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Retrofitting, example of orthotropic steel deck

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Introduction

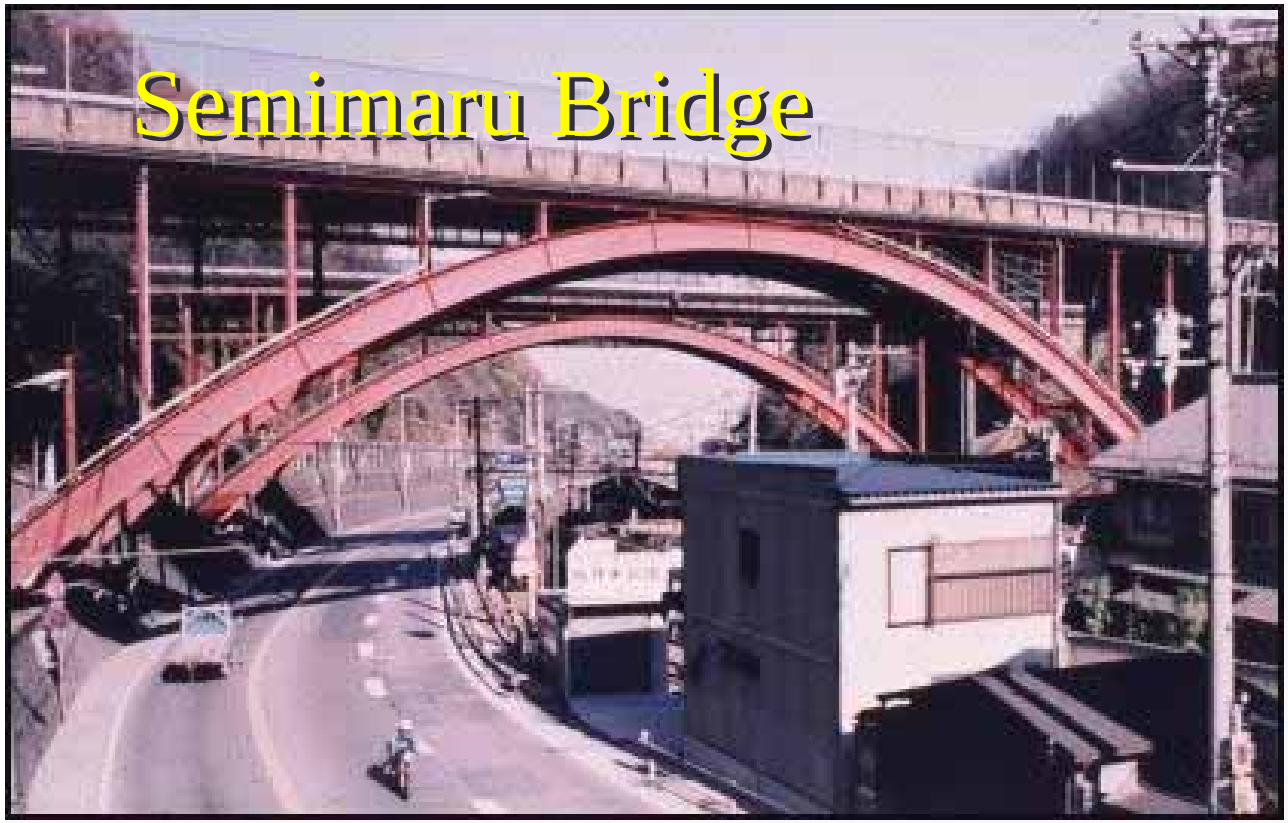
1. Bridge Management system
2. Inspection, evaluation and maintenance
3. Fatigue of steel members
4. Stress measurement and Bridge Weigh-in-Motion
5. **Retrofitting, example of orthotropic steel deck**
6. Corrosion and anti-corrosion measure

1. Retrofitting
2. Arch Bridge
3. Pier and girders
4. Orthotropic Steel Deck
5. Other

Meishin Expressway: Nagoya to Kobe

Open to traffic in 1963
The first expressway in Japan
Economical structures
Financed from the World Bank

Tunnel in both sides.
NR1 and train trucks underneath.



Arch Bridge with skew of 62 degree
ADT: 83,000 vehicles.
Minimum disturbance to traffics.

Modification was made in 13 nights.

Deterioration

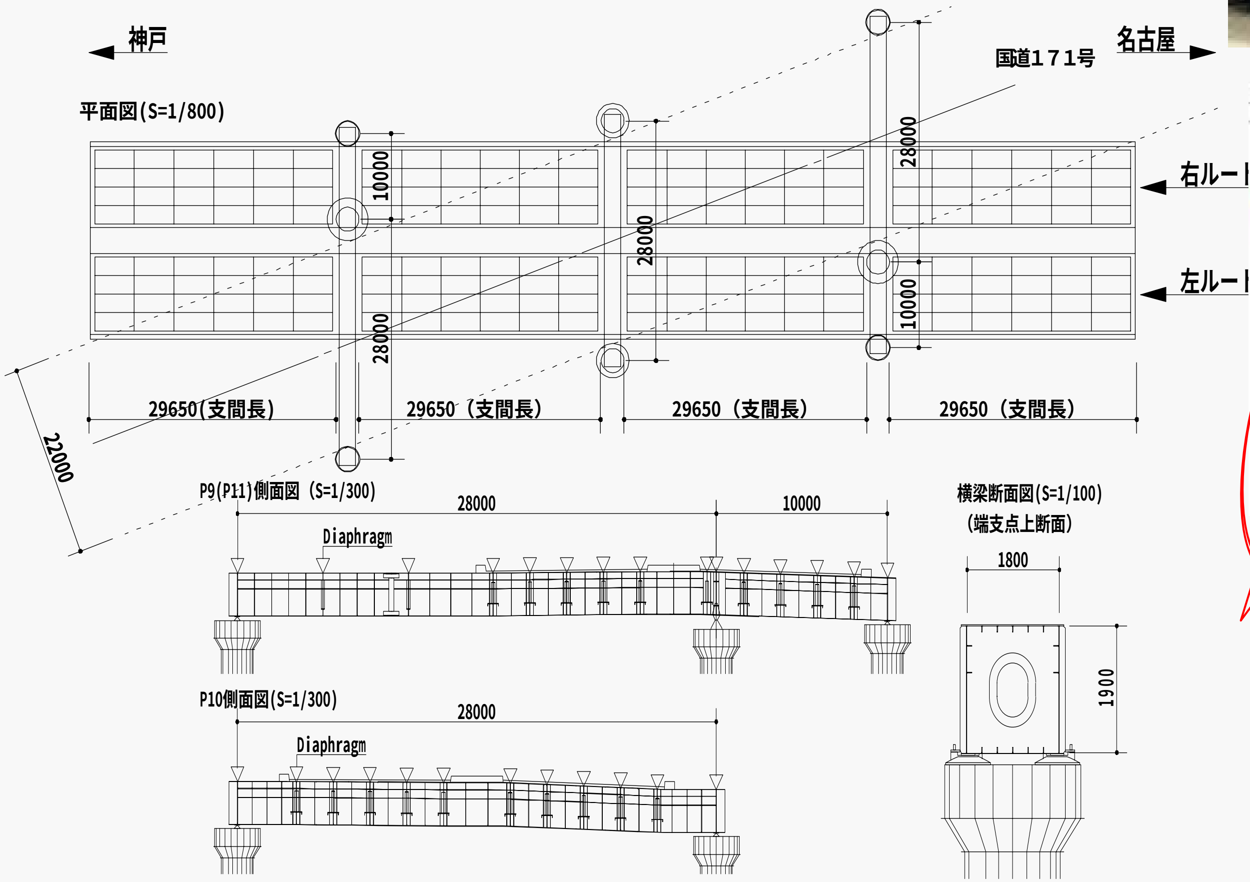
1. Concrete deck

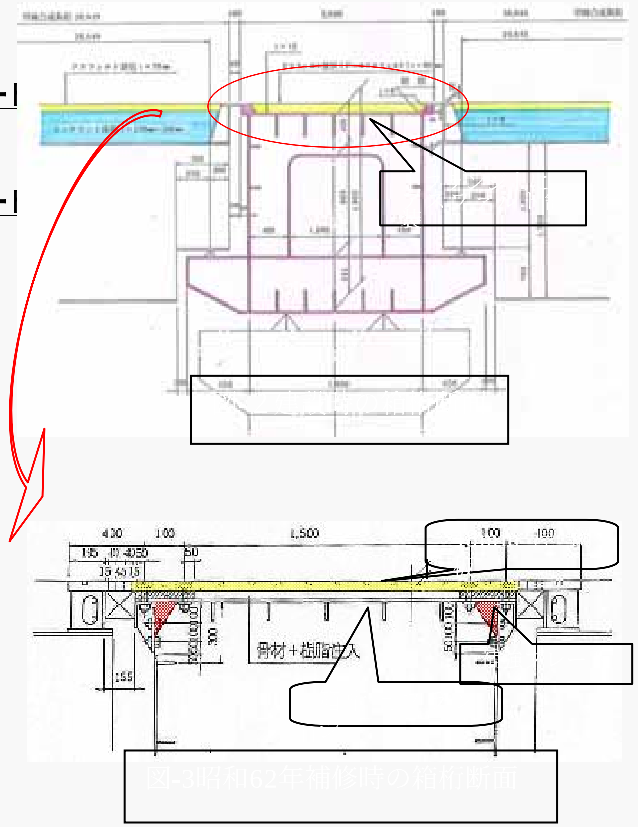
16 cm thick concrete slab
Reinforced with steel plates

2. Fatigue crack

Cross beams, stringers, short vertical members and others

Shimo-ueno Viaduct, 1963





横梁取替え工事の吊桁(左)と搬出される旧横桁(右)

