The adequate variable of deterioration rate prediction formula about a polyvinyl chloride pipe

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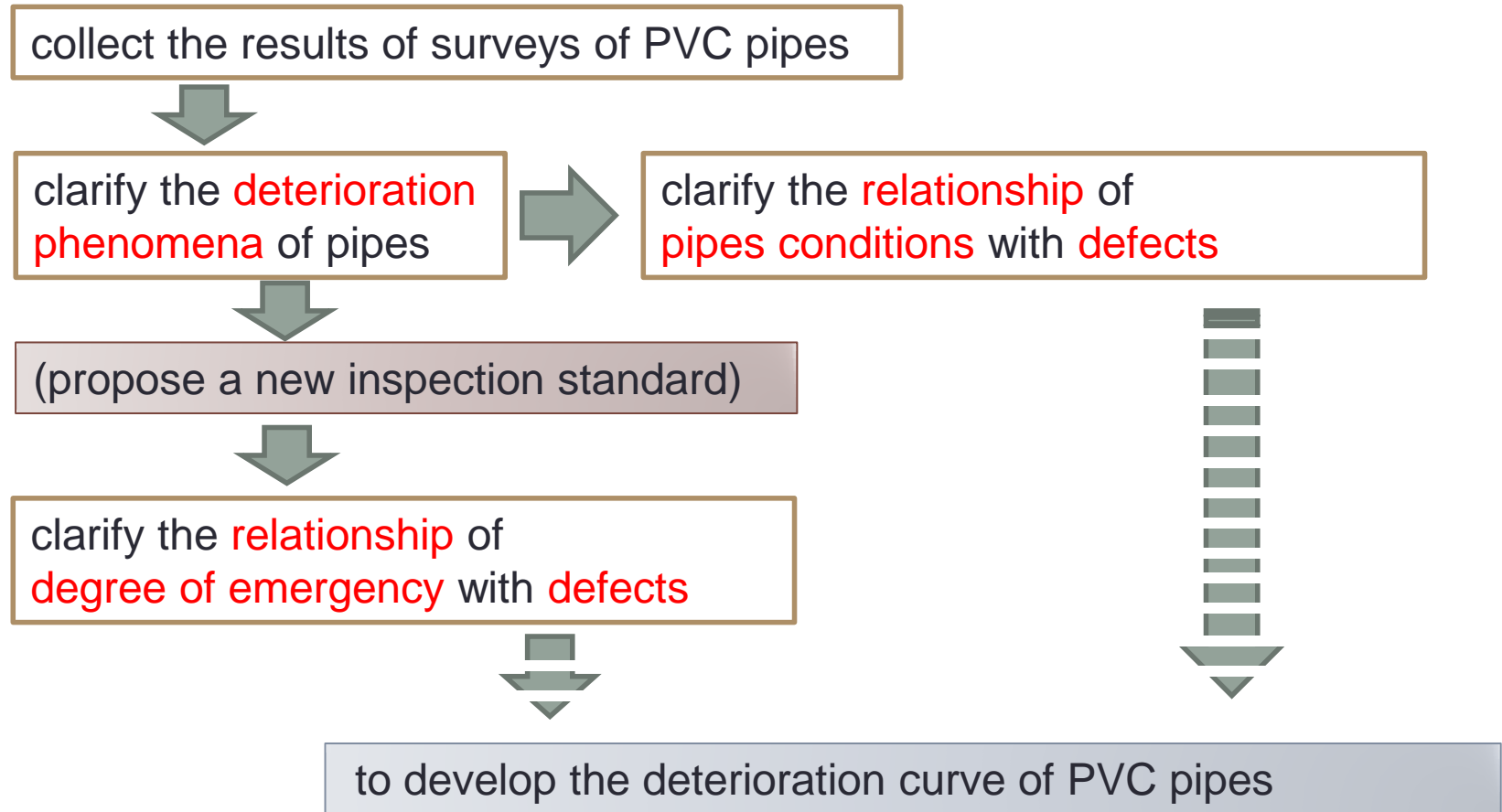
Current situation of sewer pipes in Japan
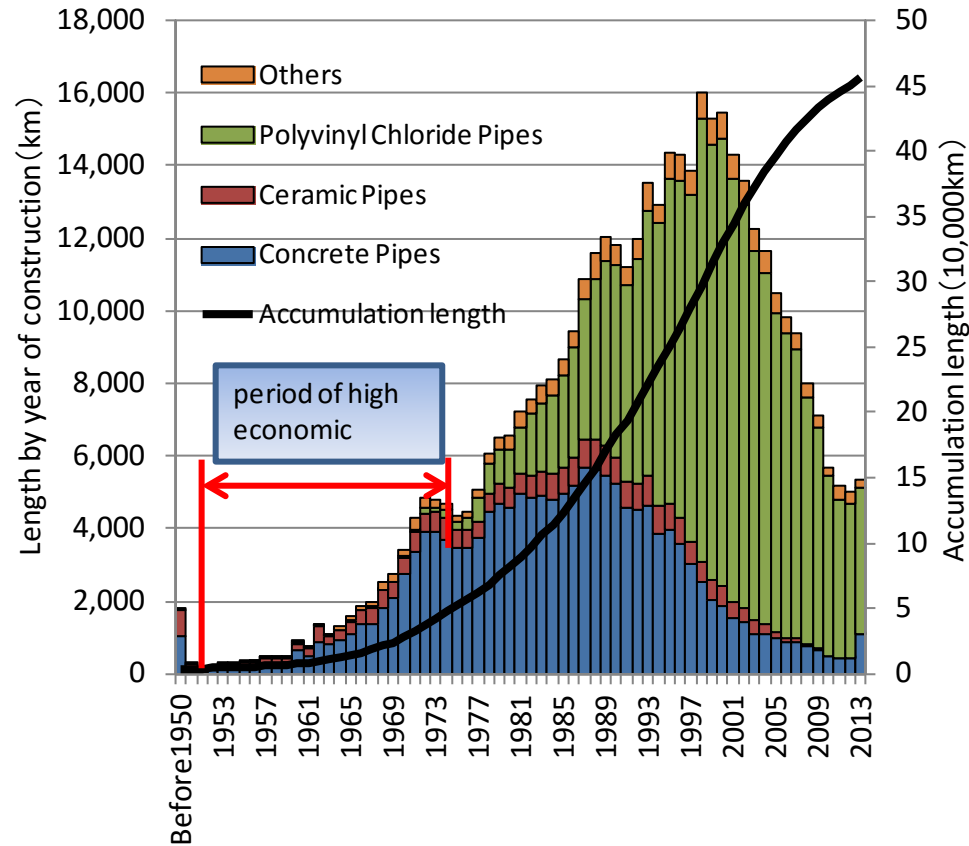
Total length by year of construction
by type of pipe in Japan

