

Consideration about reliability improvement of picture photography technology in inspection of tunnel lining

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Implementation of approach watch and a tapping sound inspection is a principle for inspection of tunnel lining. Picture photography technology is introduced aiming at efficiency of inspection in recent years. The technique using the CCD camera and the laser has been developed by picture photography technology. However, it isn't done clearly about relationship with the measure precision of the damage and the measure precision of the damage of approach watch and a tapping sound inspection of these methods. This research considered the inspection precision of the picture photography technology using real tunnel inspection data.

1. INTRODUCTION

The inspection of road tunnel is a basis "to do by the frequency of the once per 5 years by approach watch/tapping sound inspection" by a change in a road law building regulation in July, 2012. Conventional tunnel inspection depends on approach watch/tapping sound by a vehicle for high lift work in the traffic control. There is an advantage that the local situation of the small area can be grasped correctly relatively for approach watch/tapping sound inspection. But of a inspection lack person, and, to do inspection operation in a soiled wall at the dark inside of mine shaft, there has been fear of a human error of a possibility that a damage will be overlooked, progressive etc. of a crack and the precision by the inspection person. And inspection in the traffic control, it's work next to danger, and there are various problems influence to the user. On the other hand, tunnel run type measurement technology develops and makes a practical use of it to settle these problems recently, and it's being included in tunnel management. Soundness of the lining concrete the one is inspection of tunnel lining by picture photography technology, and Sano chooses as image processing, evaluation is being tried. However, it isn't to prove a inspection result by picture photography technology clearly about approach watch/tapping

sound inspection in inspection in the real tunnel. This research considered the inspection precision of the picture photography technology using real tunnel inspection data.

2. TUNNEL LINING INSPECTION METHOD

The situation of the approach watch/tapping sound inspection is indicated on figure 1. Approach watch/tapping sound inspection is the inspection method to grasp the state of the structure by grasping the state of the damage of a structure by a naked eye, approaching the distance which can be estimated, watching, striking a blow at a target structure by a fixed hammer and hearing sound.



Figure 1 Approach watch/tapping sound inspection circumstances

Inspection by picture photography technology is classified into the run type image measurement and the run type laser measurement. The way run type image measurement is it an engineer make a development at the top of a desk using a continuous print picture, and it's possess the precision equal to approach watch inspection to a crack of more than 0.5 mm of width. When detecting a damage of a crack in a picture, that depend on engineer's judgement big. The part where the stripe-like pattern of the lining concrete surface and smoke were adherent with a continuous print picture, outflow remains of a free lime and a leak of water and the back of the thing of facilities, it's necessary to mark as the viewpoint. The inspection by picture photography technology is damage as substitution of distant view watch and approach watch inspection of information, it's possible to be objective and grasp with a high precision, and speed up, and there are reduction in traffic control and an advantage of overlook prevention. On the other hand substitution of approach watch/tapping sound inspection is difficult to be, and it's placed as complementation of approach watch/tapping sound inspection.

The specification of the picture photography technology used for this analysis is indicated in table 1. Operational circumstances are indicated on figure 2.

3. INSPECTION INDEX OF TUNNEL LINING

A inspection index of tunnel lining is indicated on table 2. Writer ³⁾ subdivides a required performance table of constructed road tunnel by a mountain method of construction. A inspection index specialized in the user's safety was set in

particular here. A inspection item by inspection situation by picture photography technology and approach watch/tapping sound inspection is indicated in the table 2.

4. THE SPECIFICATION OF THE SUBJECT OF CONSIDER TUNNEL

The tunnel made a subject of consider that constructed by conventional method of construction, the tunnel measure back hollow and not measure one. The specification of the subject of consider tunnel is indicated in the table 3.

Table 1 The specification of the run type image measurement

Name	Specification	Quantity
High-definition television video camera(Made by the SONI-company HDR-CX560V)	The number of pixels : 1920 × 1080/60p	9 stand
A light	•LED Light 36W	•About 20 stand
	•LED Light bulb 9W (worth 100W)	•About 200 one's
A generater	2.5KV	2 stand
Photography stand	SUS(wilding)	1 stand
Photography vehicle	4t vehicle	1 stand



Figure2 The inspection situation by the picture photography technology

Table 2 Inspection index of tunnel lining

Required performance			Classification of the damage	Name of the damage	
Big item	Medium item	Small item		Inspection by picture photography technology	Approach watch/tapping sound inspection
Safe performance	Safety isn't threatened	Spalling by the material degradation doesn't form	Damage of detached	Exposure of aggregate(rock pocket part) Crack like tortoiseshell Crack of closure form Crack like crescent	Stood, Detached Bean shaped Scale Block form(close) Reinforcing rod exposure Degradation of repairing materials
			Damage of large size crack	Crack width over 3.0mm Crack width about 3.0mm Crack width about 2.0mm and continuously over 3m	Crack width about 3.1mm Crack width under 2.1mm~3mm
			Damage of middle size crack	Crack width about 2.0mm	Crack width under 1.1mm~2mm
		A leak of water doesn't form on the road surface	Damage of leak water	Leak of water(water dripping) Leak of water(wet part)	A gusu An outflow Flowing down Ooze out Degradation of repairing materials