架設された立体ラーメン橋の柱と梁

Old Shimo-ueno Viaduct

Rehabilitated Shimo-ueno Viaduct

Tanaka Prize, 2005

- OBC Conference by ASCE 2004.8

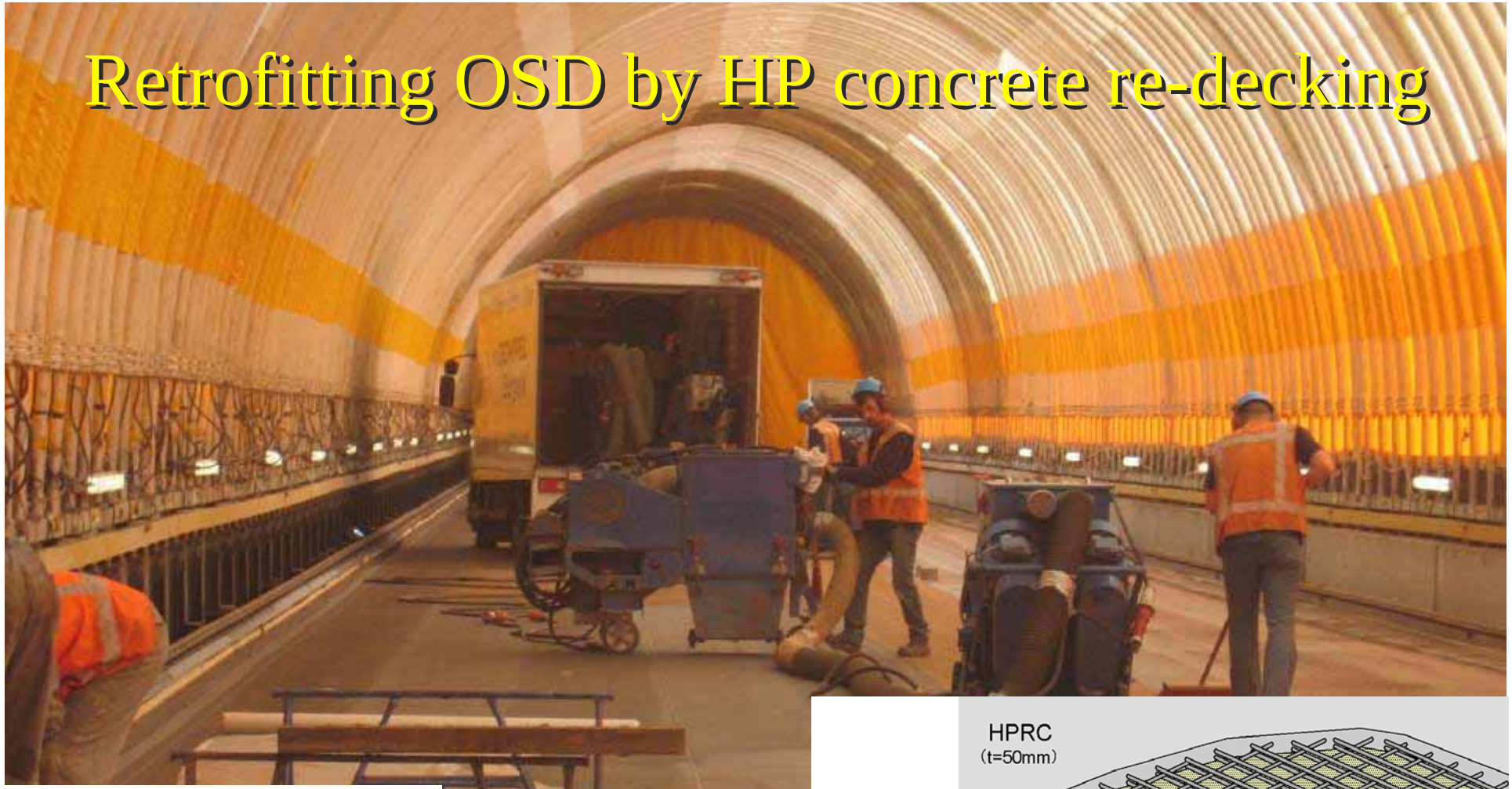
2008 International Orthotropic Bridge Conference
Sacramento, California
27-29 August 2008