- • There are now about 10,000km of pipes older than 50 years, and sewage pipes are aging rapidly.

  ⇒ Deteriorated pipes are concrete and ceramic currently.

- • PVC pipes were developed later.
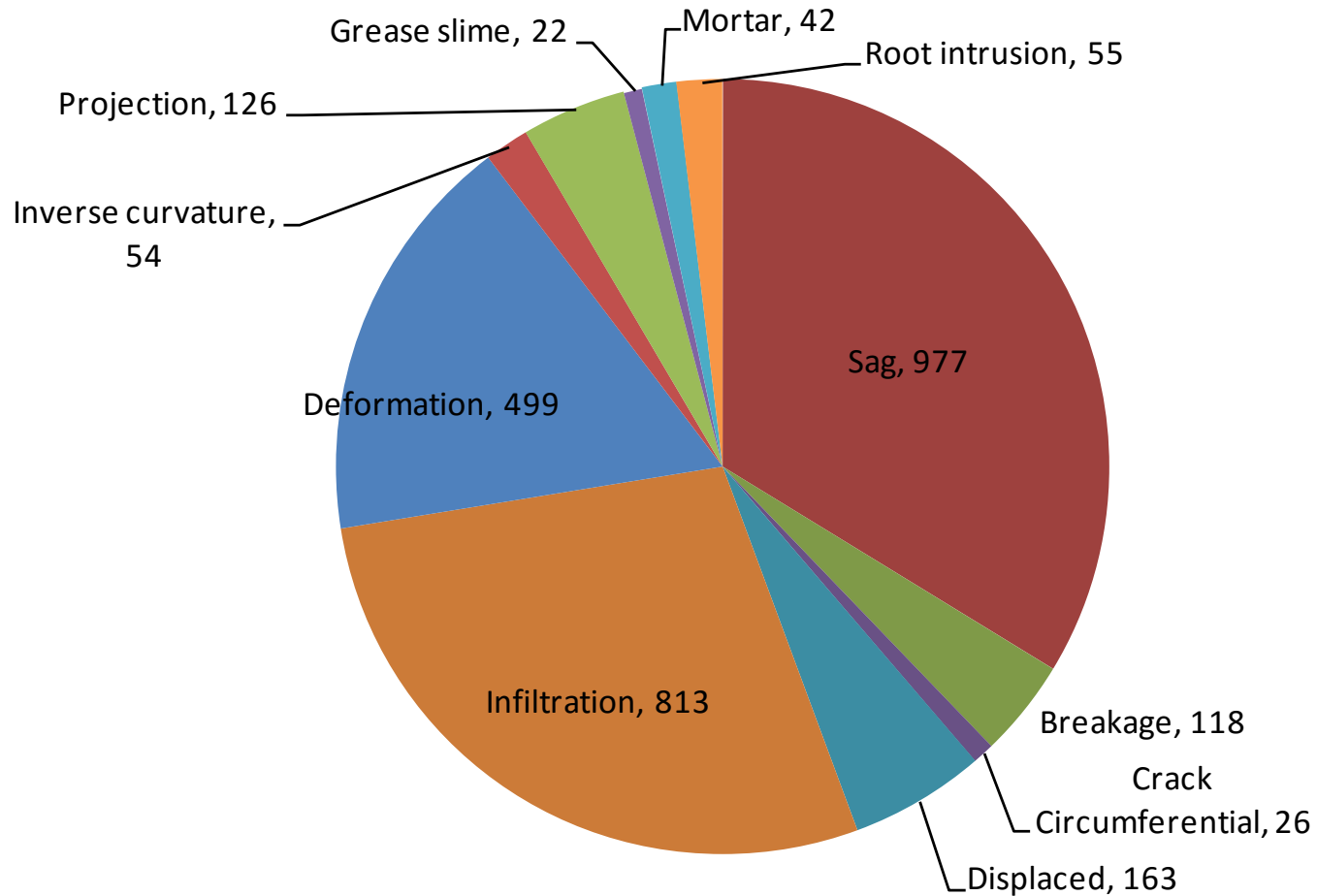
  ⇒ Few surveys

