Griffith 2007.11.14

Stress measurement

Kentaro Yamada
Graduate School of Environmental Studies,
Nagoya University

Meiko Triton

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. Stress measurement of bridge and bridge members
2. Static and dynamic
3. Stress range histogram
4. Bridge Weigh-in-Motion
5. Strain Checker

Stress measurement of bridges: Japan

1950’s – 1960’s: static

- Stress and deformation measurement
- Calculation for design vs. bridge behavior
- Safety

1960’s – 1980’s: dynamic

- Structural dynamics
- Vibration measurement

1990’s –2000’s: long term monitoring

- Stress in service and stress range histogram
- Bridge Weigh-in-Motion

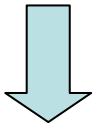
Stress measurement of bridges: Japan

1980’s – 2000’s

Digital recording

Durability evaluation

Histogram recorder



Bridge Monitoring

(using communication network)

Strain Checker for easy stress measurement

Monitoring of highway bridges

1. Bridge Monitoring

   Short term : 1-3 days, 1 week,

   1 month or 1 year

   Examples

2. Weigh-in-Motion and Bridge WIM in Japan

   GVW and axle loading

Michigan, USA, 11-axle truck

Example of Bridge Monitoring

- Semimaru Bridge

  Skewed arch bridge

  Semimaru

- Minato Shinbashi Bridge

  3-span continuous box girder

  Minato

- Ohdaka Overpass

  Simple skewed box girder

  Odaka

Bridge Weigh-in-Motion

(Use strain response of bridge member as scale)

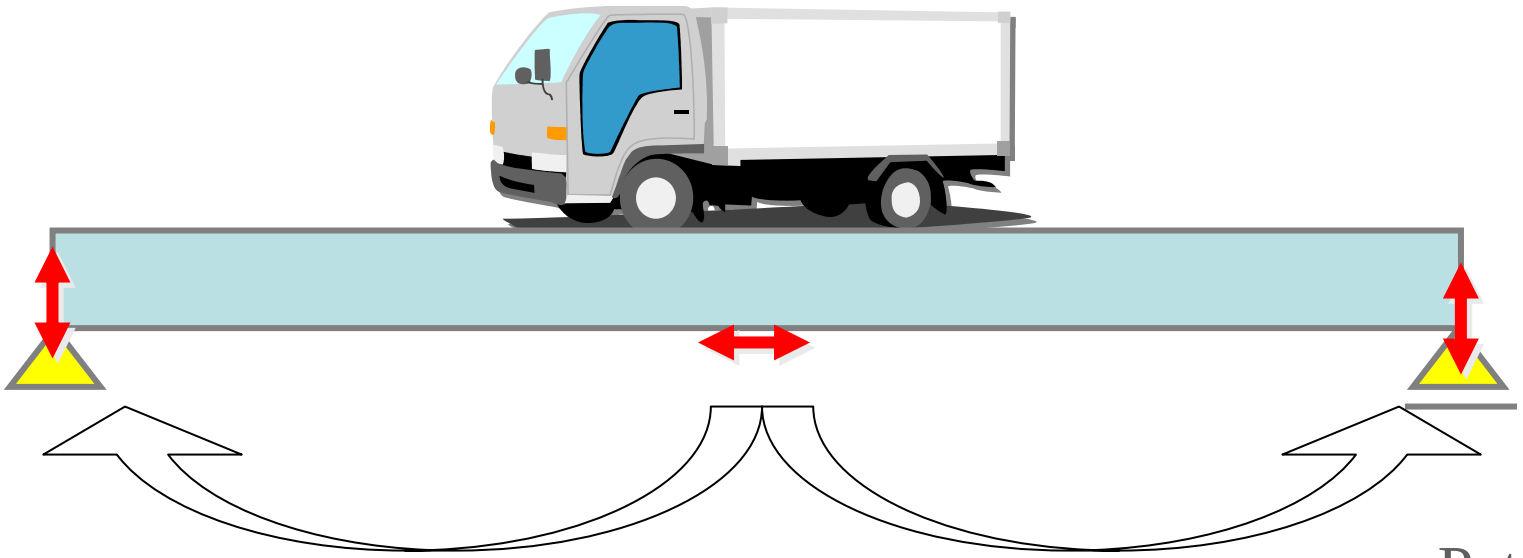
(Moses, Miki, PWRI, etc.)

Bending strain of beam

↓

Reaction Force Method

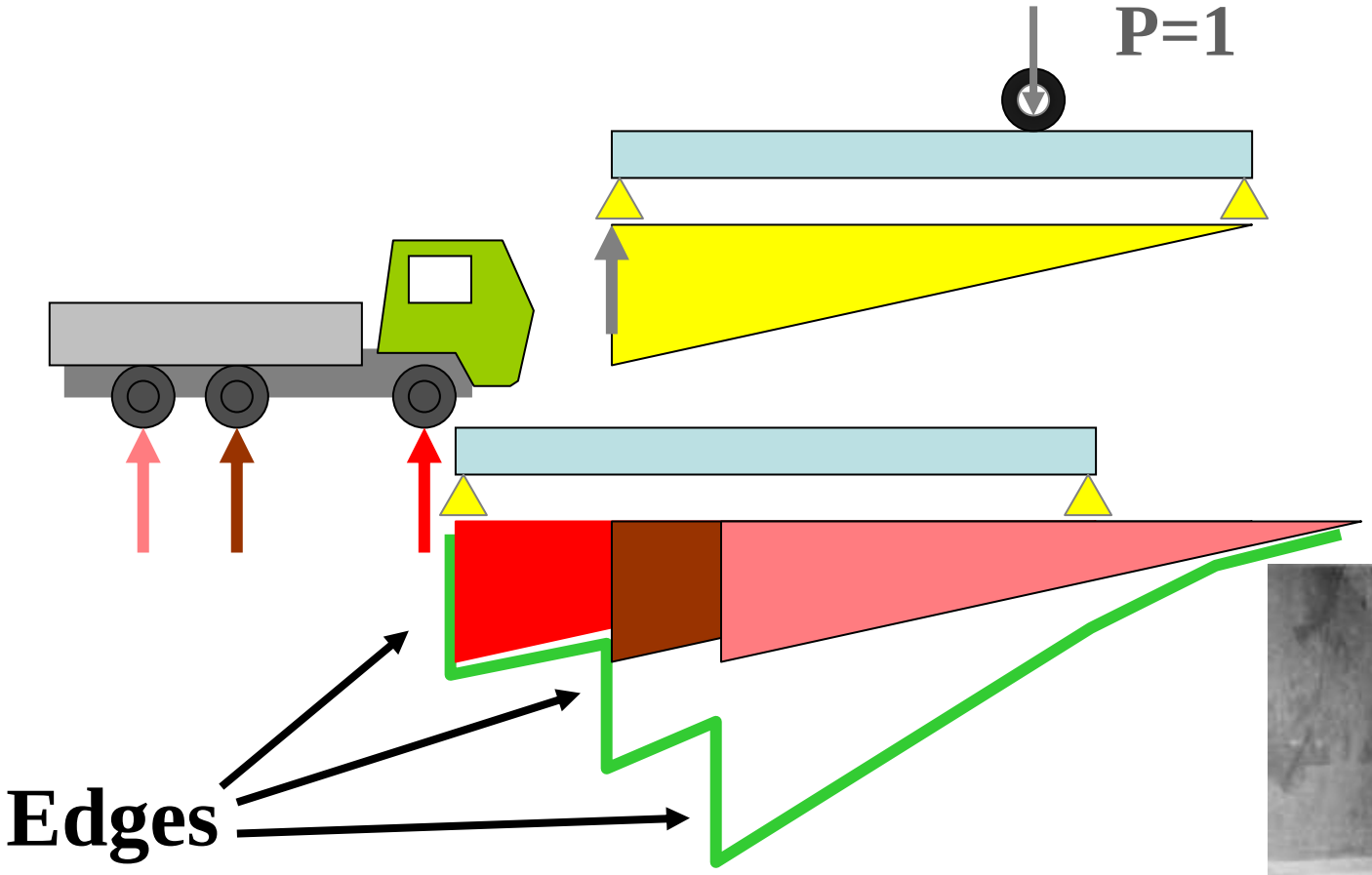
(Ojio and Yamada, Nagoya U.)



