# The method for selecting representative stress in a section of the concrete pavement

15-17 April 2013, Airport Pavement working Group Meeting of FAA

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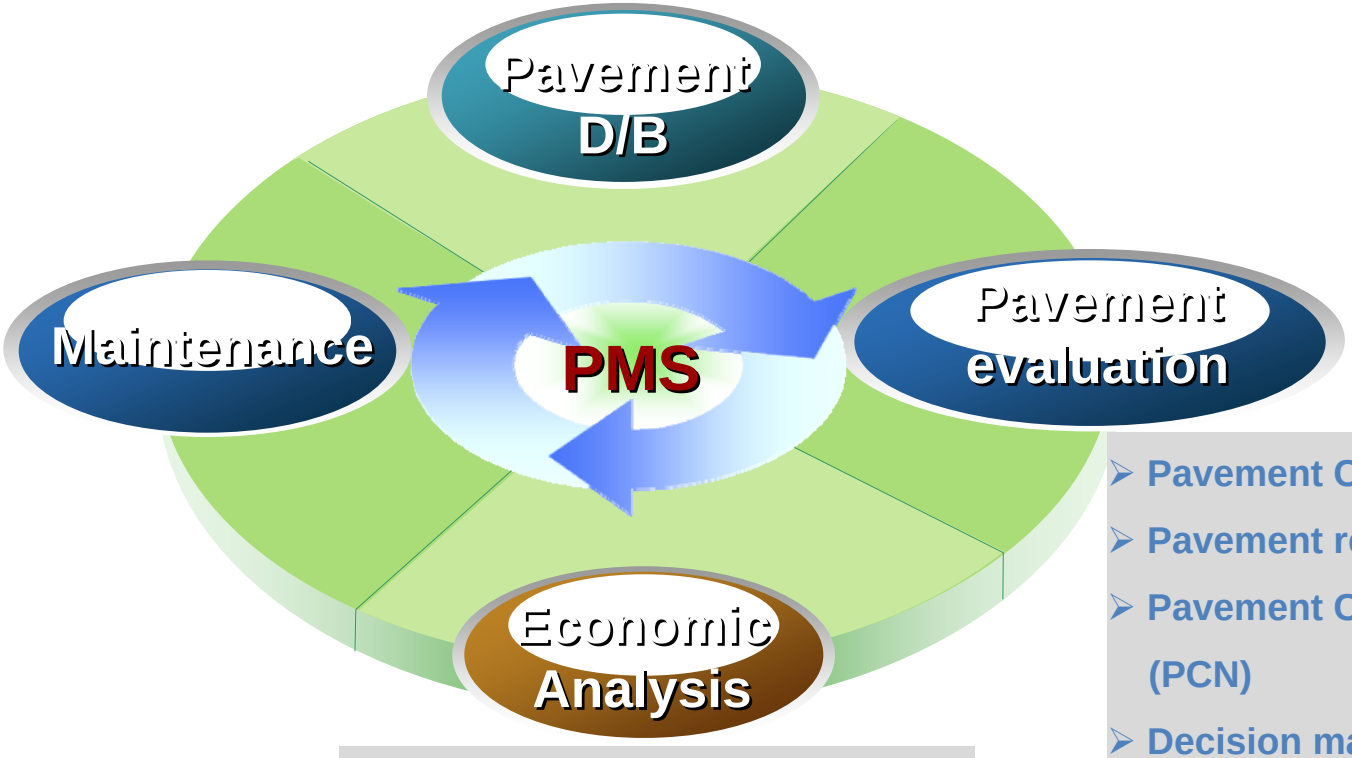
# General

## PMS operation




- Pavement Condition Index (PCI)
- Pavement remaining life
- Pavement Classification Number (PCN)
- Decision making and M&R plan