The properties of the PVC pipe deterioration must be clarified.

Factors contributing to 'degree of emergency' must be evaluated.

Approach of this study

collect the results of surveys of PVC pipes

clarify the deterioration phenomena of pipes

clarify the relationship of pipes conditions with defects

(propose a new inspection standard)

clarify the relationship of degree of emergency with defects

to develop the deterioration curve of PVC pipes

Defects that appear on PVC pipes

Pie chart data:
- Grease slime, 22
- Mortar, 42
- Root intrusion, 55
- Projection, 126
- Inverse curvature, 54
- Sag, 977
- Deformation, 499
- Infiltration, 813
- Breakage, 118
- Crack Circumferential, 26
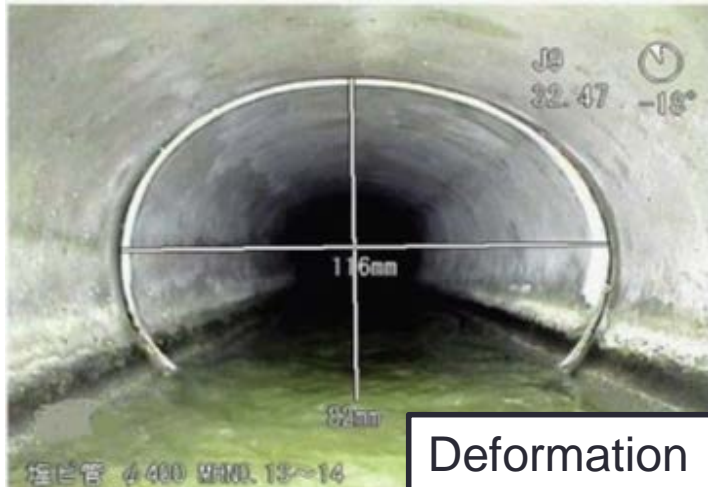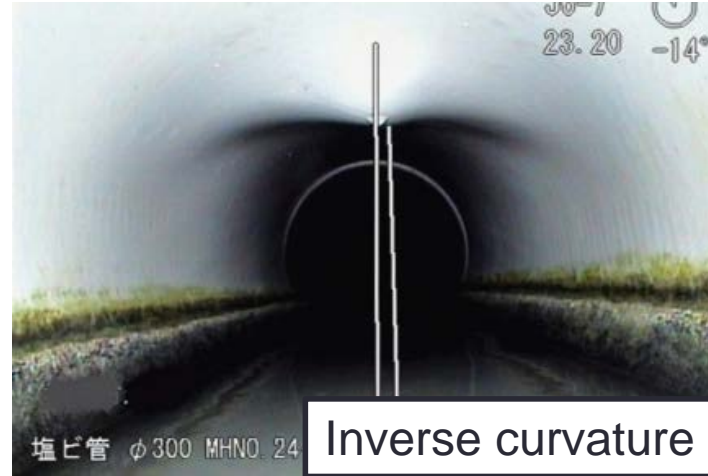- Displaced, 163

4115 spans were analyzed.
The results of surveys of PVC pipes (conducted by Local government)

Major and specific deterioration phenomena on PVC pipes

Deformation

Inverse curvature

phenomenons typical of flexible pipe

Breakage

Cracking in the pipe axis direction quickly causes breakage of pipes.

