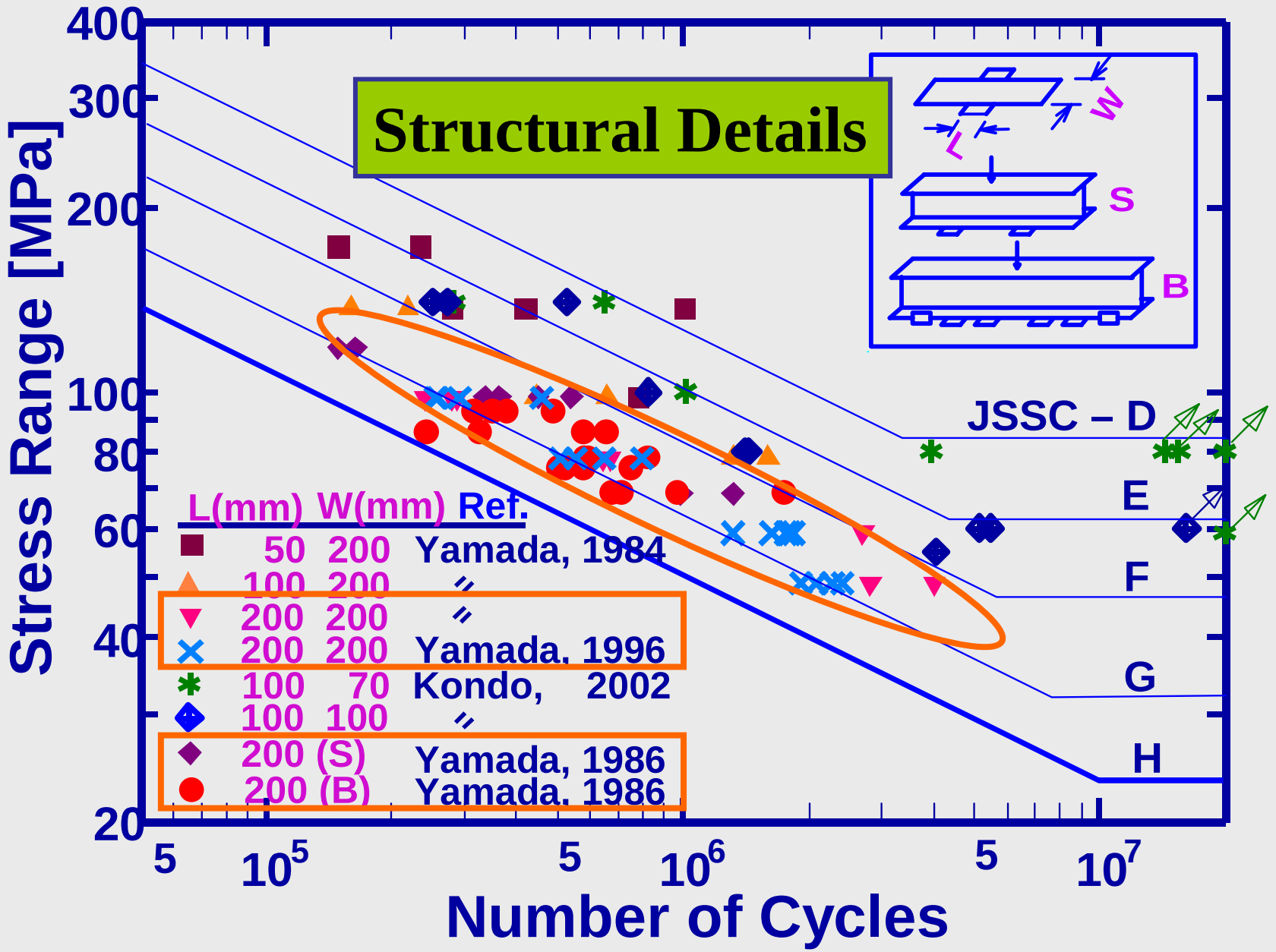
- Structural Detail
- Stress Range
- Number of Cycle