- Optimum repair time
- Priority
- Budget planning for 14 airports

# General

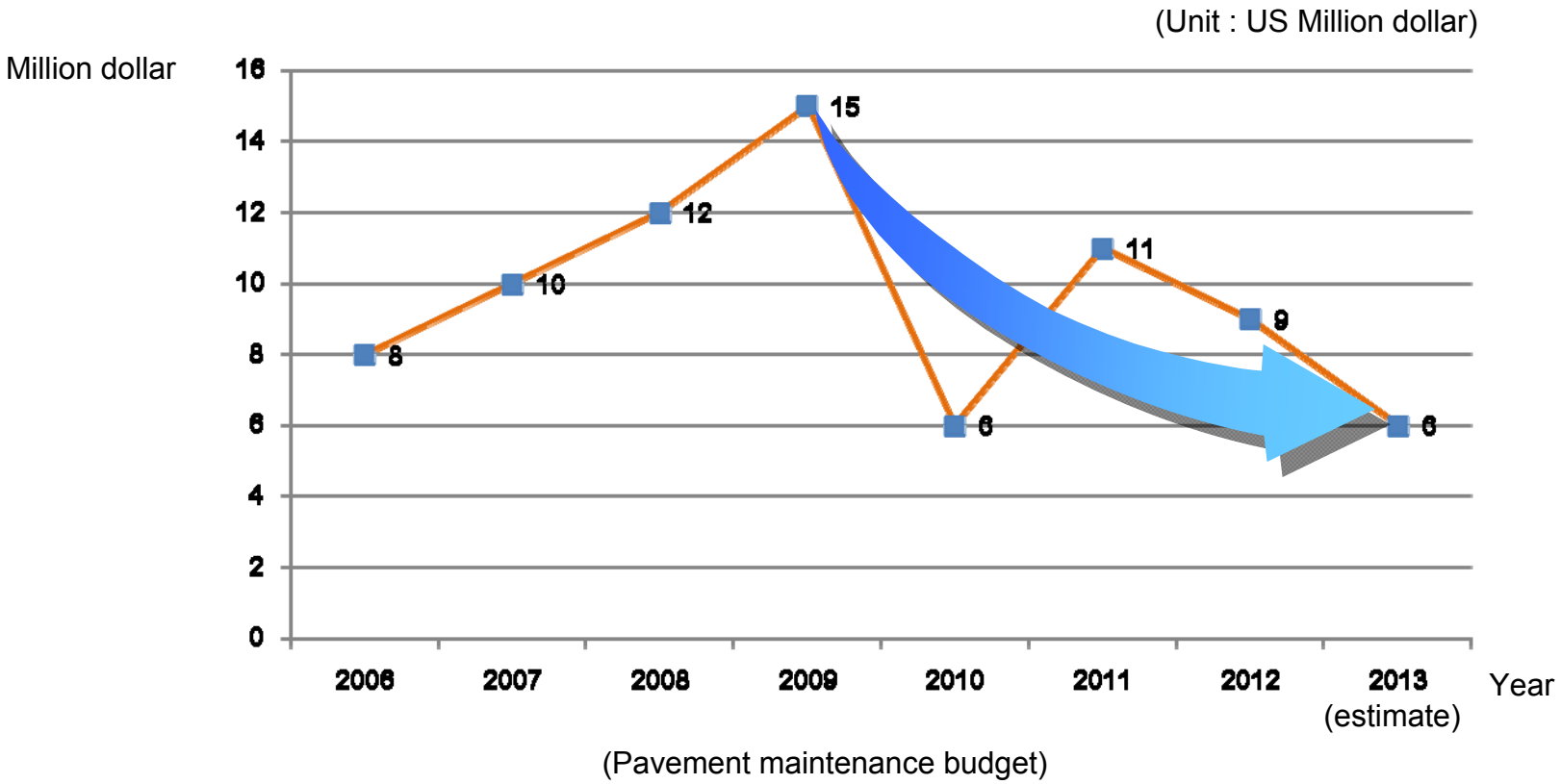
## PMS operation

| 14 airports' runway | |
|---|---|
| Age | Number |
| Below 10 years | 5 |
| 11~19 years | 6 |
| Over 20 years | 10 |
| Total | 21 |