New diagnostic items for PVC Pipes

Evaluation of total span	Rank		A	B	C
	Item	Application	A	B	C
	Vertical sag	Pipe diameter less than 700mm	Diameter or over	Half diameter or over	Below half diameter

Evaluation of each pipe	Rank		a	b	c
	Item		a	b	c
	Breakage and Axial direction Crack	Complicated Crack		—	—
	Breakage and Axial direction Crack	Axial direction Crack		—	—
	Crack Circumferential		5mm or over	2mm or over	Below 2mm
	Displaced		Open joint	Half connection length or over	Below half connection length
	Deformation		15% deformation with flexibility factor or over	5% deformation with flexibility factor or over	—
	Inverse curvature※ (Projection on inside surface)		10% diameter or over	Below 10% diameter	—
	Infiltration		Splashing	Flowing	Bleeding
	Projection		Half diameter or over	10% diameter or over	Below 10% diameter
	Grease slime		Half diameter or over blocked	Below half diameter blocked	—
	Root intrusion		Half diameter or over blocked	Below half diameter blocked	—
	Mortar		30% diameter or over blocked	10% diameter or over blocked	Below 10% diameter blocked

※The inverse curvature with the whitening of materials assumes it a rank

What kind of pipes conditions are correlated with defects ?
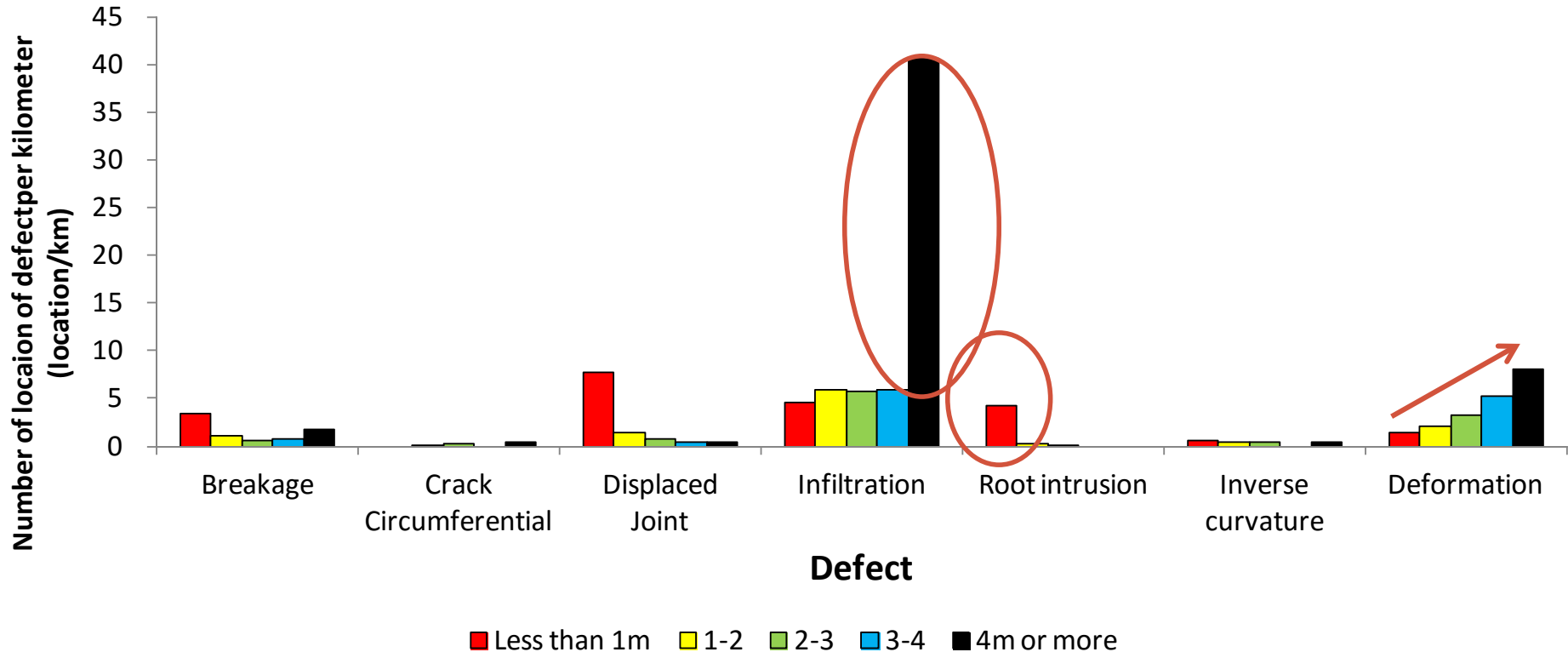
Defects occur on PVC pipes

What kind of pipes condition should be considered
to develop the deterioration curve ?