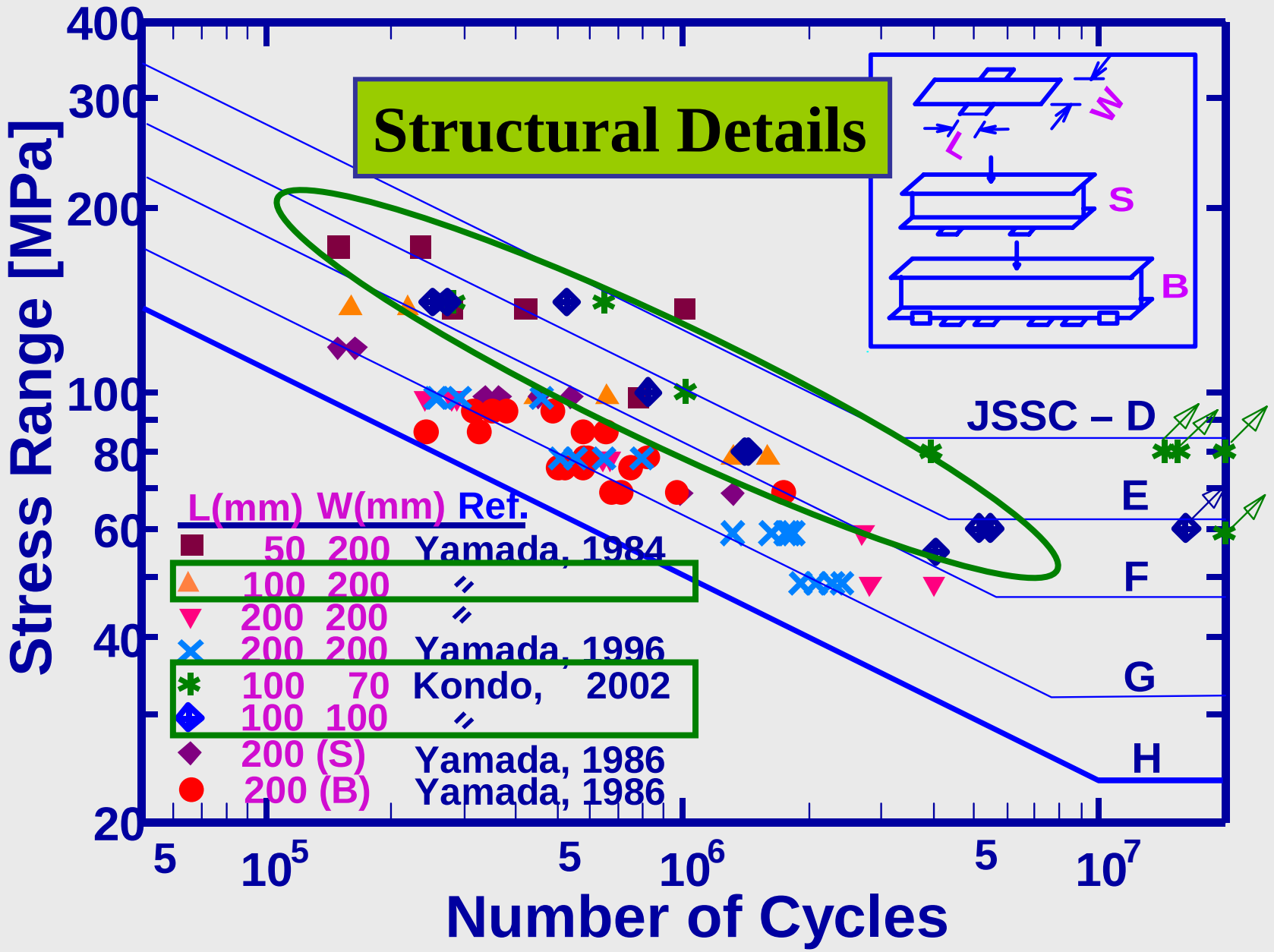


S-N curve for in-plane attachments

S-N curve for in-plane attachments



S-N curve for in-plane attachments



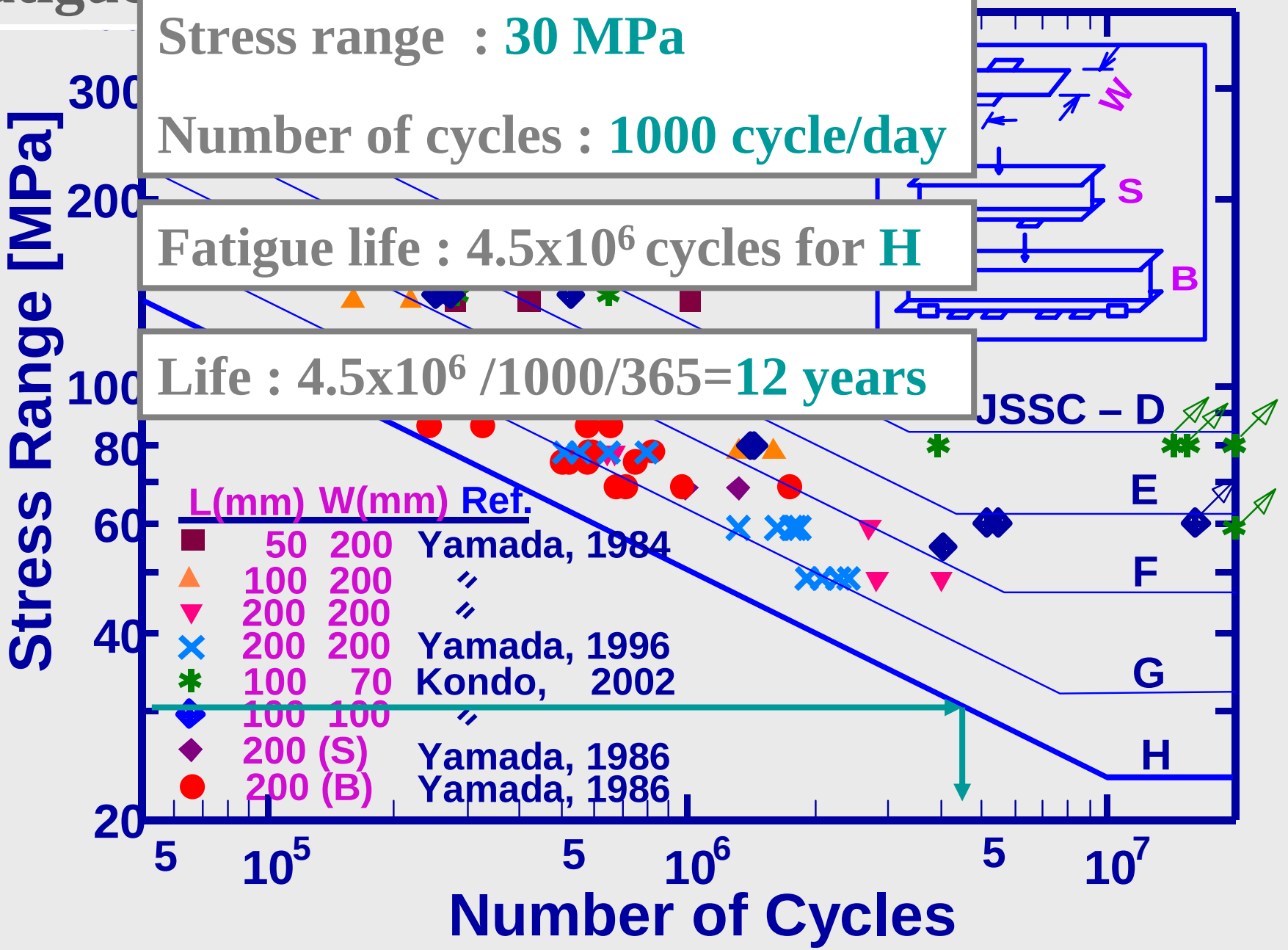
Fatigue Design for CA

Stress range : 30 MPa

Number of cycles : 1000 cycle/day

Fatigue life : 4.5×10^6 cycles for H

Life : $4.5 \times 10^6 / 1000 / 365 = 12$ years



Fatigue Design for CA

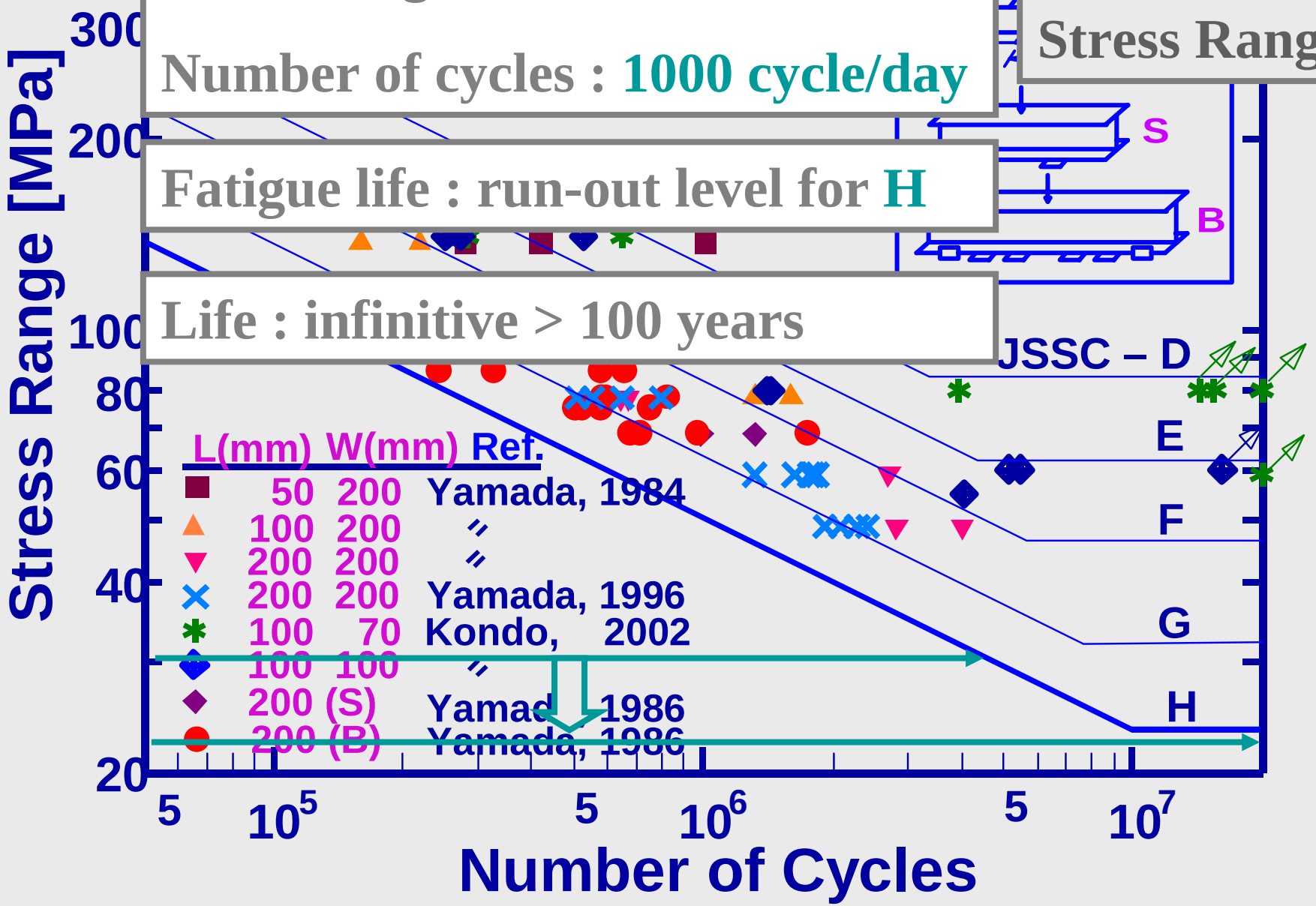