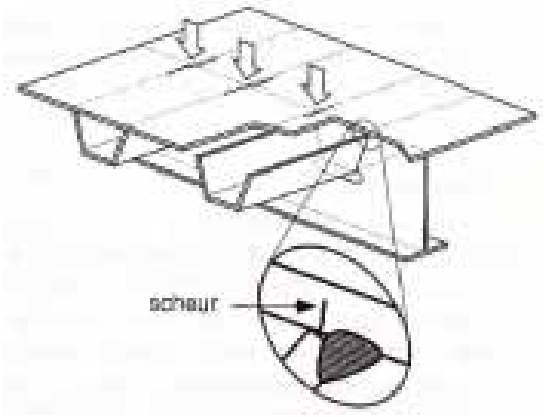
Orthotropic steel deck

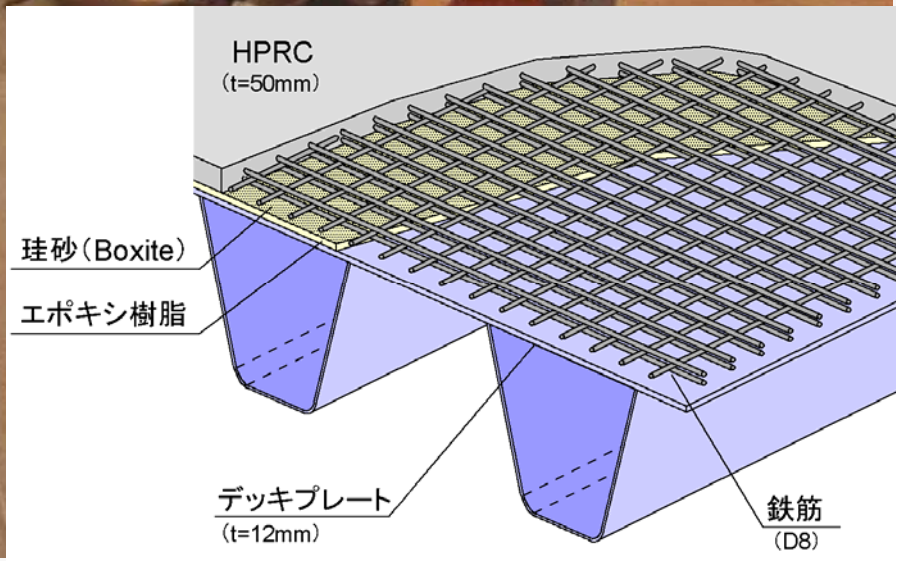
Full scale fatigue test at UCSD

Fatigue test at T.U. Delft, The Netherlands

Retrofitting OSD by HP concrete re-decking



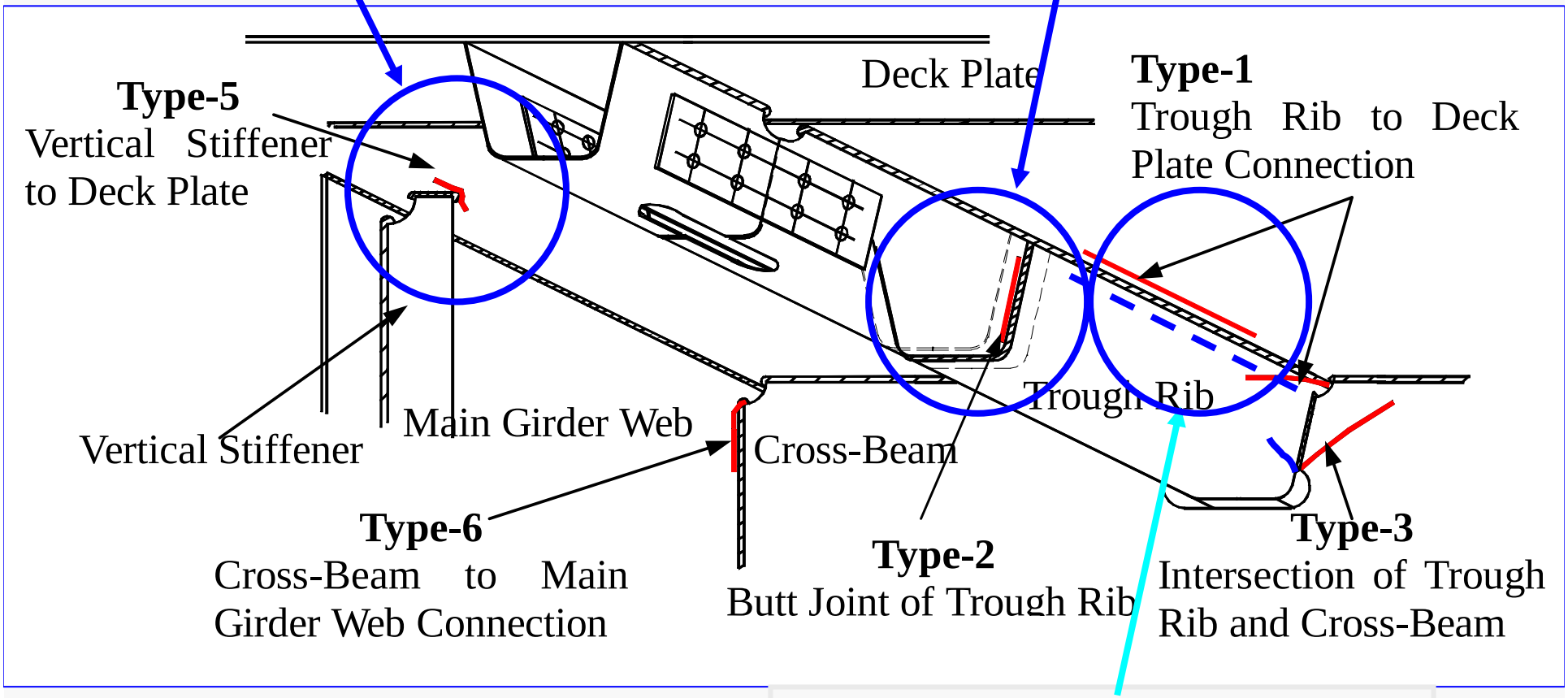




Typical fatigue cracks observed in Japan

Vertical Stiffener to deck plate

Butt weld of trough rib



Trough rib to deck plate

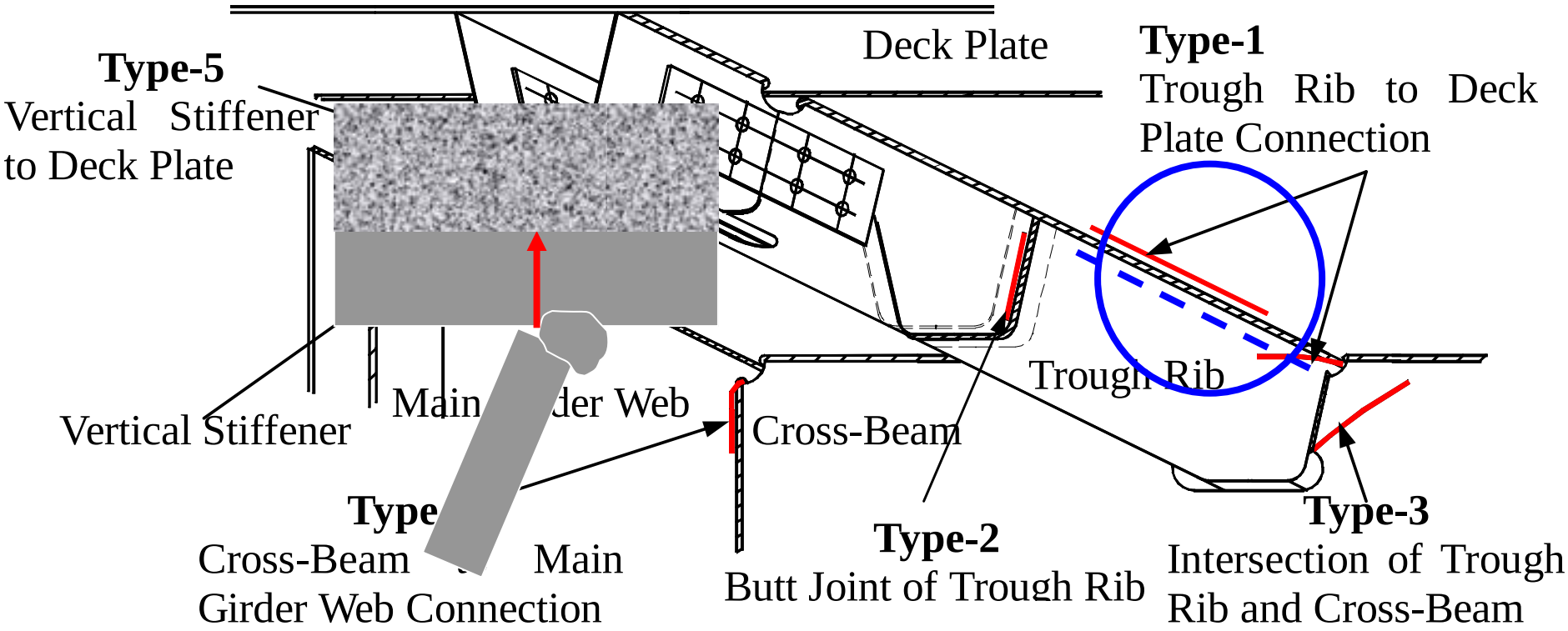
Fillet weld of trough rib

Courtesy MPE

Fatigue crack in fillet welds

Courtesy HEX

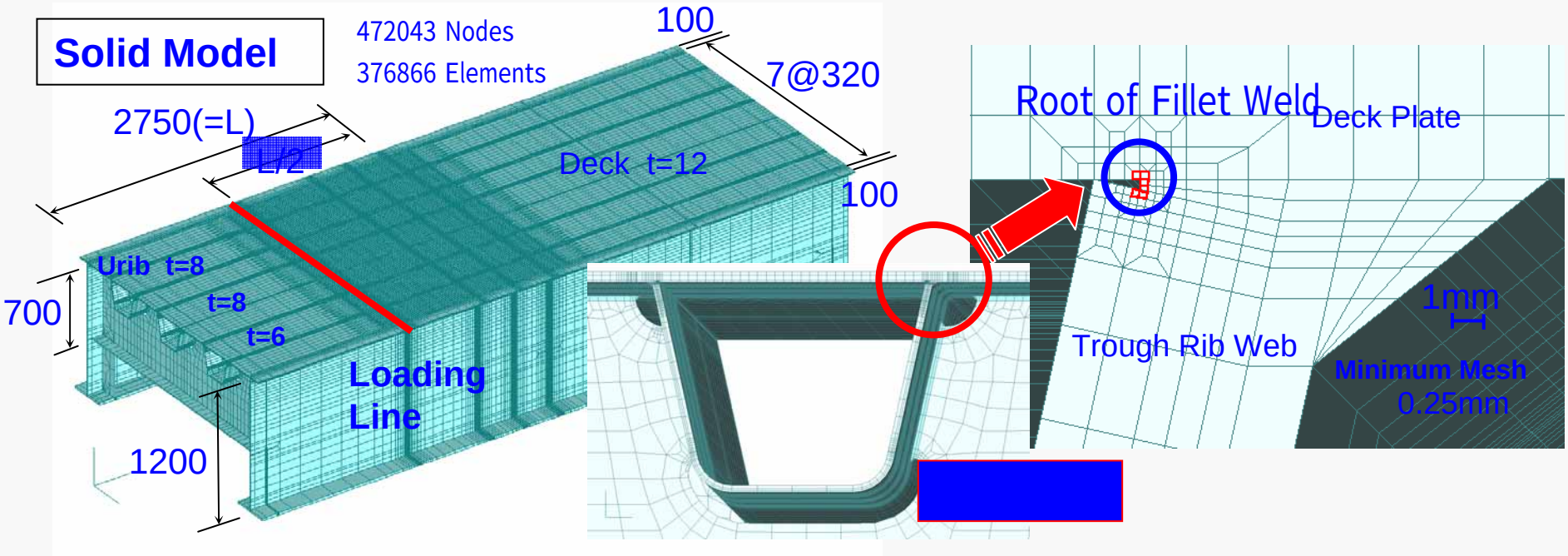
Crack from trough rib to deck plate



Difficult to inspect, damage to asphalt pavement, and danger to traffics.

Static and fatigue test at PWRI

FEM Analytical Model of Full Scale Test Specimen



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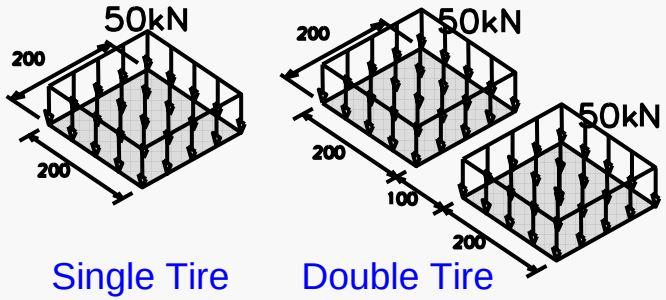
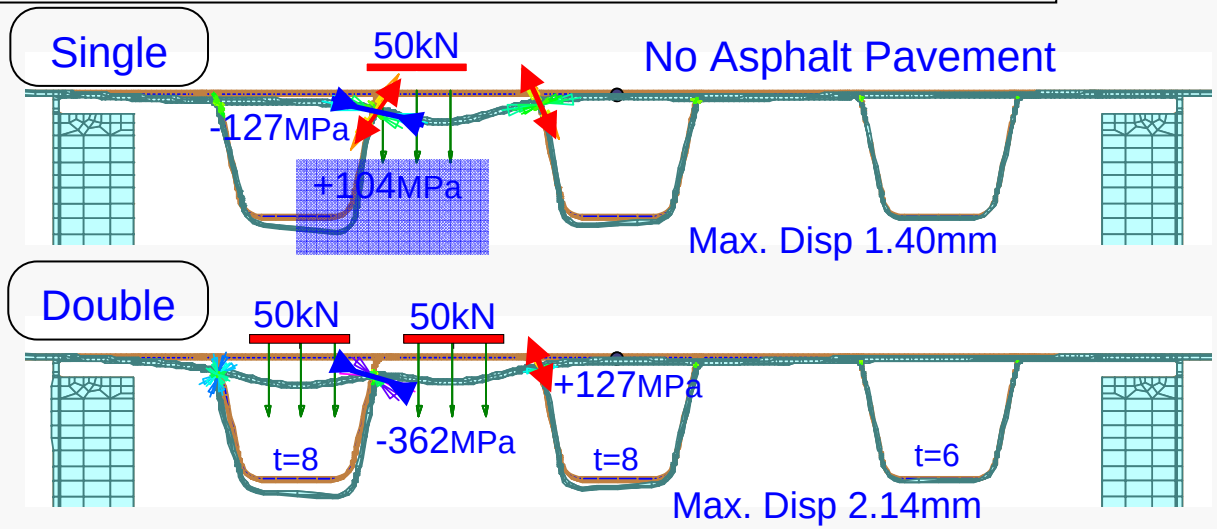