Pipes conditions correlated with defects

○ To count the number of occurrence locations per 1km for each defect
   divided by pipes conditions(depth, years of service, pipe diameter, etc.)

○ To analyze the relation between pipes conditions
   and number of deterioration occurrence locations.

Example1 (depth and number of deterioration locations)

Legend: ■ Less than 1m ■ 1-2 ■ 2-3 ■ 3-4 ■ 4m or more

Y-axis: Number of locaion of defectper kilometer (location/km)

X-axis: Defect — Breakage, Crack Circumferential, Displaced Joint, Infiltration, Root intrusion, Inverse curvature, Deformation

○ 4m or more, 'Infiltration' occurred more frequently.

○ Less than 1m, 'Root intrusion' occurred.

○ In proportion to depth, 'deterioration' occurred.

The results showed different trends acceding to each defect.

Example2 (Pipe diameter and number of deterioration locations)
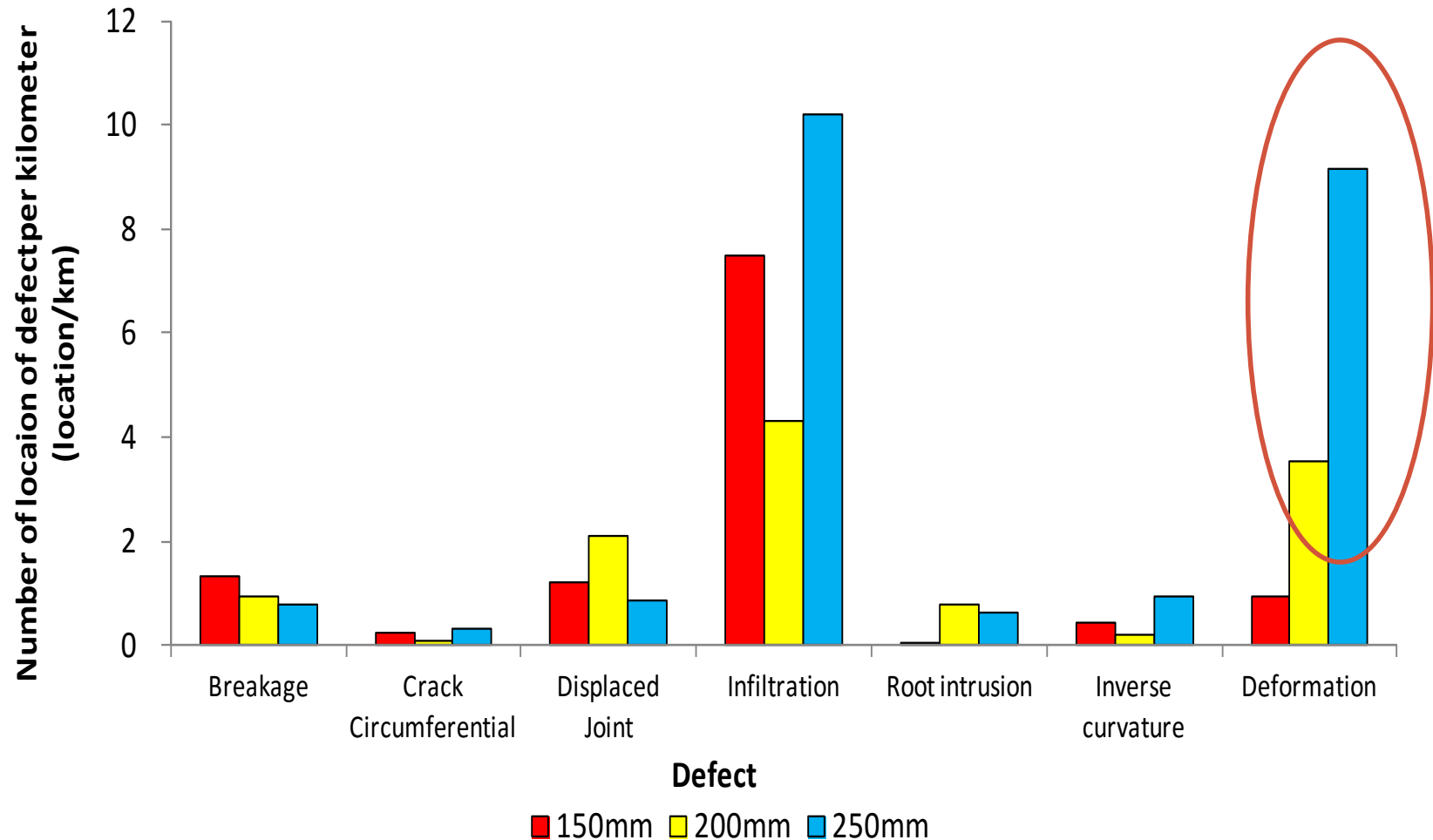
- ○ 'Deformation' have relation to the diameter.
- ○ Other, there is no clear relationship.