# General

## Effect of PMS

➢ **Pavement maintenance budget on all 14 airports**



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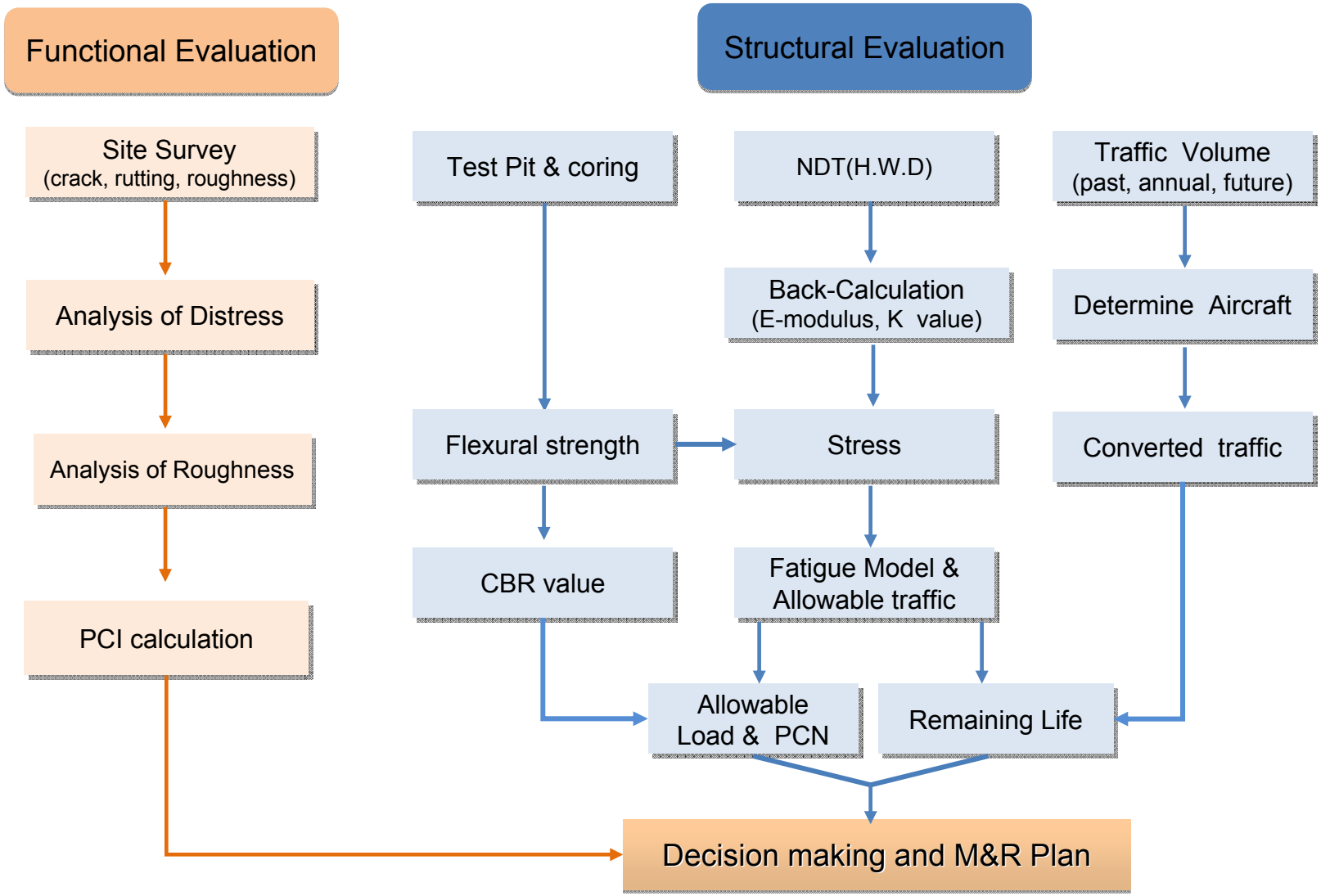
# Concrete Pavement Evaluation Process

## Evaluation Flow



# Concrete Pavement Evaluation Process

## Structural Evaluation

### Structural Analysis

**Rigid Pavement**

ILLISLAB Program

- **thickness**
- **elastic modulus**
- poison's ratio
- layer interface
- **slab size, AGG, K value**
- gear coordinate
- mesh coordinate

Maximum Tensile Stress

### Fatigue model(U.S COE)

$$\mathrm{Log}(\mathrm{COV}) = 2.13 \times \left(\frac{\mathrm{MR}}{\mathrm{stress}}\right)^{1.2}$$

COV : allowable coverage(pass) of aircraft

**MR : flexural strength**

Stress : Maximum stress

*** 50% failure standard**

# Concrete Pavement Evaluation Process

## Structural Evaluation

- Maximum Coverage(allowable maximum pass number)

$$N = COV \times (P/C)$$

N : maximum coverage

COV : coverage(=allowable coverage(pass) of aircraft)