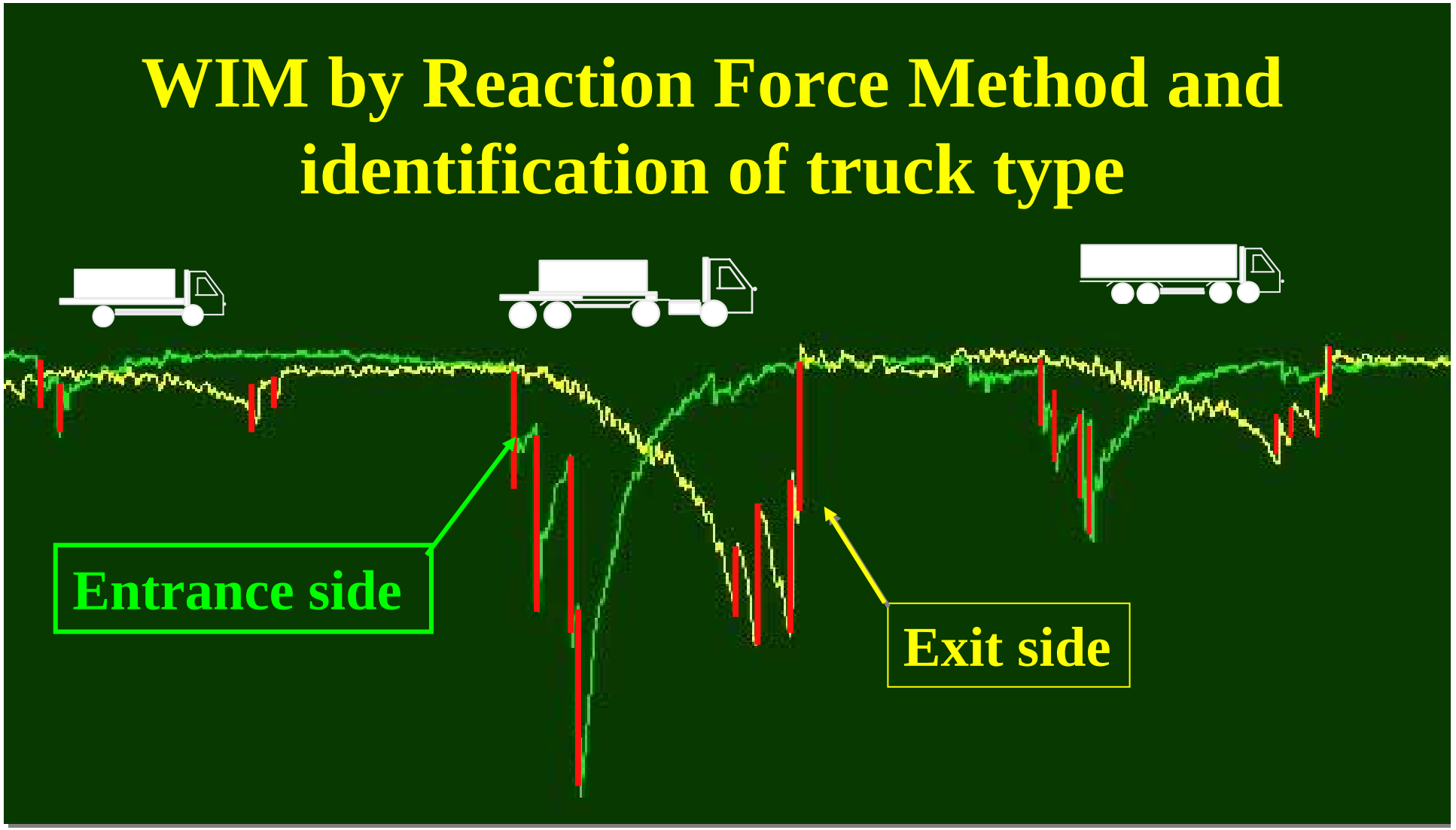
Patented

Influence Line of Reaction Force

- Edges in response wave correspond to axle loads.



WIM by Reaction Force Method and identification of truck type



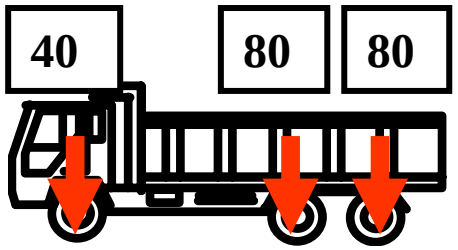
Compare axle spacing with database of trucks