# Pipes conditions correlated with defects

Sag
Severe defects have occurred mainly on pipes buried at relatively shallow depth (1-3m).

Deformation
Within the range of pipe diameter from 150mm to 250mm, the more deteriorated locations existed.
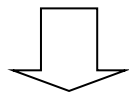In proportion to depth, 'deterioration' occurred.

The results showed different trends acceding to each defects, and to the condition of pipes.
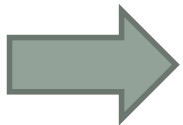
Based on the 'degree of emergency' calculation method, we tried to clarify what kind of defect should be considered.

Degree of emergency calculation method

Evaluation of total span
Vertical Sag (Evaluated as A,B,orC)
A	B	C

Evaluation of each pipe
Breakage and Axial direction Crack , Crack Circumferetial , Displaced , Infiltrarion , Projection , Grease slime , Root intrasion , Mortsr , Deformation , Inverse curvature（Projection on inside surface） (Evaluated as a , b , or c)

Evaluation of total span based on defect rate (Note 1)		
Defect rate of rank"a"＝total number of rank"a"／number of pipes in 1 supan Defect rate of rank"a+b"＝total number of rank"a" or "b"／number of pipes in 1 supan Defect rate of rank"a+b+c"＝total number of rank"a","b" or "b"／number of pipes in 1 supan Defect rate of rank"c"＝total number of rank"c"／number of pipes in 1 supan		
Rank"a" defect rate 20% or over, or rank"a+b" defect rate l40% or over , OR Fracuture rank"a" and deformation rank"b" or more , or displaced rank"a" (Note2)	Rank"a" defect rate less than 20% , or rank"a+b" defect rate less than 40% , or rank"a+b+c" defect rate 60% or over	No rank"a"or"b" , and rank"c" defect rate less than 60%
A	B	C
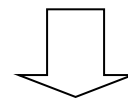
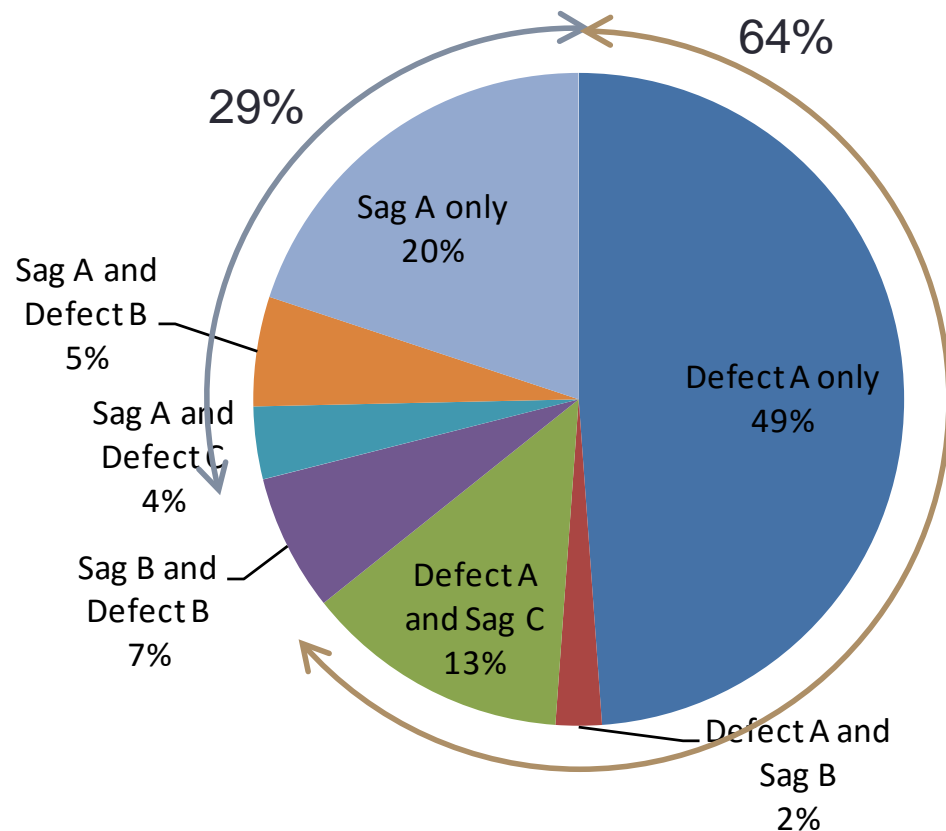| Judgment in emergency(Judgment in totals of A, B and C)	
Emergency Ⅰ	Span evaluation A for 2 items or more items
Emergency Ⅱ	Span evaluation A for 1 items or span evaluation B for 2 items or more items
Emergency Ⅲ	No span evaluation A , span evaluation B for 1 or span evaluation C
No Deterioration	Sound condition without anyy span evaluation C

Degree of emergency calculation method

Emergency	Category
Ⅰ	An early treatment is required
Ⅱ	A required can be postponed up to 5 years by a plain action
Ⅲ	A required can be postponed over 5 years by a plain action
No Deterioration	----------

Totally, 4115 spans were collected.