Single Tire Double Tire

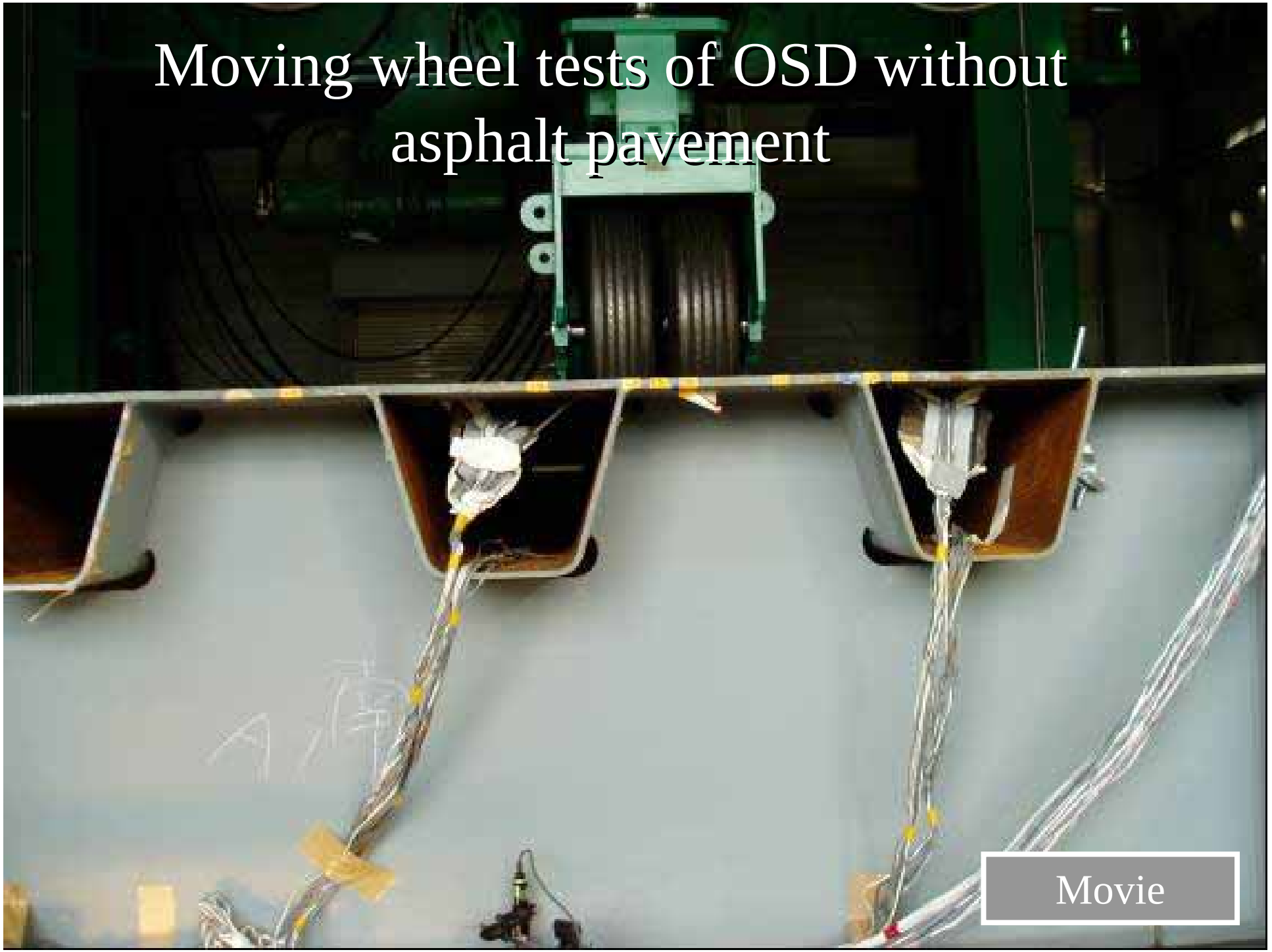
Local Stresses due to single and double tires



Courtesy PWRI, MLIT

Moving load test by JBA

Moving wheel tests of OSD without asphalt pavement



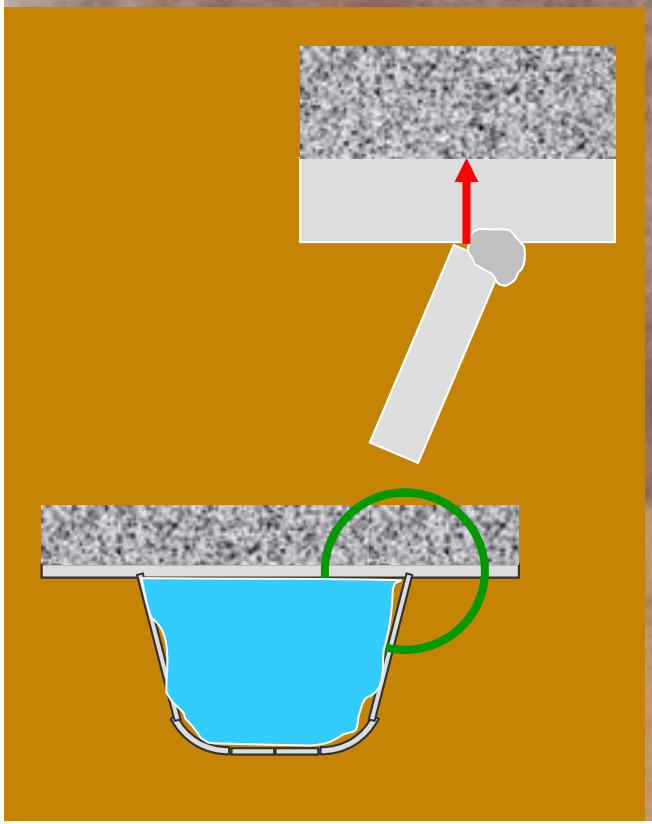
Tenpaku Bridge

Constructed in 1984

2003 deterioration of asphalt pavement, then fatigue crack was found

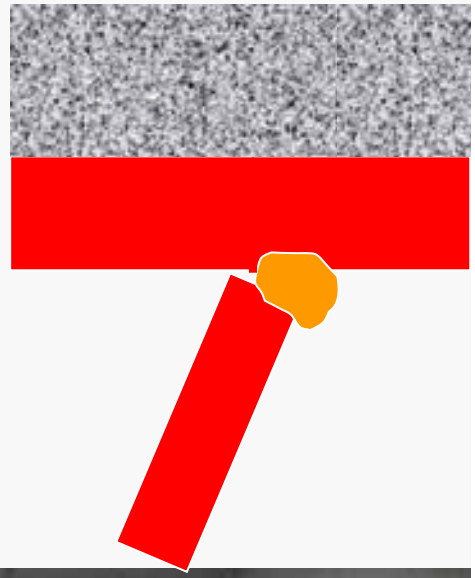
Courtesy of Nagoya City

Fatigue crack from root to deck plate

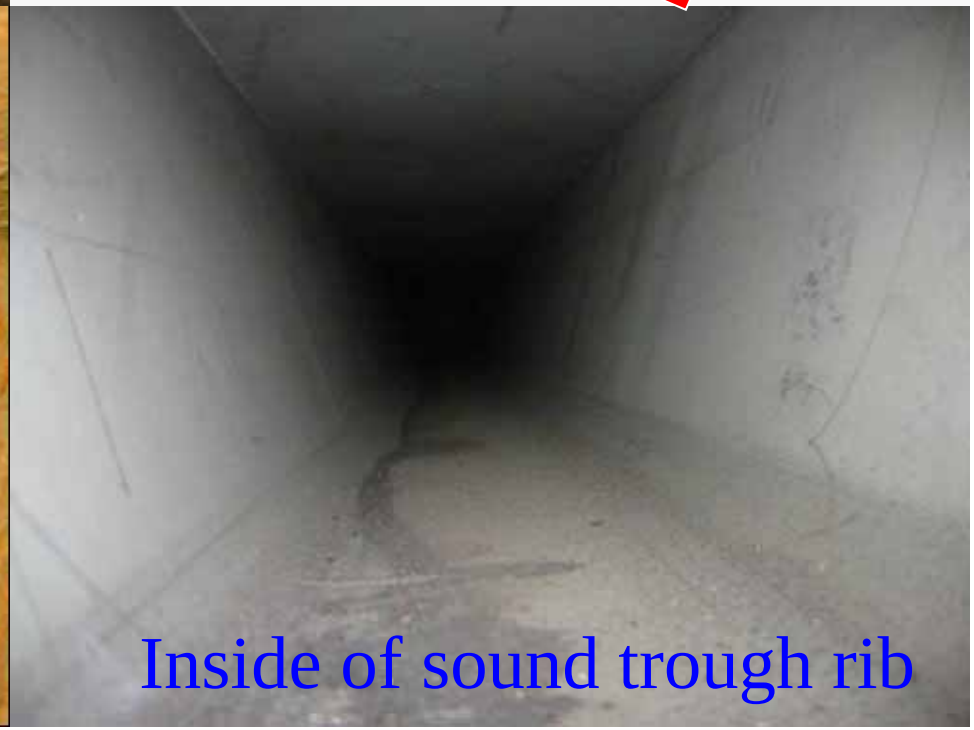


名古屋市提供

Water and debris from crack



2004年

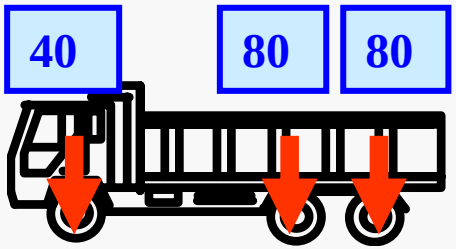


Inside of sound trough rib

GVW measured by BWIM

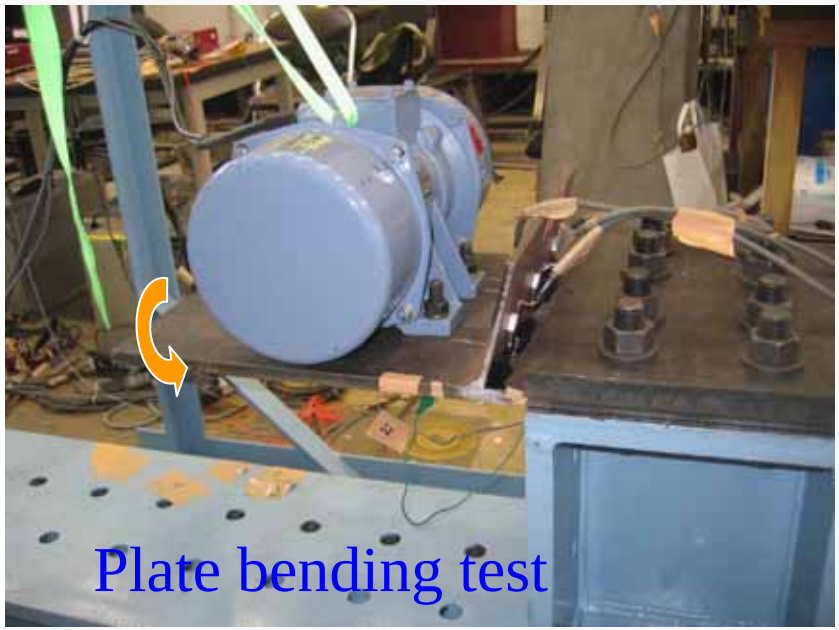
走行車線１			走行車線２			追越車線		
GVW (t)	Axle	V (km)	GVW (t)	Axle	V (km)	GVW (t)	Axle	V (km)
114.1	6	42	125.1	6	28	93.7	4	38
88.1	6	35	102.3	6	60	71.8	6	45
85.0	6	38	97.2	6	51	70.6	6	64
82.3	4	36	95.3	6	45	69.8	6	55
77.8	6	50	95.1	6	58	69.0	6	74