Stress range : 22 MPa

Number of cycles : 1000 cycle/day

Fatigue life : run-out level for H

Life : infinitive > 100 years

Reduce Stress Range



Fatigue Design for CA

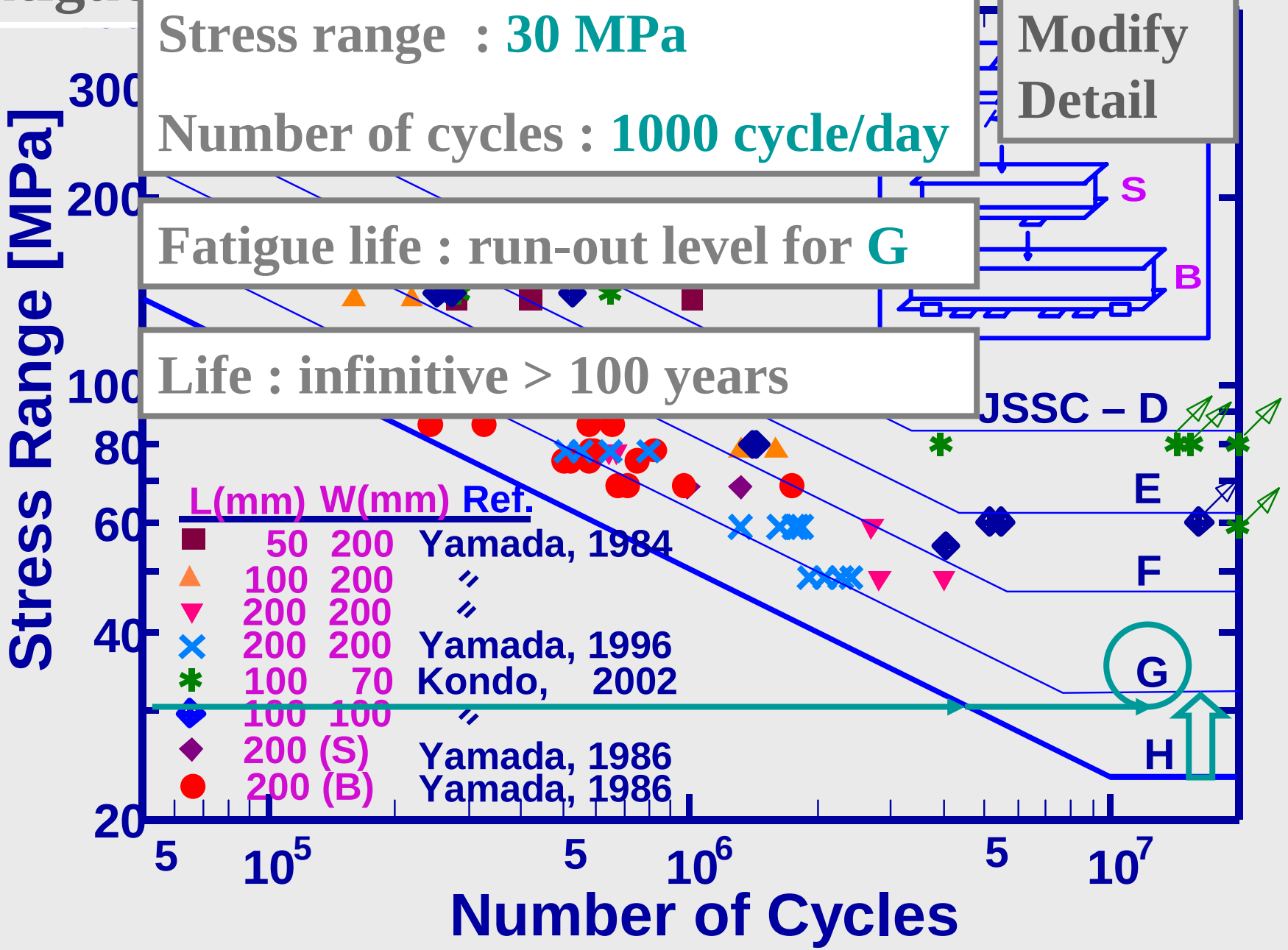
Stress range : 30 MPa

Number of cycles : 1000 cycle/day

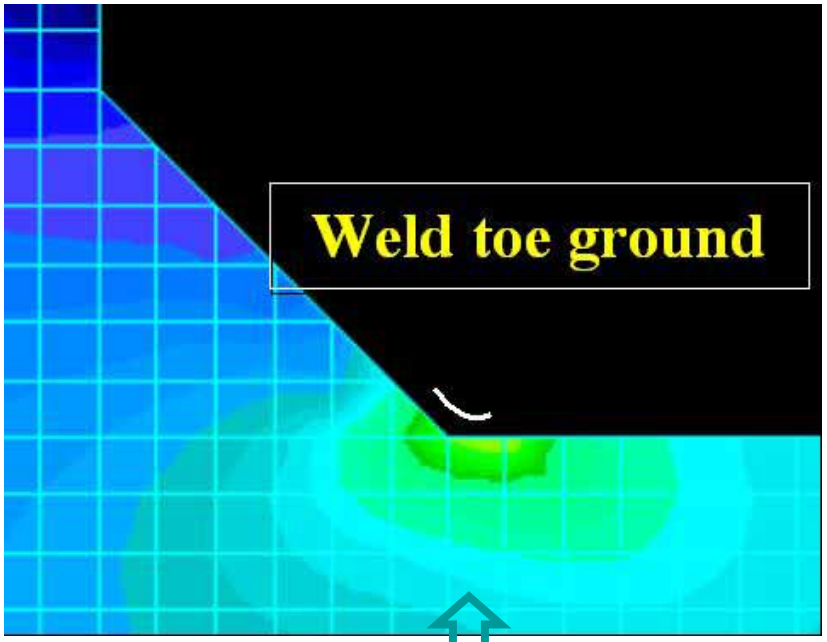
Fatigue life : run-out level for G

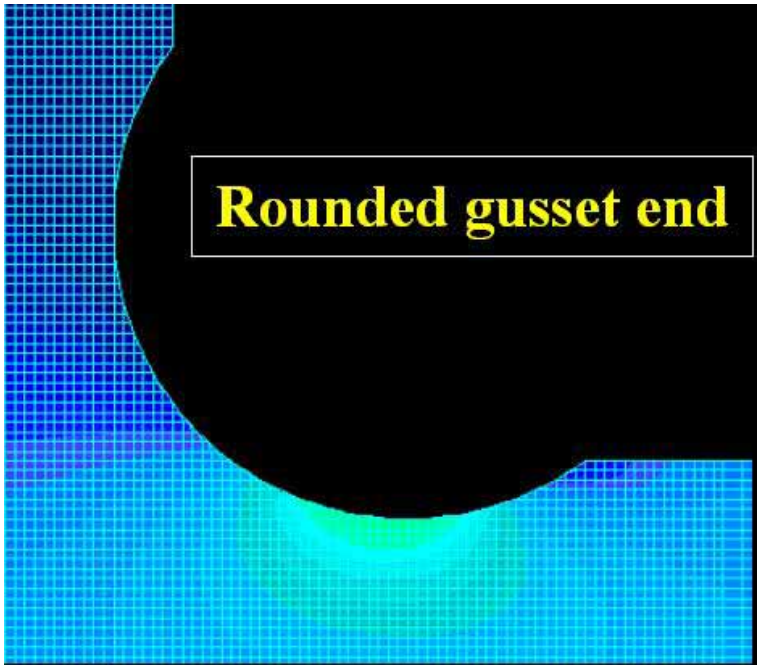
Life : infinitive > 100 years