○ Emergency Ⅰ :
In a past survey the authors conducted, no such spans could be discovered

○ Emergency Ⅱ :
There are 221 spans to analysis.

○ Emergency Ⅲ :
There are 1329 spans to analysis.

Contribution rate to degree of emergency by determining factor (emergency Ⅱ)

$$Determining\ factor\ contribution\ rate\ (\%) = \frac{Number\ of\ spans\ by\ determining\ factor}{number\ of\ degree\ of\ emergency\ spans}$$

64%

29%

Sag A only
20%

Sag A and
Defect B
5%

Sag A and
Defect C
4%

Sag B and
Defect B
7%
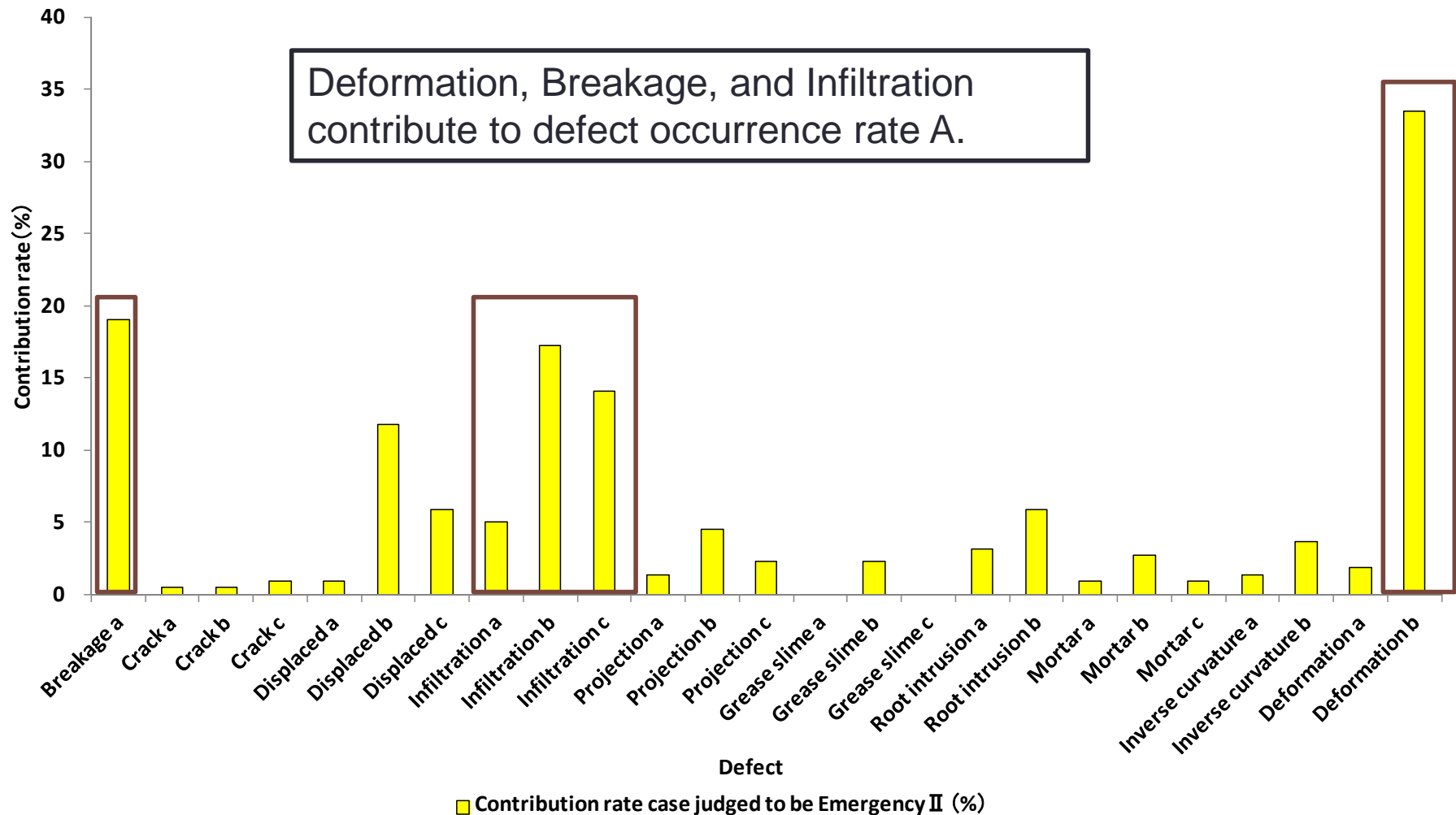
Defect A only
49%

Defect A
and Sag C
13%

Defect A and
Sag B
2%

Degree of emergency II is a case where defect occurrence rate A or sag A have occurred in a span.