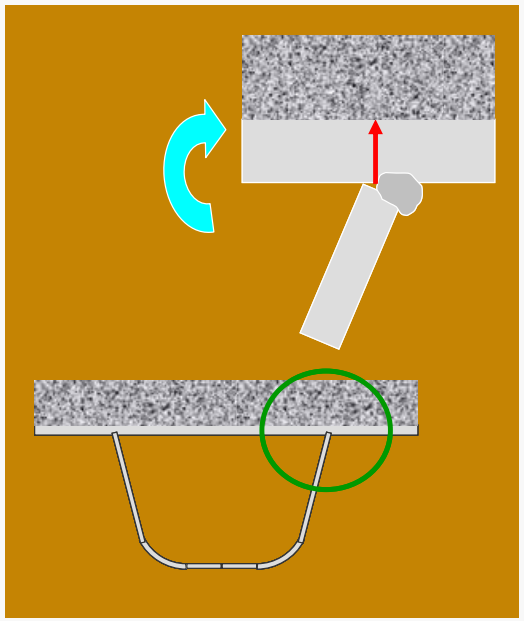
T-20 Truck

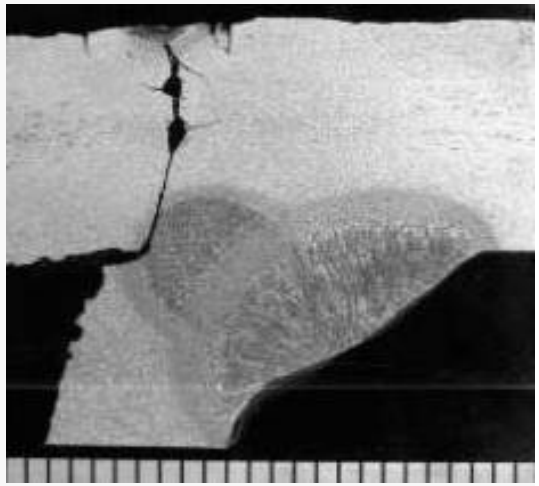


Courtesy Nagoya City

Crack from root of trough to deck plate







Ya Samol

Rehabilitation of deck crack

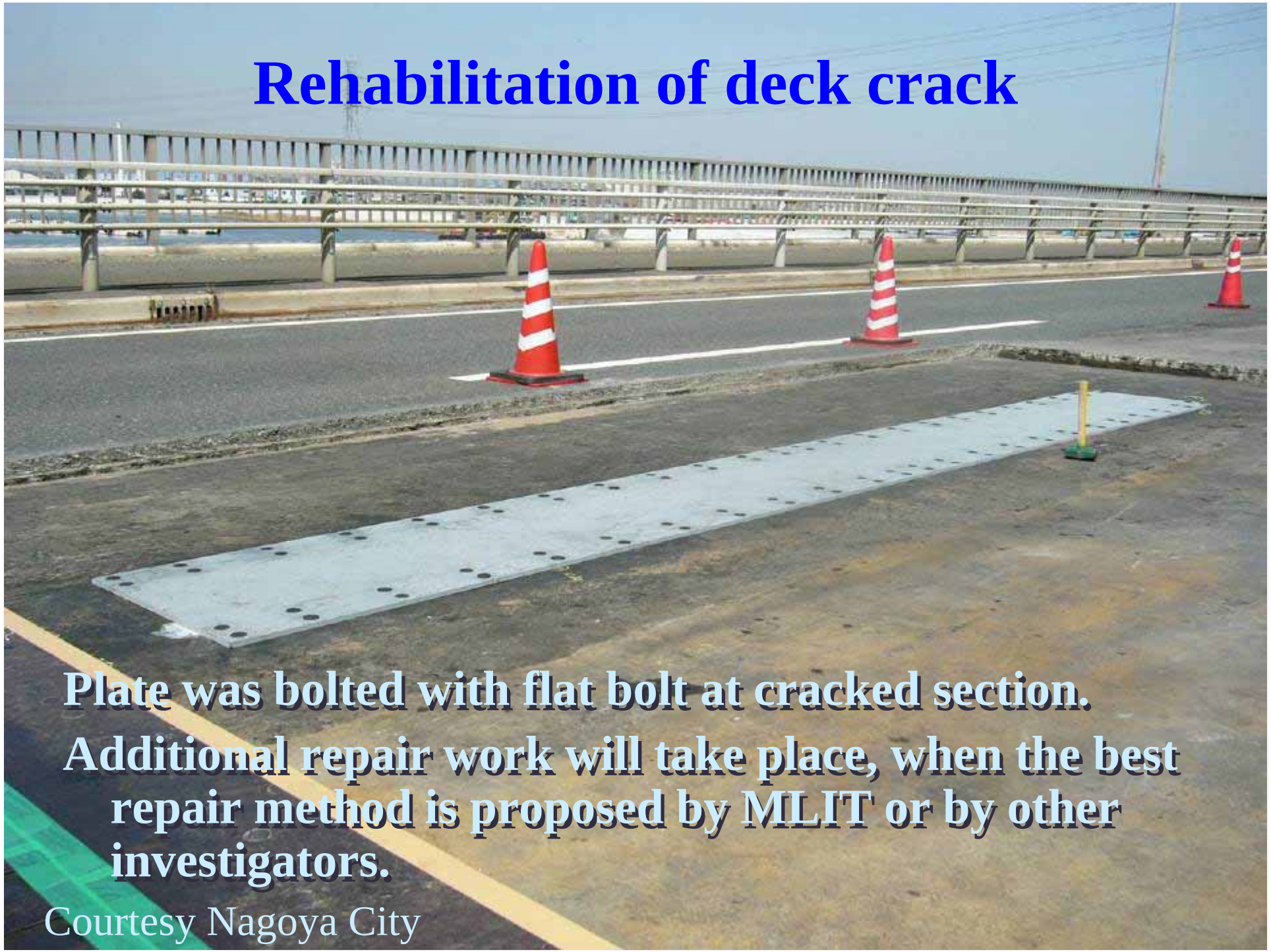


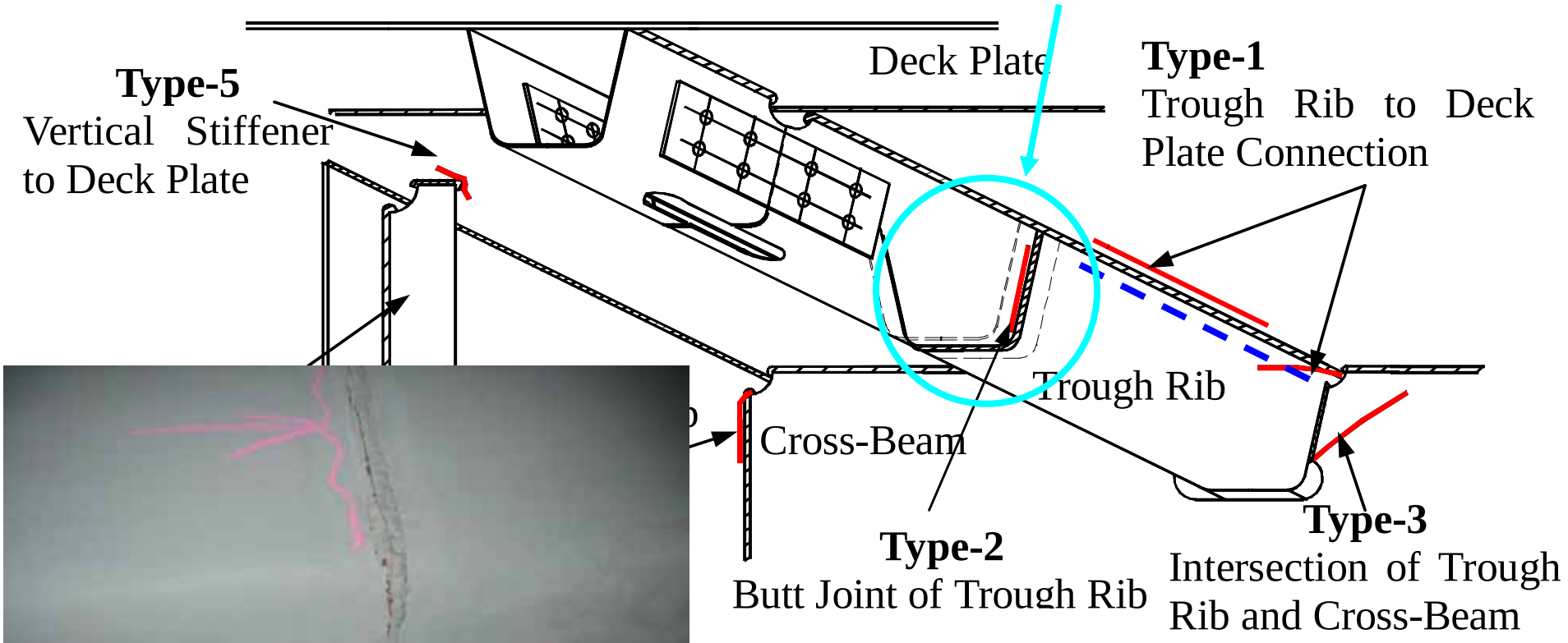
Plate was bolted with flat bolt at cracked section.