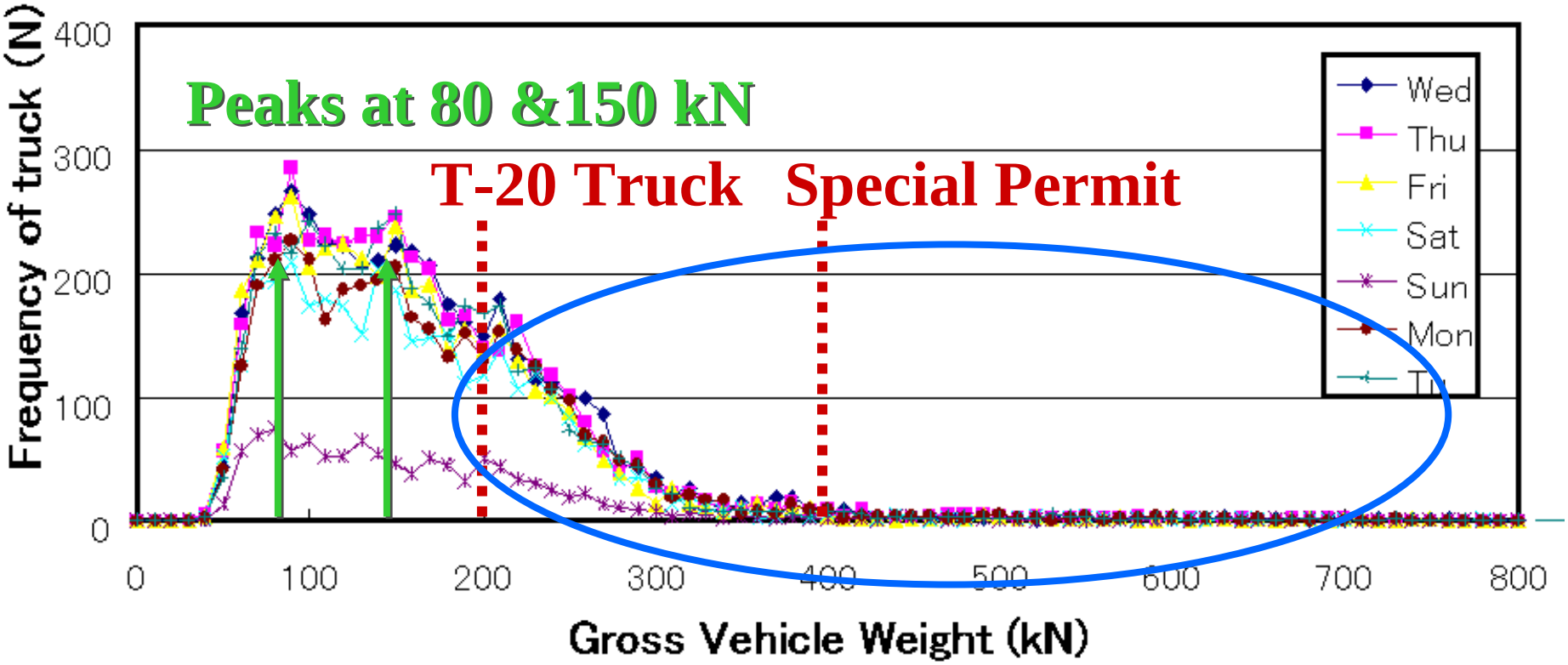
→ identify truck type

Measurement of trucks in service by WIM and BWIM

Distribution of GVW
Daily Trucks on NR23

T-20 Truck



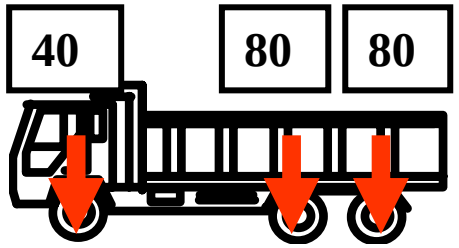


One week

Emphasis on heavy loading

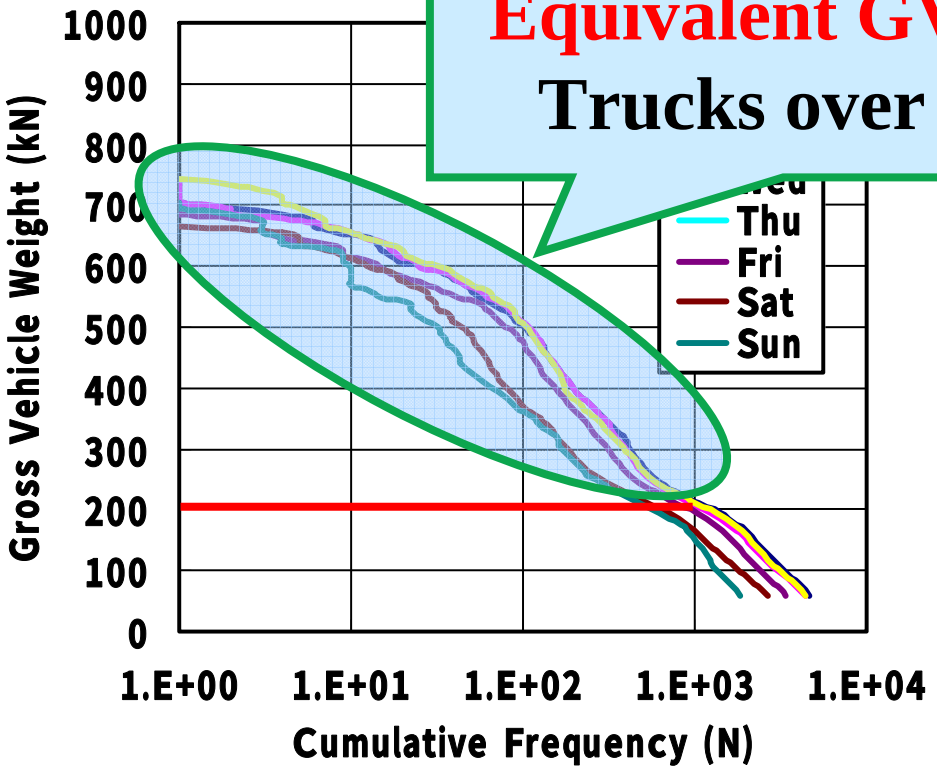
Distribution of GVW

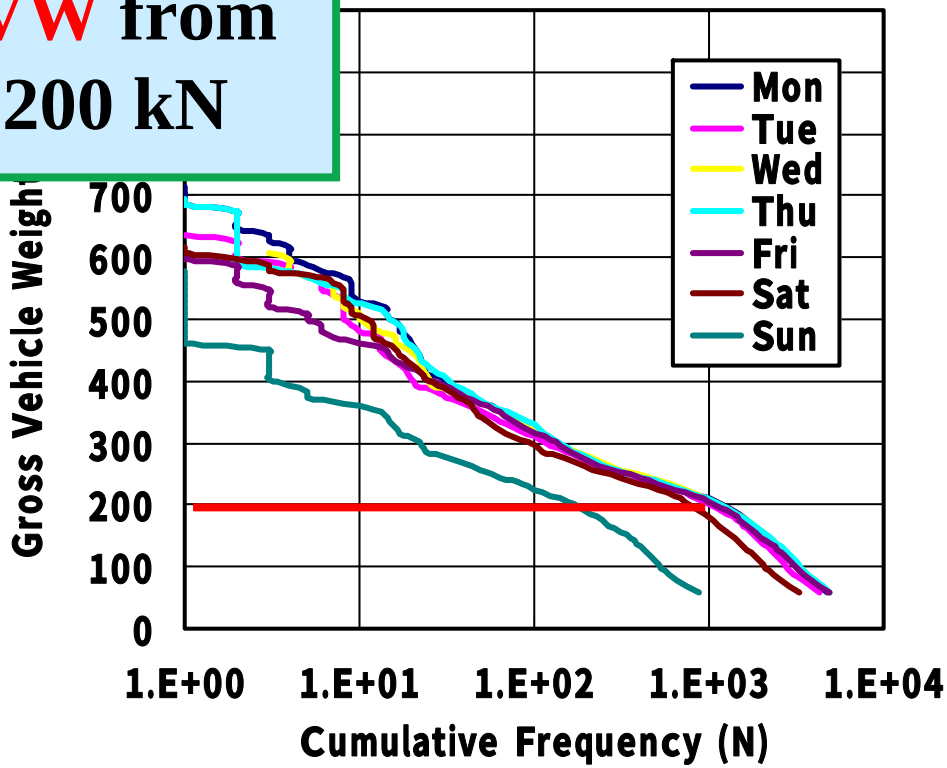
Slow and Passing Lanes



T-20 Truck

Equivalent GVW from Trucks over 200 kN