The percentage that defect occurrence rate A has contributed at this time is about 64%, which is 29% higher than the percentage contributed by sag A.
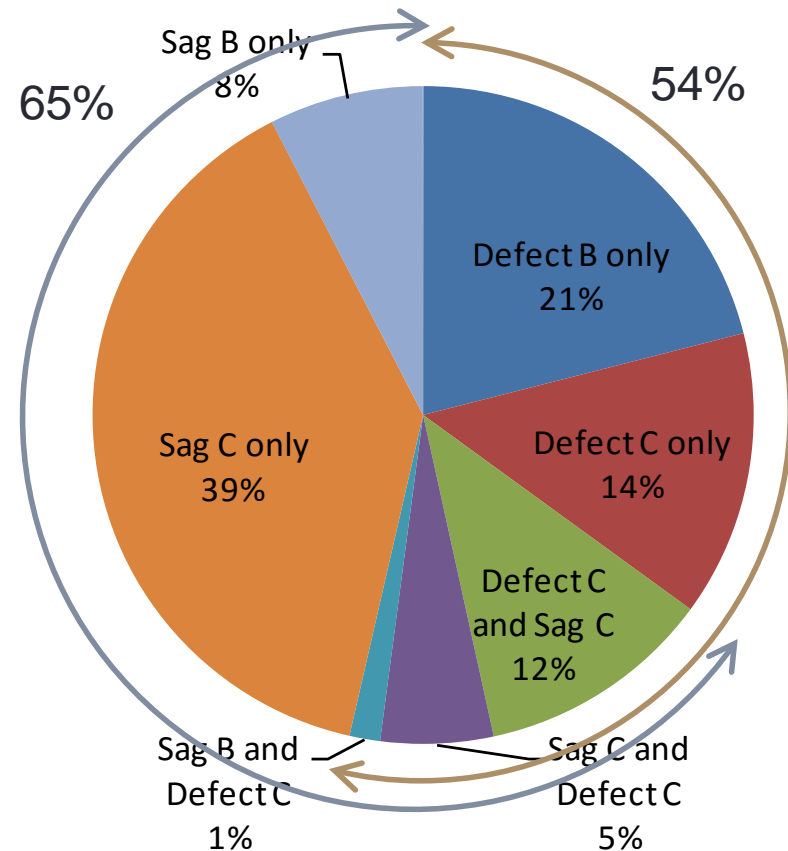
Which defects contribute to the defect occurrence rate A?

Contribution rate to degree of emergency by determining factor

$$defect\ item\ rank\ contribution\ rate\ (\%) = \frac{number\ of\ spans\ by\ defect\ item\ rank}{number\ of\ degree\ of\ emergency\ spans}$$

Deformation, Breakage, and Infiltration contribute to defect occurrence rate A.

Contribution rate (%) — Defect

☐ Contribution rate case judged to be Emergency Ⅱ（%）

Contribution rate to degree of emergency by determining factor (emergency Ⅲ)

$$Determining\ factor\ contribution\ rate\ (\%)\ =\ \frac{Number\ of\ spans\ by\ dtermining\ factor}{number\ of\ degree\ of\ emergency\ spans}$$

65%   54%

Sag B only 8%

Defect B only 21%

Defect C only 14%

Sag C only 39%

Defect C and Sag C 12%

Sag B and Defect C 1%

Sag C and Defect C 5%

There were many items that contributed to degree of emergency III, and the contribution rate was also the same for the defect occurrence rate of 54% and sag of 65%.

It is necessary to further analyze pipe conditions that impact degree of emergency III by determining factors.

Summary

◆Even in PVC pipes with relatively few defects,
there are defects that result in early pipe failure.
so, appropriate inspections are required.

◆Defects that occur in PVC pipes are affected
by pipe diameter and depth

◆locations of deformation, breakage, and infiltration
are at high priority for repairs or other countermeasures.

It is suggested that these parameters, especially correlated with deformation, breakage, and infiltration, should be considered to develop the deterioration curve of PVC pipes.

Example3　(Years of service　and number of deterioration locations)