Additional repair work will take place, when the best repair method is proposed by MLIT or by other investigators.

Courtesy Nagoya City

Case 2: Fatigue cracks in butt weld of ribs

Crack in butt weld with backing bar



Courtesy of MEX

AK Bridge: Fatigue crack in butt weld of ribs


Fatigue crack at butt weld of trough rib
2003年6月

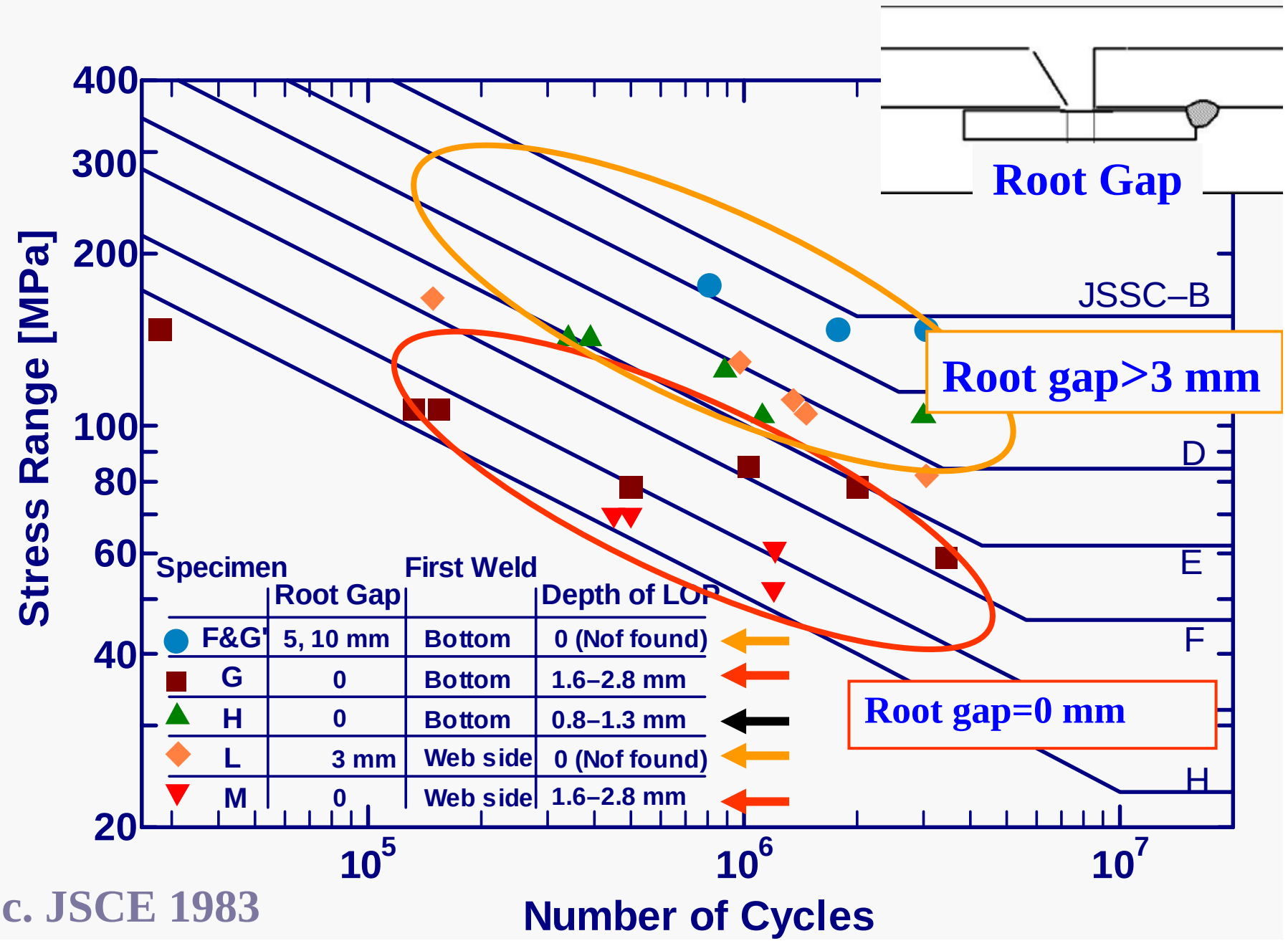
Repair and rehabilitation (plan)

Plate attached with one-side bolts.
(Ishikari Kako Bridge)

Gauging and re-welding
(Honshu-Shikoku B.A.)
(Fatigue test data)

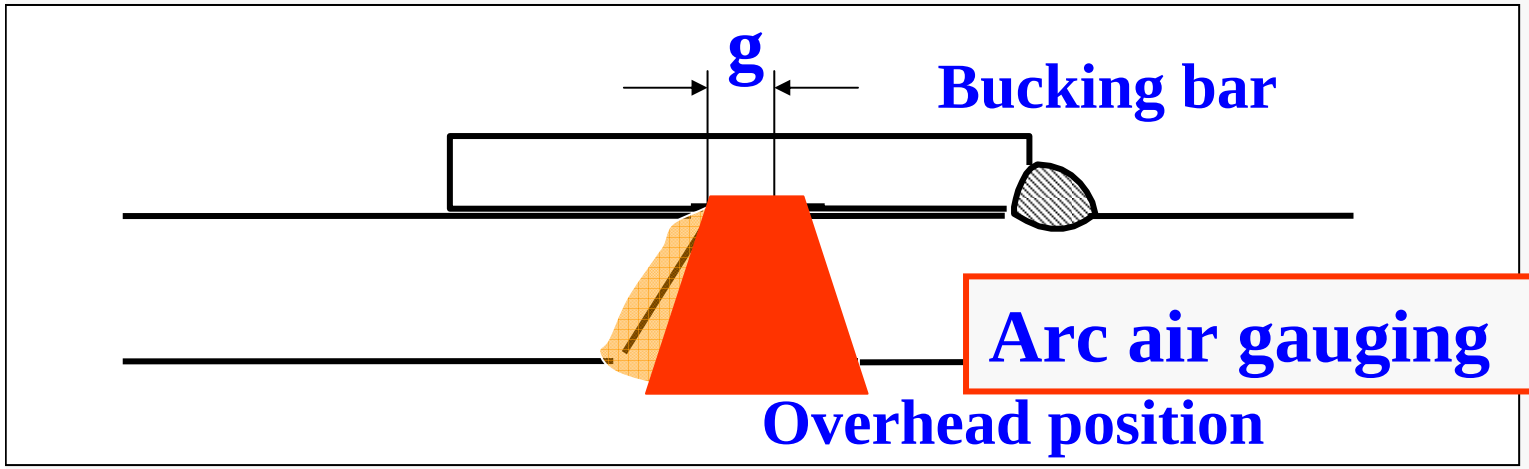
Replace whole cracked part with new members.

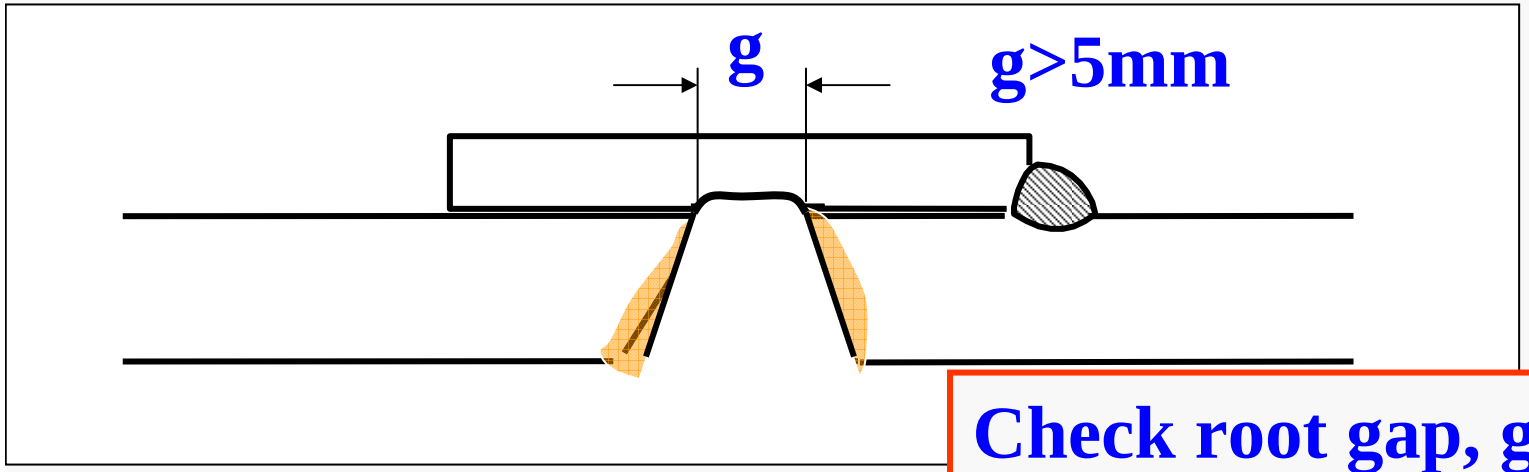
Fatigue tests of butt weld of trough rib