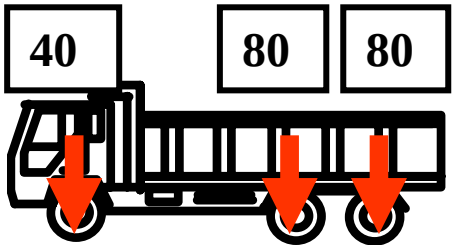


NR 23 Yokkaichi Viaduct
West Bound **Slow Lane**

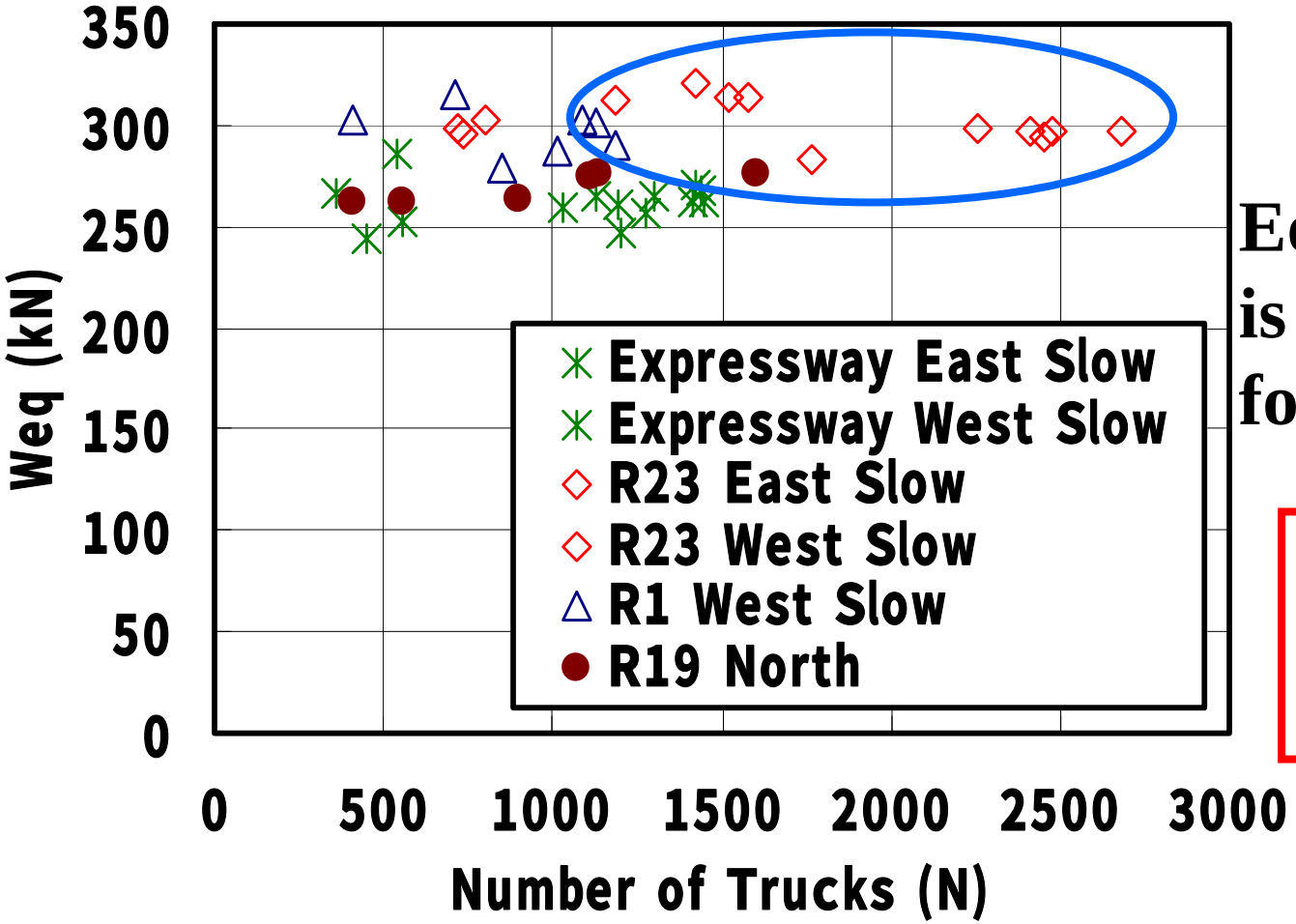
NR 23 Yokkaichi Viaduct
West Bound **Passing Lane**

Cumulative frequency distribution of GVW

Equivalent GVW and N



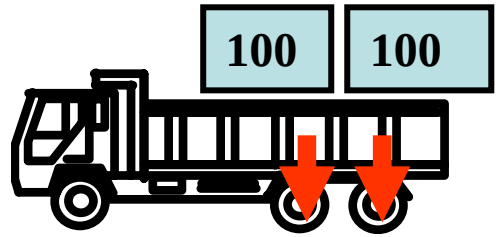
T-20 Truck



Equivalent GVW is computed by the following equation.

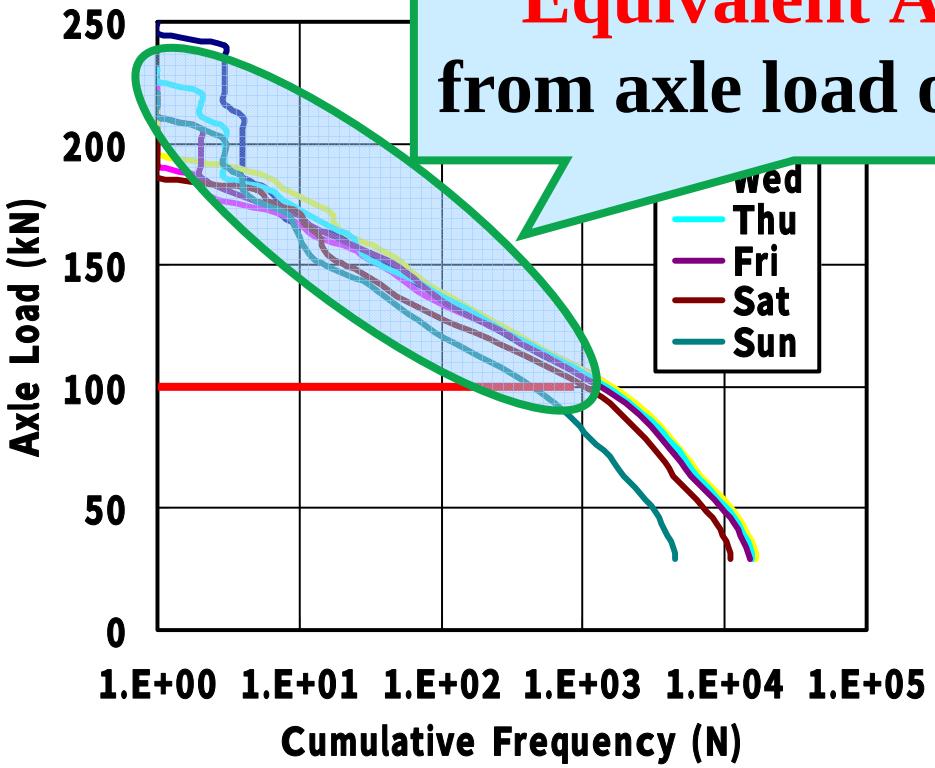
$$Weq = \sqrt[3]{\frac{\Sigma W_i^3 \cdot n_i}{\Sigma n_i}}$$