P/C : Pass to Coverage ratio of aircraft

→ *consider wandering of aircraft*

- Remaining Life

*Background theory ; Miner's Damage*

$$Miner's\ Damage = \sum \frac{n_i}{N_i}$$

**Remaining Life Equation**

$$R_L = X \times \left( \frac{n_1}{N_1} + \frac{n_2}{N_2} + \frac{n_3}{N_3} + \cdot \cdot \cdot \right)$$

RL : 1- Past Damage

X : remaining life (year)

ni : annual departure of "i" aircraft

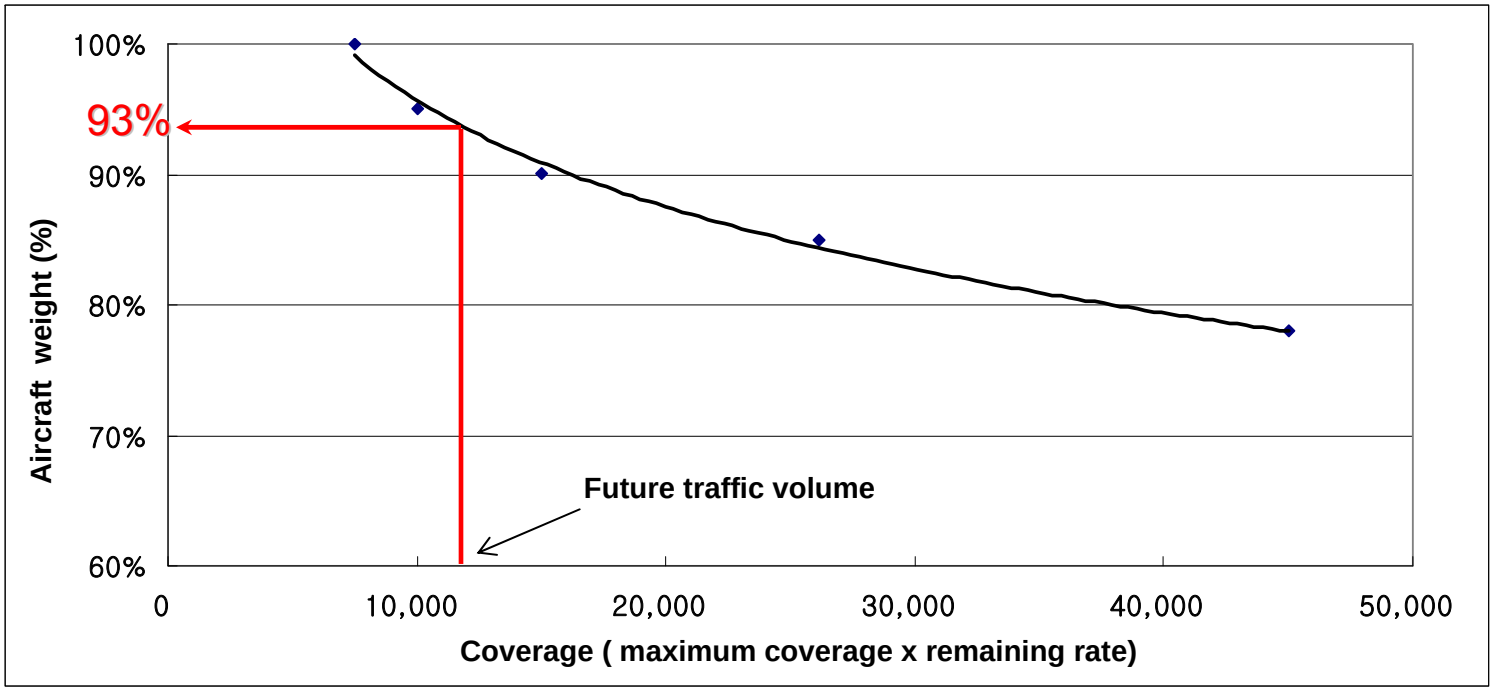
Ni : maximum coverage of "i" aircraft

# Concrete Pavement Evaluation Process

## Structural Evaluation

- Allowable weight and PCN

100-60% of Aircraft load → **stress** → N [=COV x P/C x remaining rate]