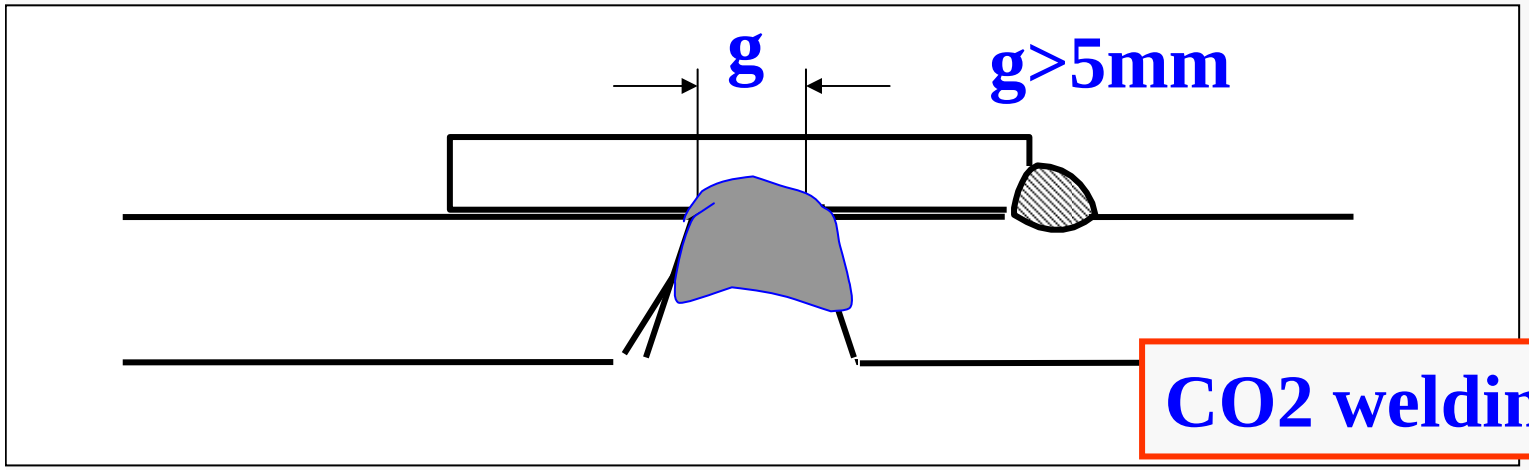
Proc. JSCE 1983

Gauging and re-welding cracked part

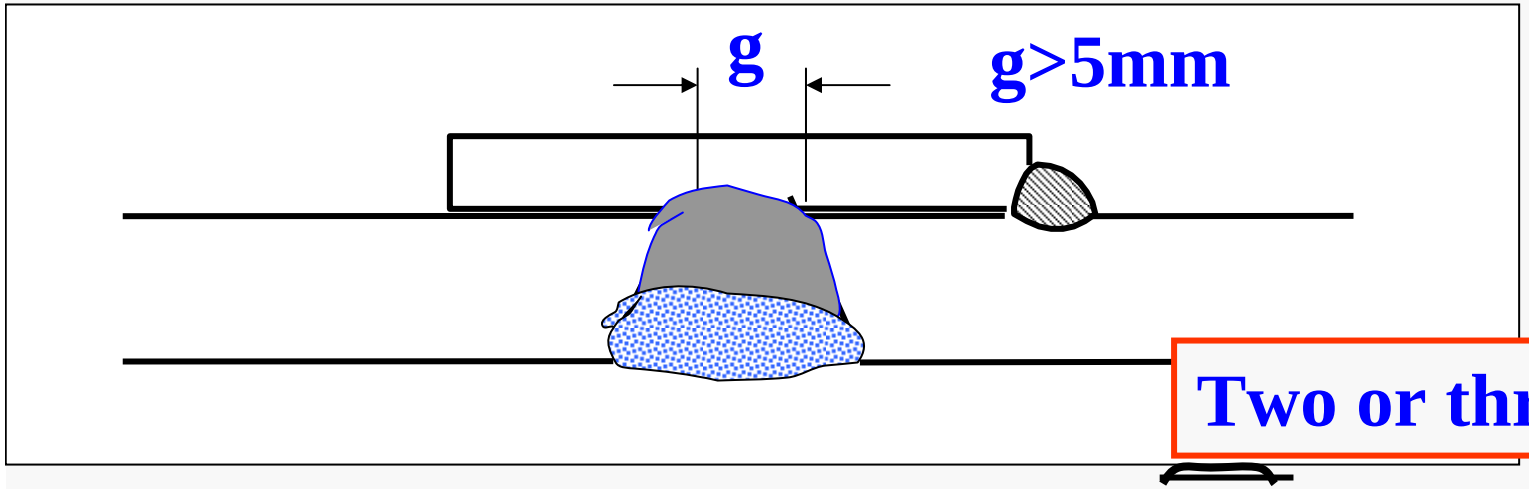




Gauging and re-welding cracked part



CO2 welding with Ar



Two or three passes

Cracked parts were re-welded.

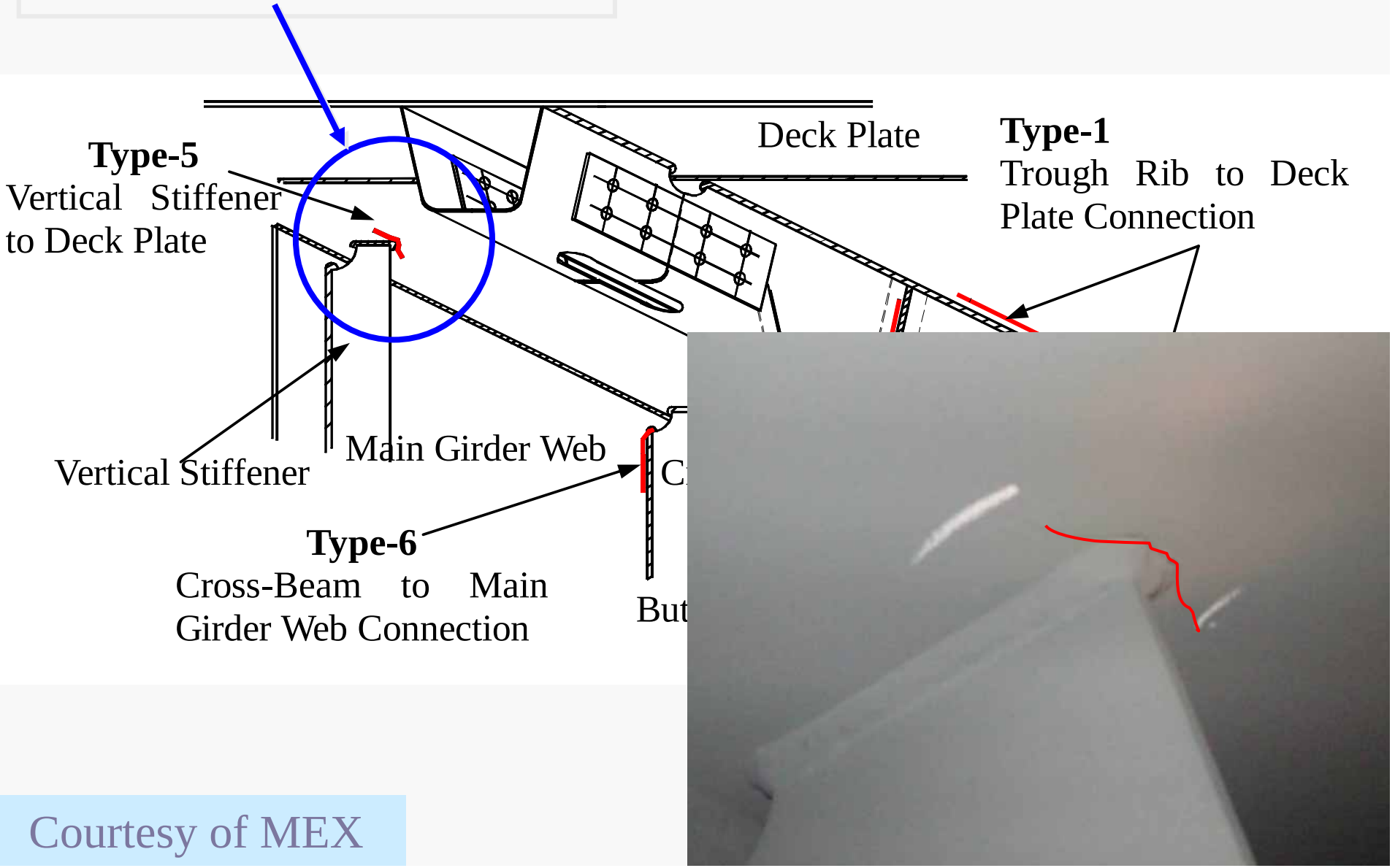
Importance of information transfer and training of welders