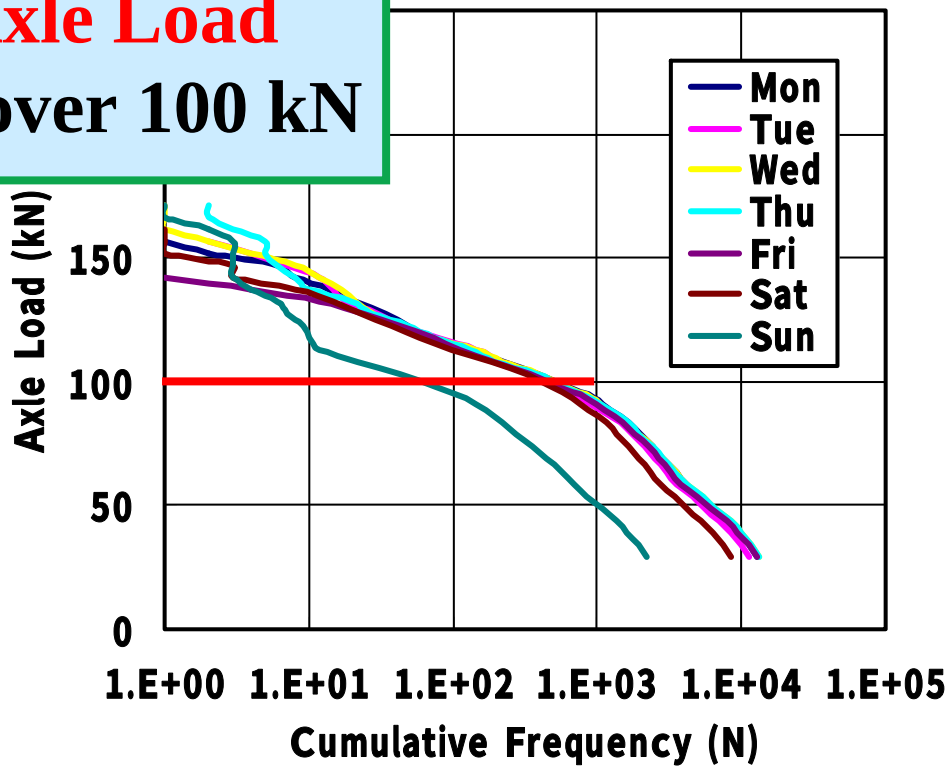
Distribution of Axle Load
Slow and Passing Lanes



Axle Load

Equivalent Axle Load
from axle load over 100 kN





NR 23 Yokkaichi Viaduct
West Bound **Slow Lane**

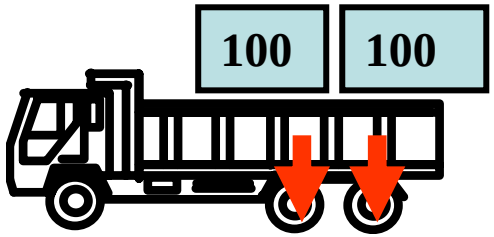
NR 23 Yokkaichi Viaduct
West Bound **Passing Lane**

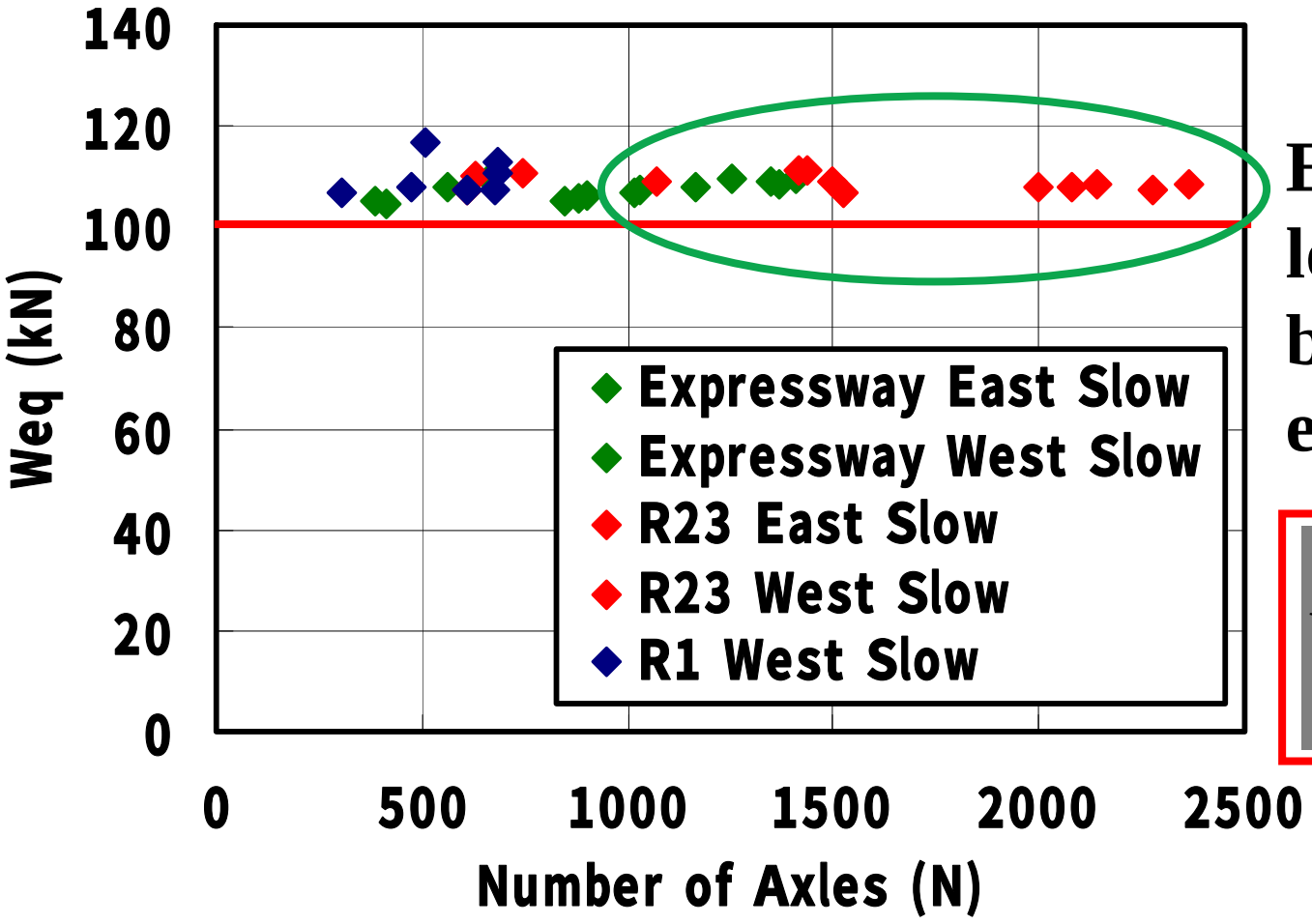
Cumulative frequency distribution of Axle Load

Equivalent Axle Load and N

Slow Lane

Axle Load



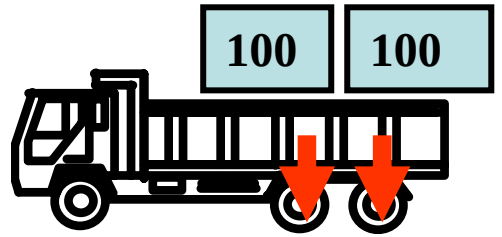


Equivalent axle load is computed by the following equation.