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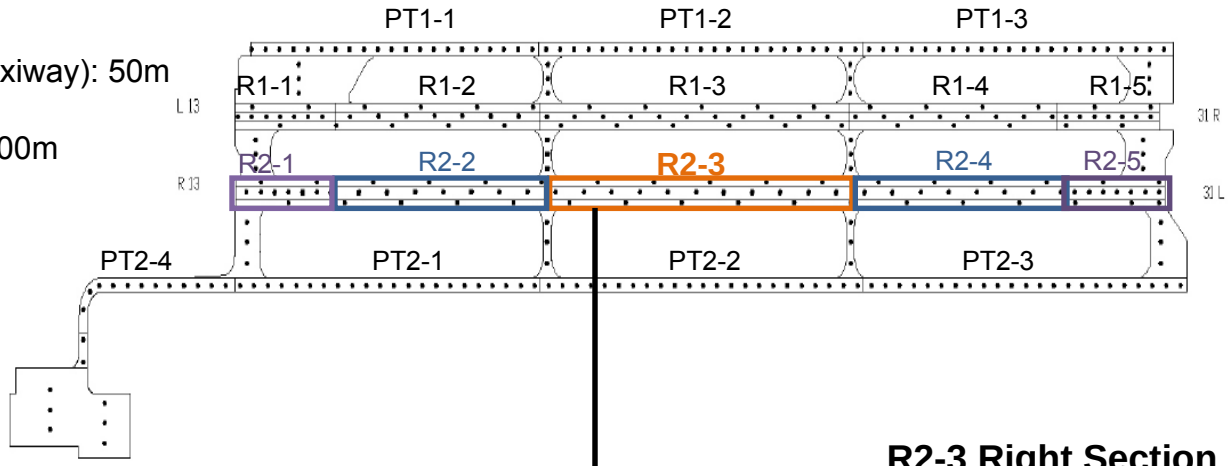
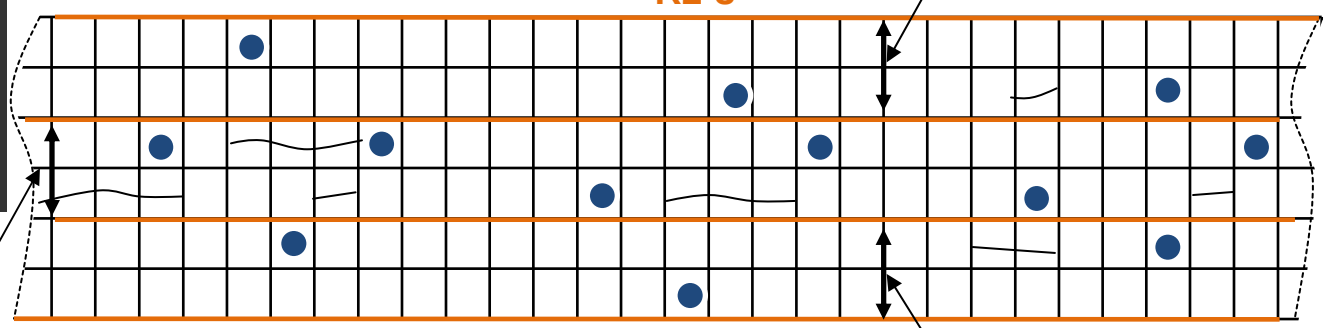
# Selecting representative stress in a section

## Non Destructive Test

- Low speed area (end of runway and taxiway): 50m
- High speed area (middle of runway): 100m
- edge of runway: 200m
- Apron: 60 m x 60 m



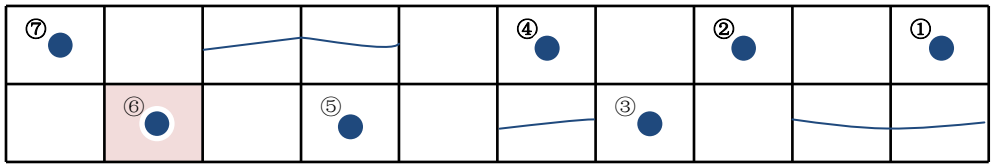

<Concrete pavement>

# Selecting representative stress in a section

## Existing method

✓ **If we assume that a section has 5 fatigue cracked slabs out of total slabs of 20**

<A section >




● HWD test point

✓ **If we assume that the stresses are as below;**

<In descending order>

| Number | Stress(psi) |
|---|---|
| ③ | 510 |
| ② | 480 |
| ⑦ | 450 |
| ① | 410 |
| ⑥ | 400 |
| ⑤ | 390 |
| ④ | 380 |

**Select as a representative stress**

< 50% failure standard >

$$\frac{5}{20} \xrightarrow{\text{5 more fatigue crack}} \frac{10}{20} = 50\%$$

❖ Reliable in the small test area
❖ It is definitely inefficient to test all slabs that are located in extensive area of the runway and apron
❖ In case of sample test, a wide stress deviation is expected.