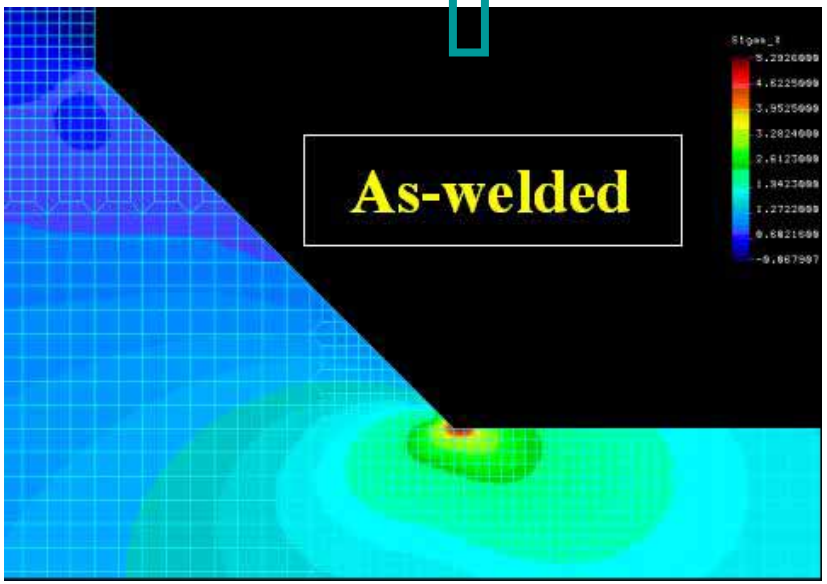
Modify Detail

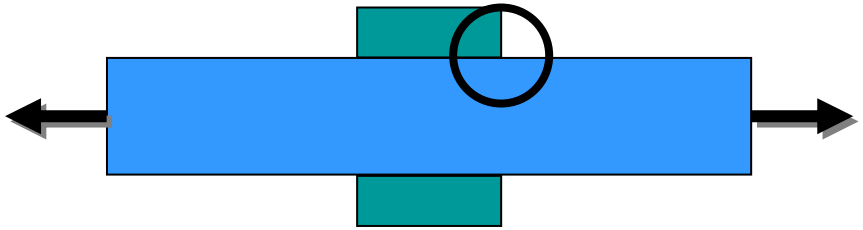


Improving fatigue strength by rounding gusset ends

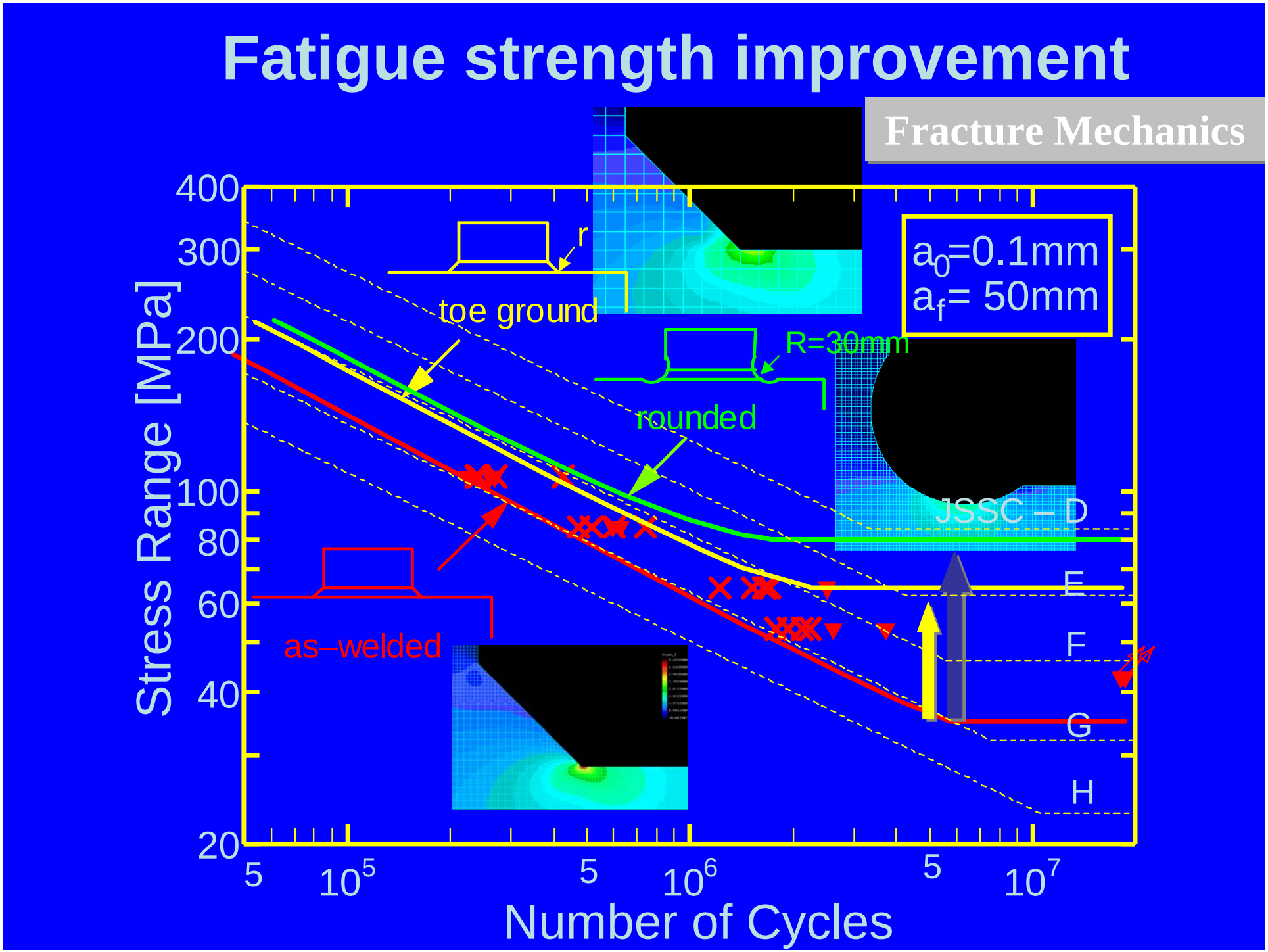








Fatigue strength improvement

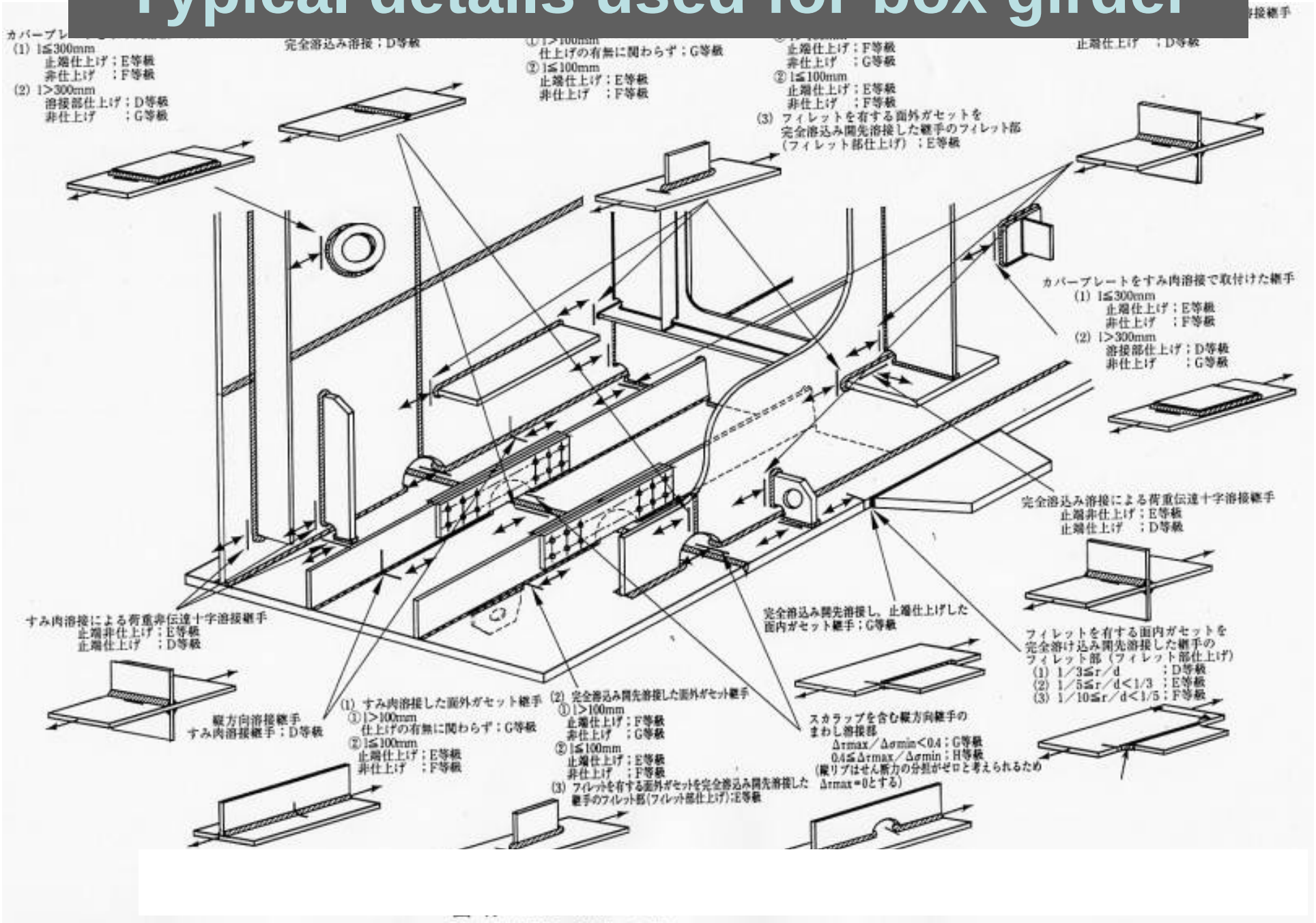


Fatigue Design Procedure

1. **Give loading**

   Give truck type, their weight and volume. Alternatively use an equivalent truck.