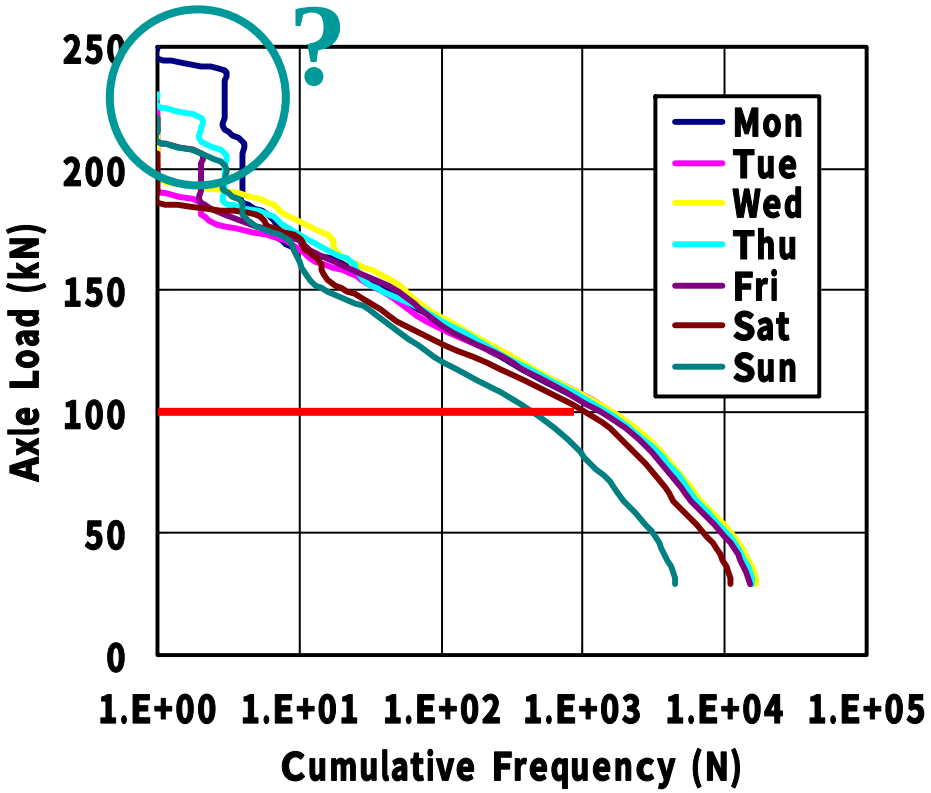
$$Weq = \sqrt[3]{\frac{\Sigma W_i^3 \cdot n_i}{\Sigma n_i}}$$