# Selecting representative stress in a section

## Actual stress

✓ **Total test area(HWD test) : 229 slabs in the 42 sections of 3 airports**

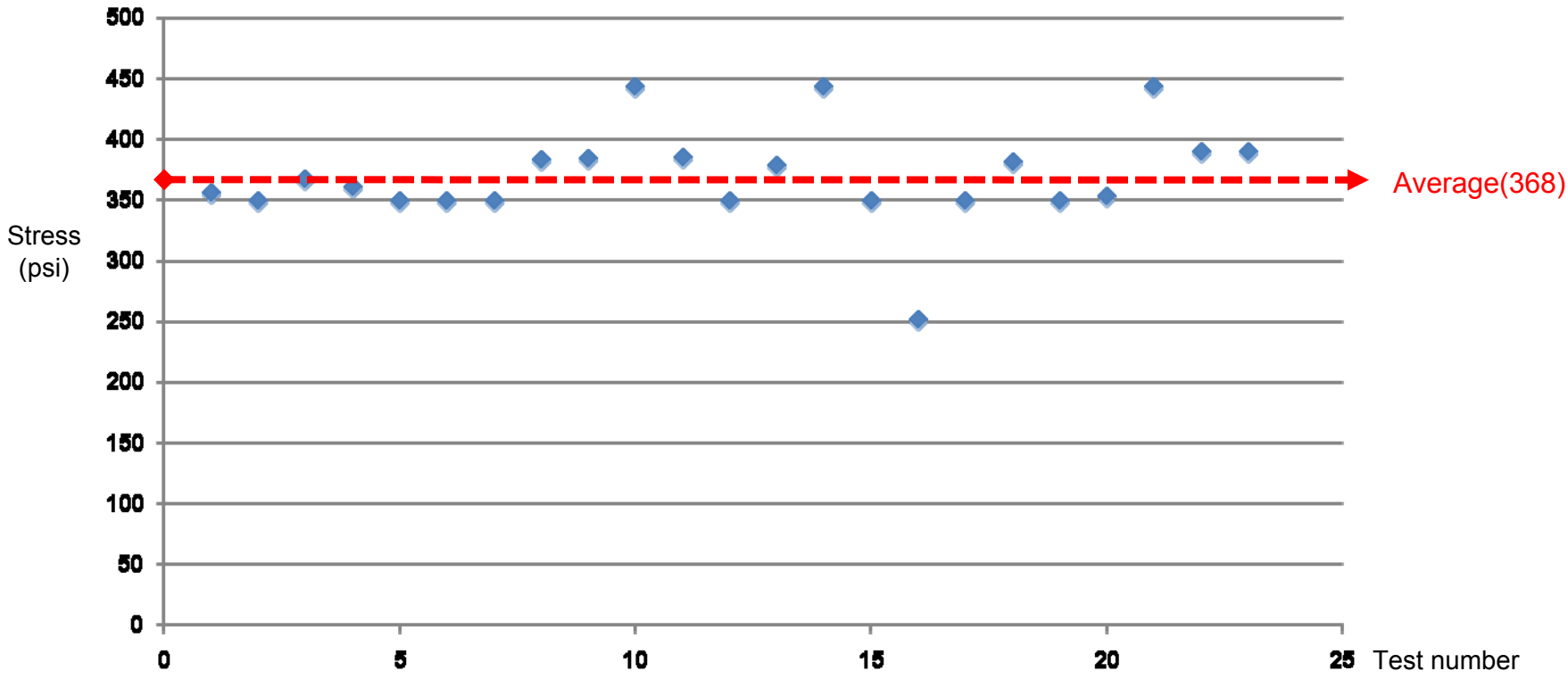
<Runway center section and parallel taxi way>

| Airport | Number of slabs | Average (psi) | Max. (psi) | Min. (psi) | Max.-Min. (psi) | Standard Deviation (psi) |
|---|---|---|---|---|---|---|
| Sacheon (center section of runway) | 23 | 368 | 443 | 250 | 193 | 40.53 |
| Sacheon (parallel taxi way) | 46 | 399 | 448 | 355 | 93 | 27.83 |
| Gwangju (runway center section) | 18 | 311 | 320 | 302 | 18 | 5.13 |

- ❖ Huge gab in standard deviation
- ❖ Standard deviation of Sacheon airport: 40.53psi
  - Remaining life: 24 to 8 years between maximum and minimum value of stress
- ❖ Average value of standard deviation in the 42 sections was 11.72 psi.