Steps

1. Gauging
2. Check of root gaps.
3. Re-welding
4. NDT

Case 3: The upper end of vertical stiffeners

Vertical stiffener end

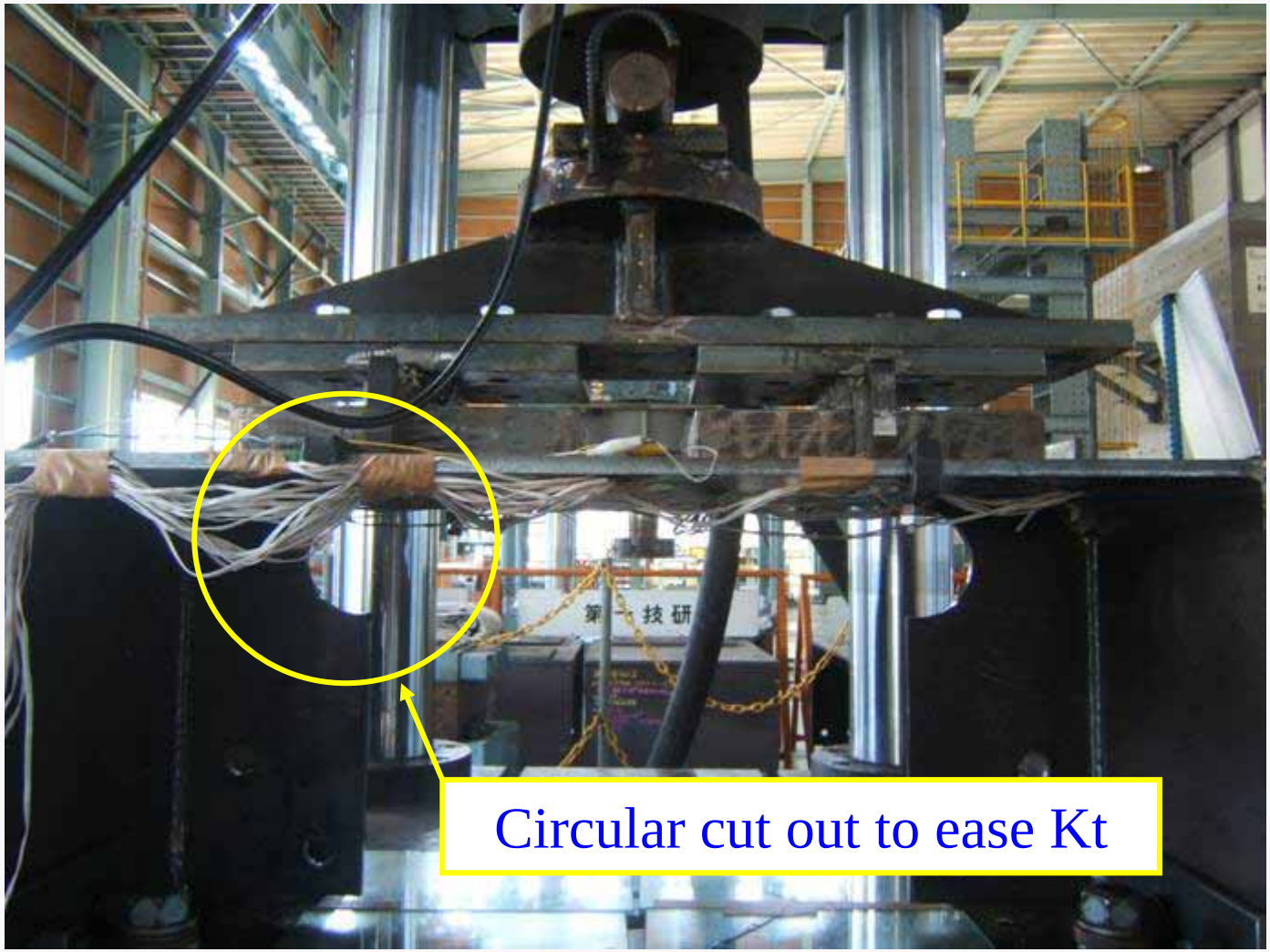


Courtesy of MEX


Fatigue crack from weld toe to deck plate

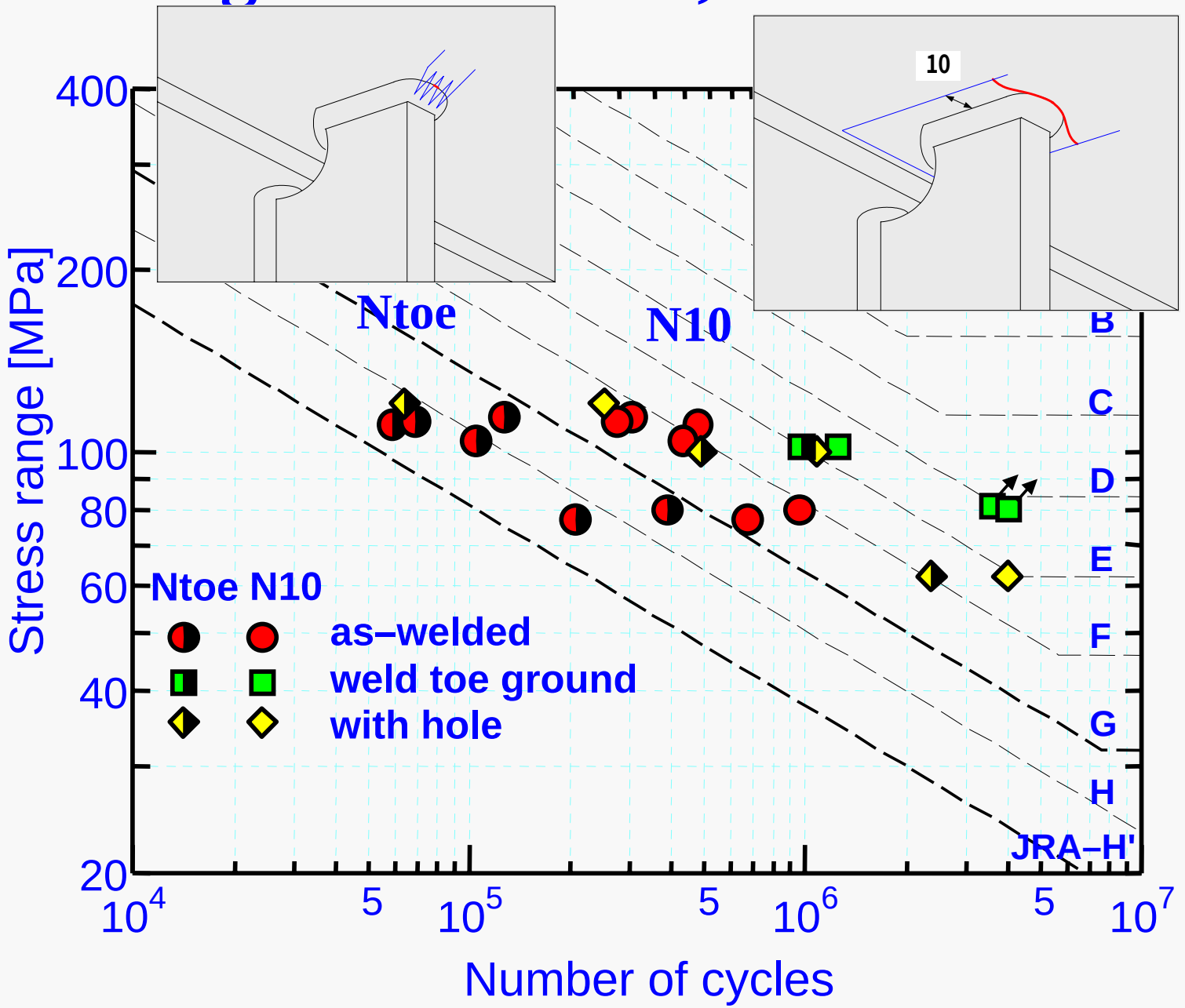
Repair with high strength bolted splices

Fatigue tests



Courtesy Topy

Fatigue test results, Ntoe and N10



Proposed repair method with circular hole

Ease stress concentration with circular hole. Hole saw was used.

Proposed repair method

No crack →Circular hole

Small crack→Circular hole

Medium crack→Circular hole
+CFRP sheet?

Large crack→Circular hole
+CFRP sheet?

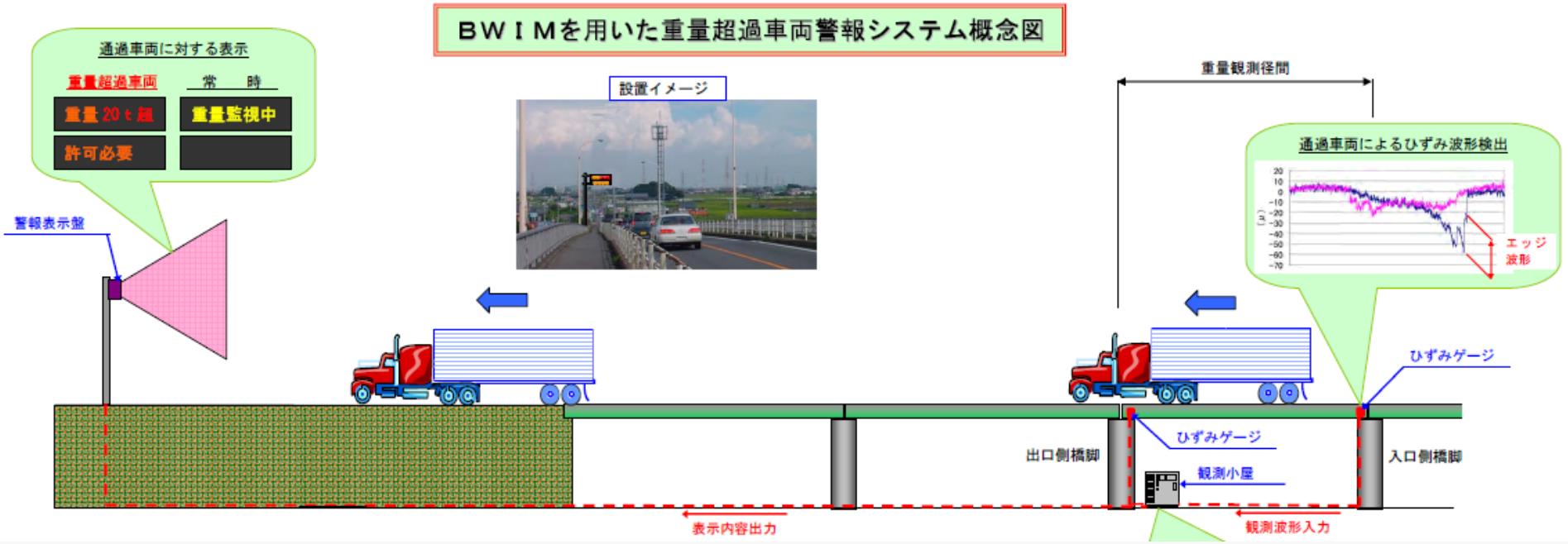
Penetrated crack →splice plate

Asphalt pavement to SFRC

To reduce overloaded trucks, warning system

BWIM to measure GVW, then to warning system

Reduce illegally overloaded trucks



Courtesy Aichi Pref. and PC

Nagoya Expressway under construction

New approach to strengthen pavement

Nagoya Expressways used SFRC with asphalt pavement in 1980s in experimental bases.

The SFRC was placed on a new orthotropic steel decks under construction in 2007.


Small studs welded


Steel mesh needed


Steel fibers
Wiremix


Steel fiber sent to C. Mixer


Steel fiber concrete


Surfacing

Basic fatigue test for orthotropic steel deck

End of vertical stiffener

Fillet weld of trough rib

Shear connectors

Lifting pieces