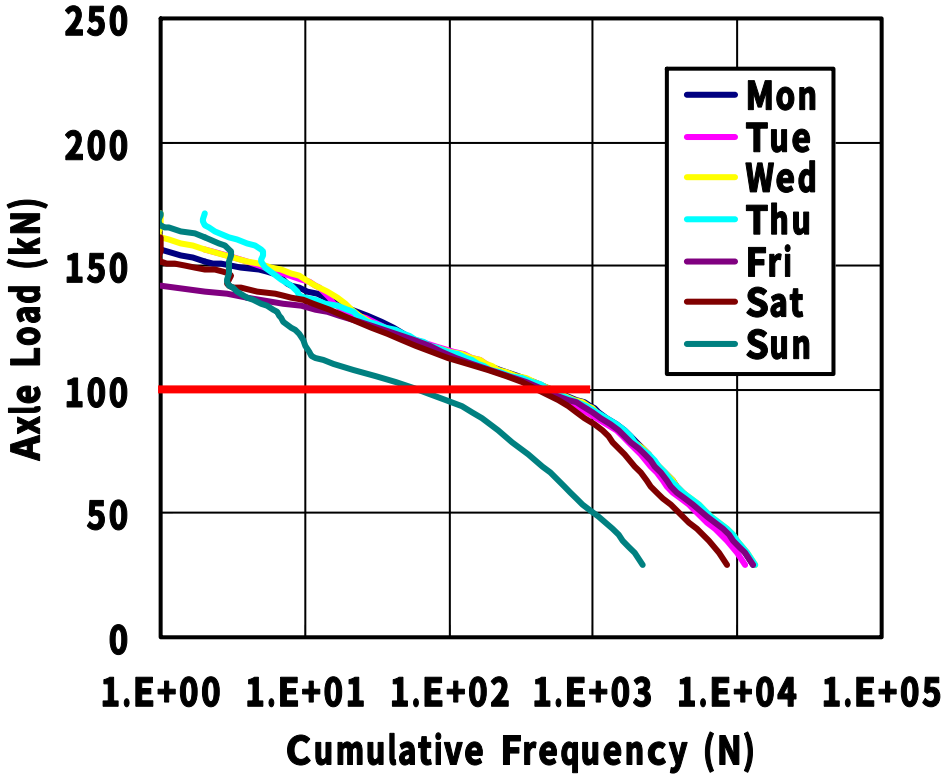
Slow Lane

Distribution of Axle Load
Slow and Passing Lanes



Axle Load

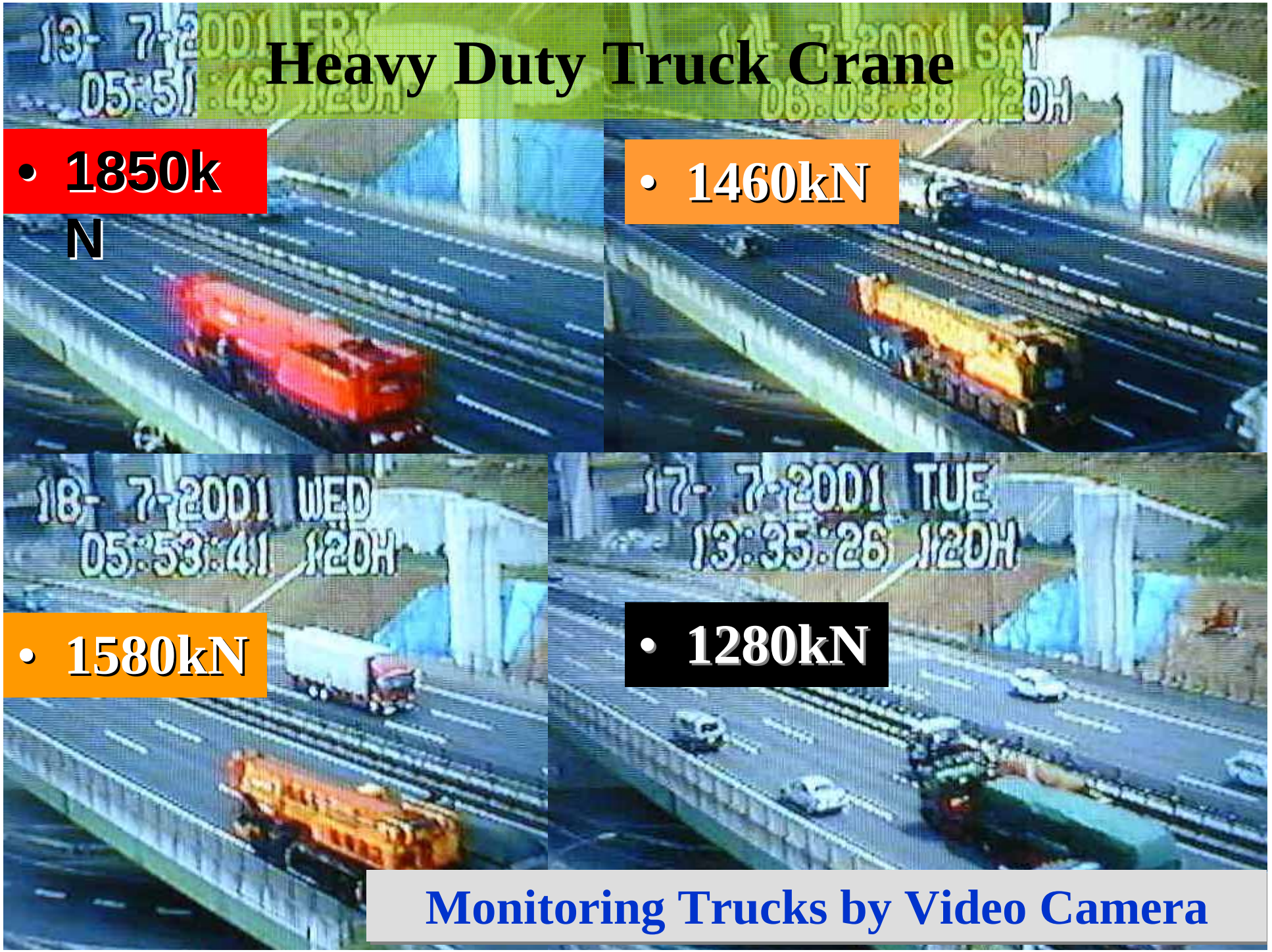




NR 23 Yokkaichi Viaduct
West Bound **Slow Lane**

NR 23 Yokkaichi Viaduct
West Bound **Passing Lane**

Heavy Duty Truck Crane



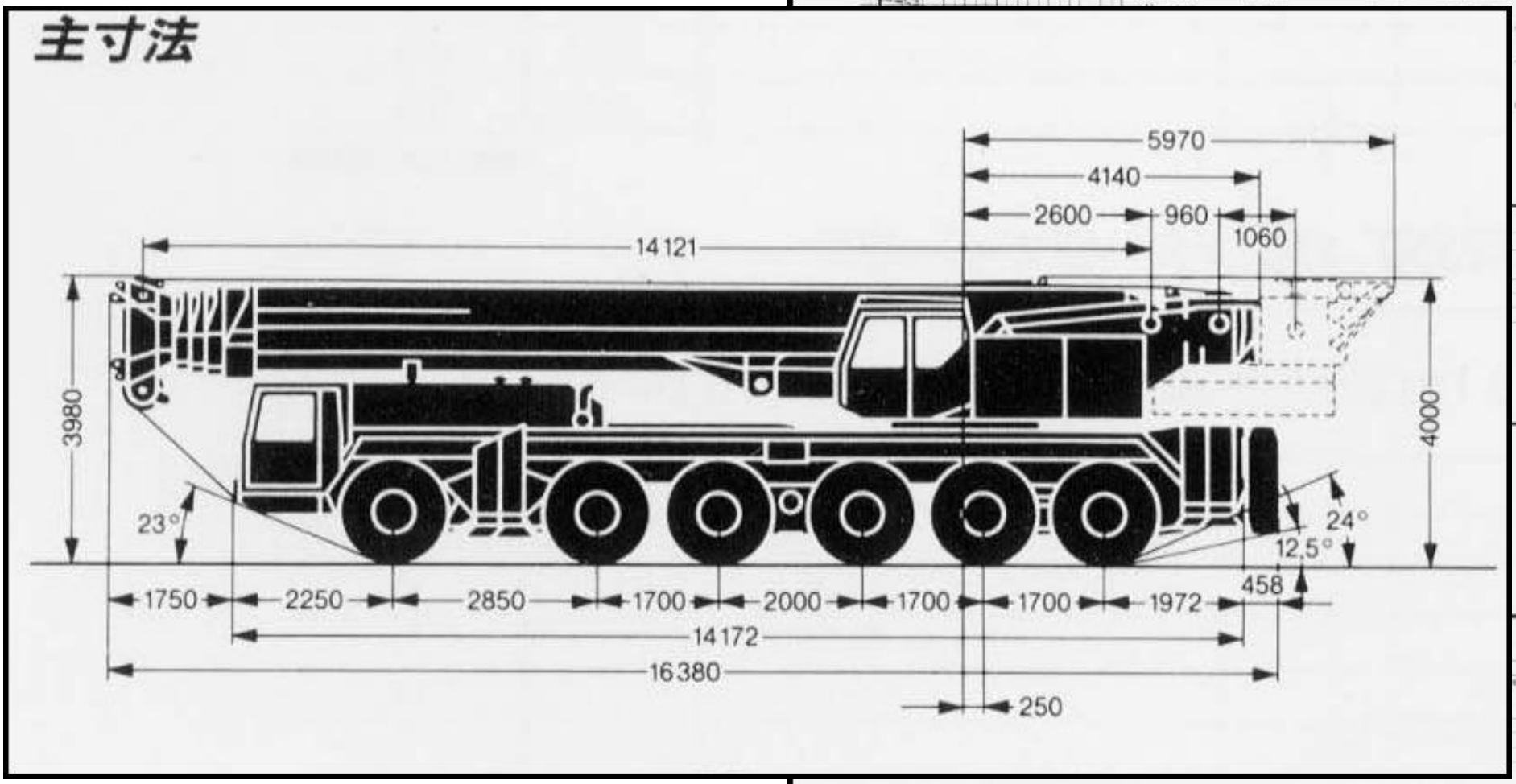
Monitoring Trucks by Video Camera

200t Truck Crane 6 axles

200t 全油圧式トラッククレーン LIEBHERR LTM1200N

クレーン主仕様

主寸法



Catalog of truck crane

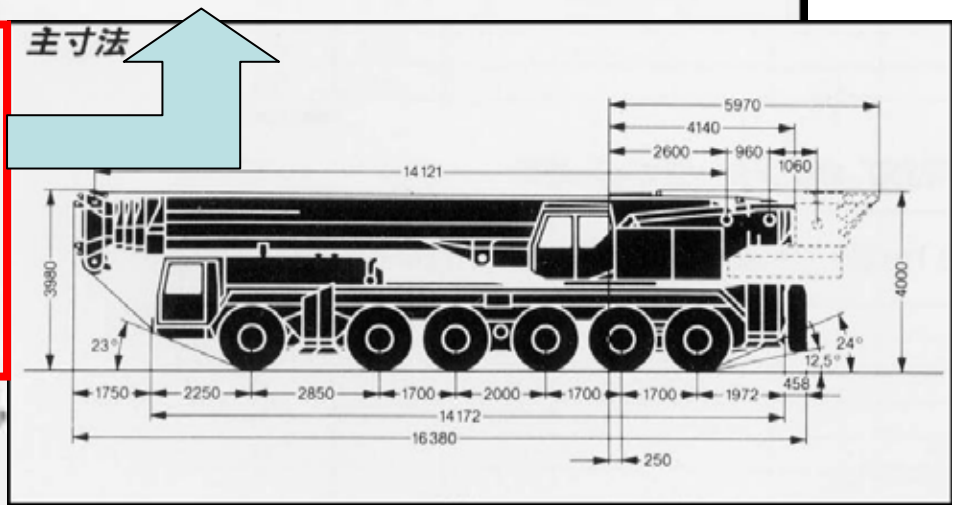
200t Truck Crane　6 axles

Carrier (6-axle truck)	34ton
Crane	72ton
Fully Equipped Crane	160ton

キャリヤ総重量	34ton
クレーン装備重量	72ton
クレーン全装備重量	160ton

※注　本機は公道を走行する時、台車のみ

主寸法



Heavy Duty Truck Crane

- 1850kN
- 1460kN

Michigan 11-axle truck : 70 tons

70 ton / 10= 7 ton/axle

- 1580kN
- 1280kN

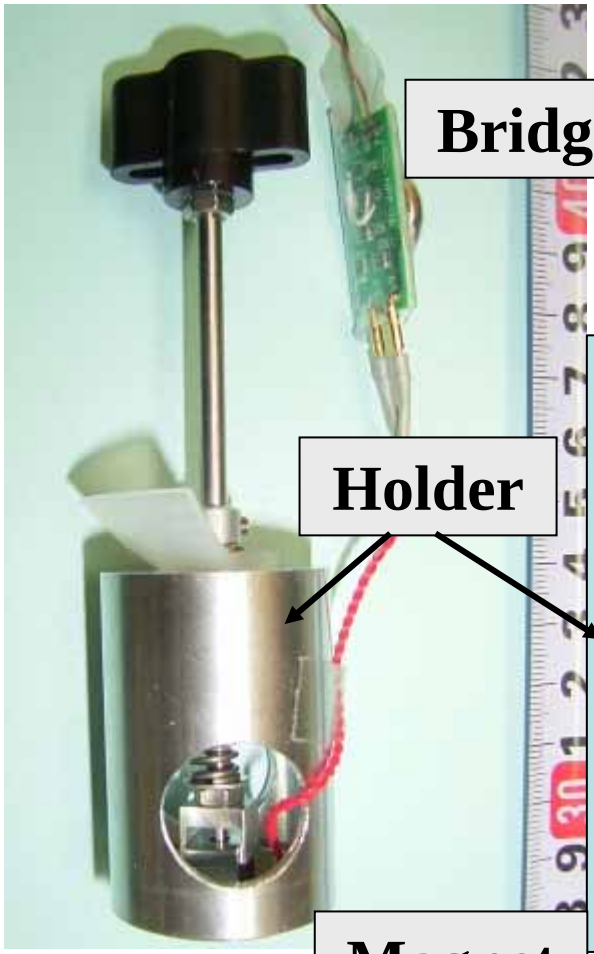
160 ton / 6=25 ton/axle