# Selecting representative stress in a section

## Stress distribution



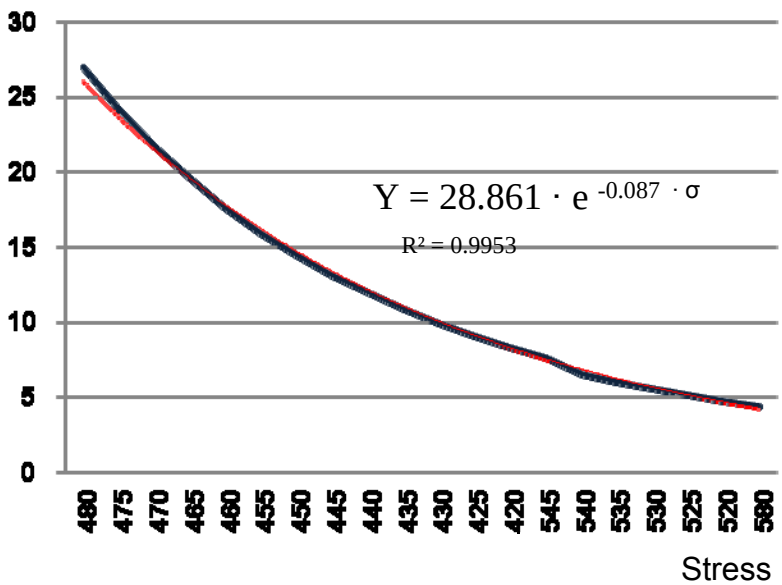

❖ Stress distribution of the center section of runway at Sacheon Airport

# Selecting representative stress in a section

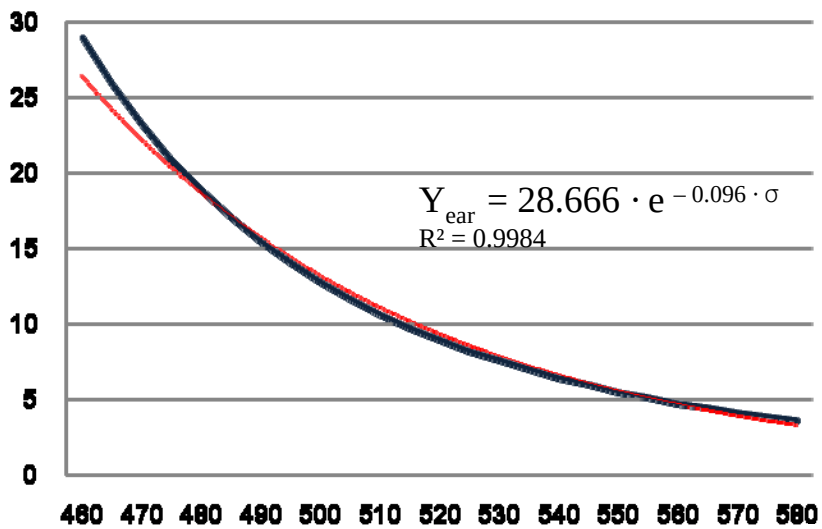
## Stress & Remaining life curve(1)

$$Y_{ear} = F(\sigma) = A \cdot e^{-B \cdot \sigma}$$

Remaining life (year)




Sacheon Airport
(Runway center)