2. **Analyze to determine stress ranges at point where fatigue life is assessed.**
3. **Determine detail category, A-H', for the detail.**
3. **Check if computed life is over design life.**
4. **If life is less than design life, modify detail to meet fatigue design requirement.**

Typical details used for box girder



Classification of joint details

BS5400 Part 10 Fatigue 1985

AASHTO

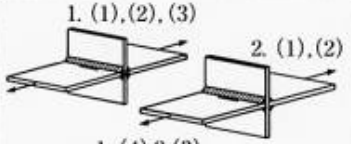
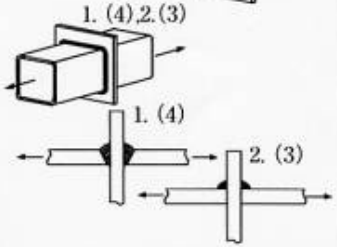
Fatigue design recommendation for welded structures, JSSC 1993

IIW

Eurocode3

Fatigue design recommendation of steel highway bridges, JRA 2002

(e)荷重伝達型十字溶接継手

継手の種類			強度等級 ($\Delta\sigma_f$ (N/mm²))	備考
1.完全溶込み溶接	(1)なめらかな止端を有する継手		D (100)	
	(2)止端仕上げした継手		D (100)	
	(3)非仕上げの継手		E (80)	
	(4)中空断面部材(片面溶接)	1)裏当て金なし	F (65)	
		2)裏当て金あり	G (50)	
2.すみ肉溶接および部分溶込みすみ肉溶接	(1)止端破壊	1)なめらかな止端を有する継手	E (80)	