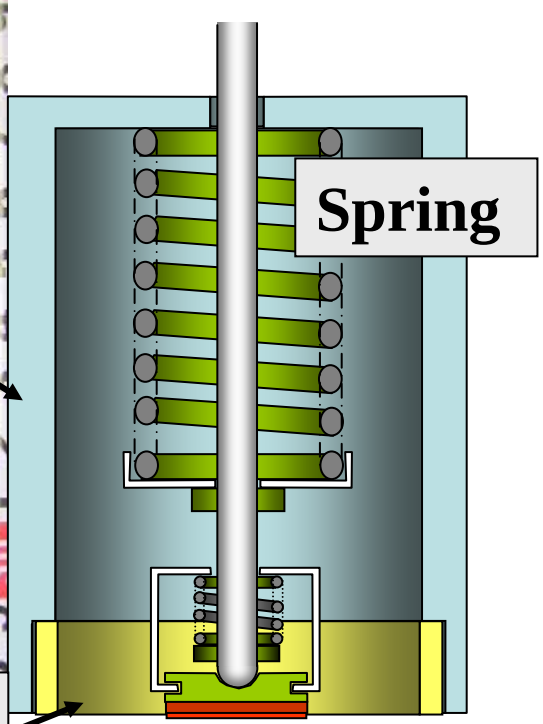
Summary of BWIM Study

1. **BWIM using reaction force method is simple and effective to obtain GVW, axle loads and truck type in service.**
2. **Overloaded trucks were found on major highway and national routes in Japan. Situation may be the same in other Asian countries.**
3. **Law enforcement is necessary to control such heavy trucks to maintain highway bridges in good condition.**

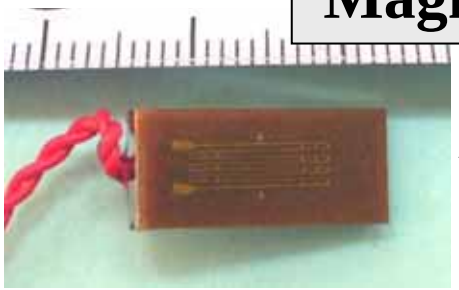
Strain Checker for easy stress measurement

Ojio and TML





Strain measurement set (4ch)



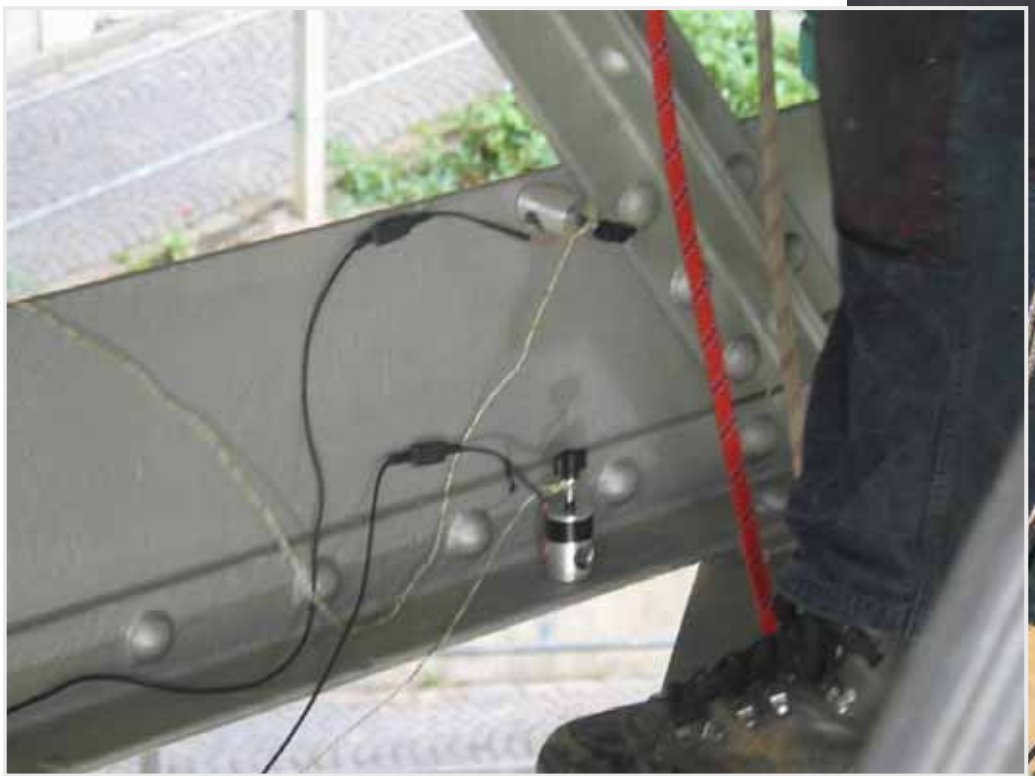
Application of strain checker in Switzerland

Kirchenfeldbrucke in Bern, 1882

2005.9


Use buses and trams for loading
2005.10.25


2005.10.25




2005.10.25

Use of strain checker to diagnose old bridge

Courtesy ICOM, EPFL, 2007

Arch members and floor systems

Orthotropic steel decks