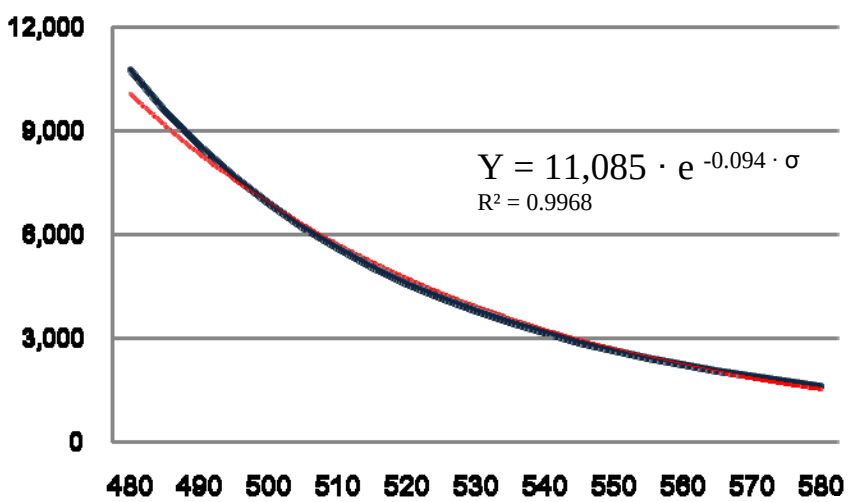

Kwangju Airport
(Runway center)

# Selecting representative stress in a section

## Stress & Remaining life curve(2)

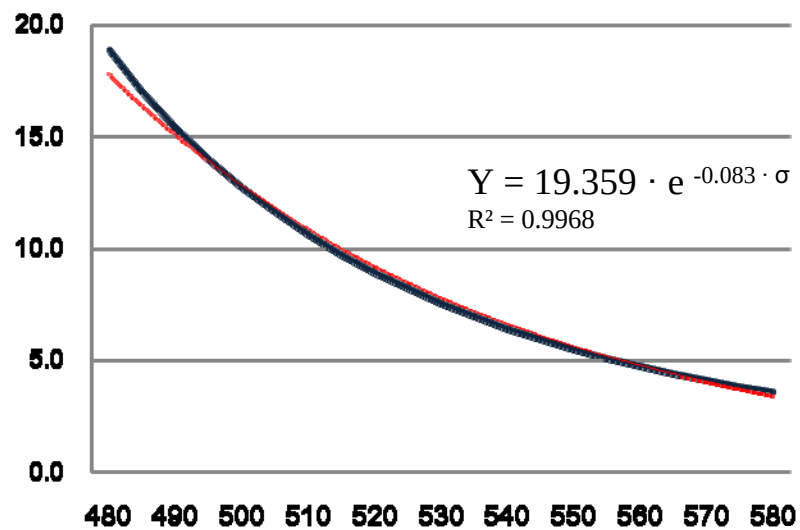
$$Y_{ear} = F(\sigma) = A \cdot e^{-B \cdot \sigma}$$

Remaining life (year)




Pohang Airport
(Runway center)

Stress




Pohang Airport
(Parallel taxiway)

❖ sensitivity analysis

The difference of 5psi makes up to1 to 3 years of difference in remaining life

# Selecting representative stress in a section

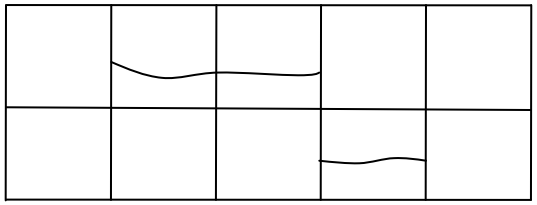
## Reflecting fatigue damaged slabs

< 50% failure standard >

- Remaining rate = 1 – past damage
- Past damage = $\dfrac{\text{The number of damaged slab}}{\text{The number of total slab / 2}}$

< damaged slab>

ex)



A section

Remaining rate = $1 - \dfrac{3}{10 / 2} = 0.4$

Total slab = 10
Damaged slab : 3

- Suppose10 slabs makes up one section; if three slabs have fatigue cracks, the remaining rate will be 0.4.

100~60% of Aircraft load → **stress** → N [=COV x P/C x remaining rate]

# Conclusion

- ✓ Wide stress deviation may occur according to the selected slab in a section.
- ✓ Average value of standard deviation was 11.72 psi.
- ✓ The difference of 5 psi makes up to 1 to 3 years of difference in remaining life.
- ✓ In case, the standard deviation in a section exceeds 5 psi, it is reasonable to select average value of stress as a representative stress to minimize influence of the stress deviation on analyzing remaining life and PCN.
- ✓ To analyze the remaining life and PCN, reflect fatigue damaged slabs by multiplying the calculated maximum coverage by remaining rate.

# THANK YOU

## QUESTIONS