		2)止端仕上げした継手	E (80)	
		3)非仕上げの継手	F (65)	
		4)溶接の始終端を含む継手	F (65)	
	(2)ルート破壊(のど断面)		H (40)	
	(3)中空断面部材(片面溶接)	1)止端破壊	H (40)	
		2)ルート破壊(のど断面)	H (40)	

注) 1.(1), 1.(2), 1.(3)の継手の強度等級は，溶接内部のきずす法が次のものを対象とする。

厚板 t	きずす法
t≦18 mm	3 mm 以下
t>18 mm	1/6 以下

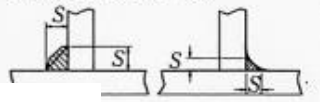
これらの継手において，溶接内部のきずす法を板厚の 1/6 をこえ，板厚の 1/3 以下とした場合は，強度等級はF等級としなければならない。

注) 1.(1), 2.(1)1)の継手において，アンダーカットは除去する。このとき，仕上げは応力の方向と平行に確実に行わなければならない。

注) 1.(2), 2.(1)2)の継手において，仕上げはアンダーカットが残らないように応力の方向と平行に確実に行わなければならない。

注) 1.(3), 1.(4), 2.(1)3), 2.(1)4), 2.(3)1)の継手の強度等級は，アンダーカットが 0.3 mm 以下の継手を対象とする。
これらの継手において，アンダーカットを 0.3 mm をこえ，0.5 mm 以下とした場合は，強度等級を1等級低減しなければならない。

注) 2.(2), 2.(3)2)の継手の強度等級は，溶接の脚長（あるいはサイズ）sが板厚の 0.4 以上の継手を対象とする。
のど断面積は，(のど厚)×(溶接長) より求める。また，のど厚は$s/\sqrt{2}$より算出する。



7 mm, 0.2~1 のアスペ

Fatigue Design Recommendation of Highway Bridge, 2002