Table 3 The specification of the subject of consider tunnel

Tunnel name	A tunnel	B tunnel
Linear division	Down line	Down line
Route name	Hokuriku way	Hokuriku way
Using year	1980/6/13	1976/11/2
Using number of year	35years	39years
Constructing method	Traditional method	Traditional method
Extension(m)	1155	622
Number of general spans	99	59
Inspectin year [Inspection by picture photogrphy technology]	2013	2013
Inspectin year [Approach watch/tapping sound inspection]	2015	2015
Object scope of the inspection	Fast line	Fast line
Presence in the back hollow	Exist(unsupported)	Exsit(supported)
Measure date in the back hollow		2002/2/1

5. ANALYSIS OF PICTURE PHOTOGRAPHY TECHNOLOGY AND APPROACH WATCH AND A TAPPING SOUND INSPECTION RESULT AND CONSIDERATION

The detection state of the damage in the tunnel lining surface is compared and the inspection precision of the picture photography technology is inspected using the picture photography technology and the approach watch/inspection data acquired by a tapping sound inspection result. A damage of inspection which is to compare picture photography technology and a result of the approach watch/tapping sound inspection and depends on picture photography technology, detection accuracy is considered. A damage which aims at the span in which a damage is detected intensively, and is picture photography technology and approach watch/tapping sound inspection, the tendency of the detection is grasped. The difference in its tendencies is compared, a strange document, detection accuracy is analyzed.

A result of the picture photography technology and approach watch/tapping sound inspection in A tunnel are indicated on figure 3. Equally, a inspection result of the B tunnel is indicated on figure 4. Vertical axis is the size of the damage. Transverse axis is the span number. A damage of inspection by picture photography technology of the inspection index of tunnel lining indicated in inside front, inspection data was put in order every item. A damage of large size crack and middle size crack indicated in classification of a damage, the size of the item is expressed in extension. Other damage, the size of the item is expressed in the area. A crack like tortoiseshell, a closure crack and a crack like crescent, it's record a circled area in a

inspection result as the area because a crack is the damage which becomes one box. The crack system large and a crack in the crack system can't express it in the area because damage is tied and there are no circled areas. Extension was used for comparison instead of the area.

There is back hollow in A tunnel, but there are no B tunnels. When the detection amount of the leaking system is seen, there are B tunnels a lot more than A tunnel without the back hollows. The thing inspection by picture photography technology is detecting big finds out but that a result of the approach watch/tapping sound inspection is seen.

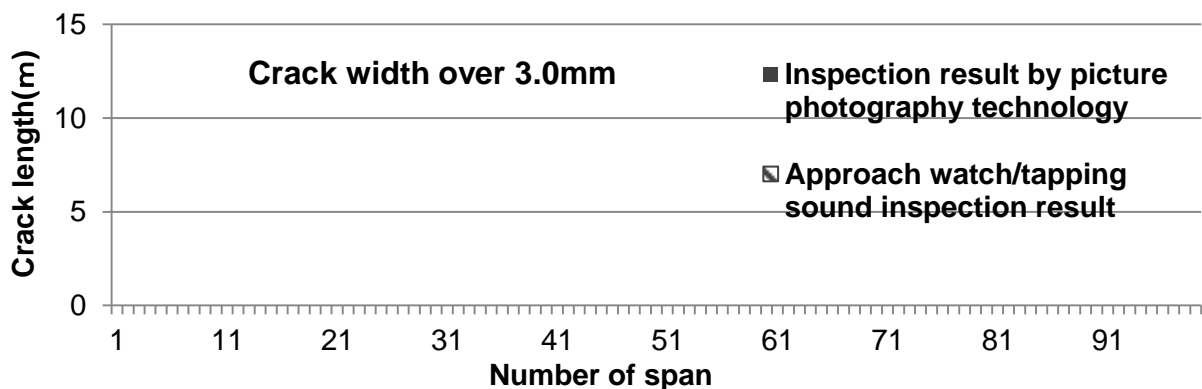
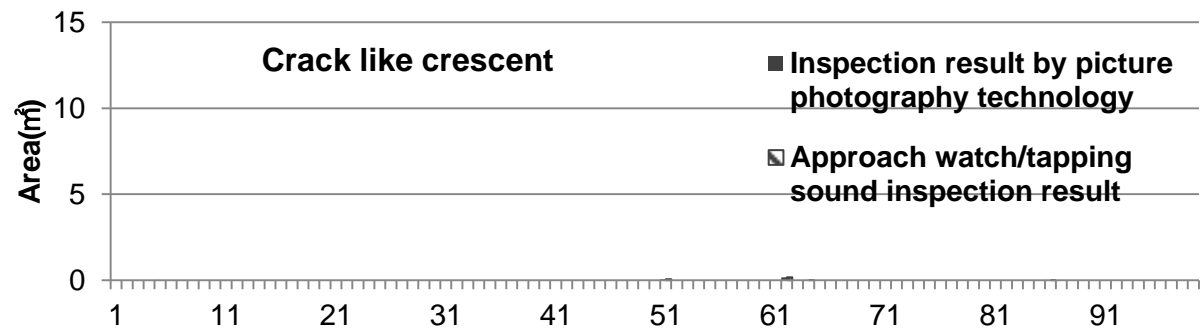
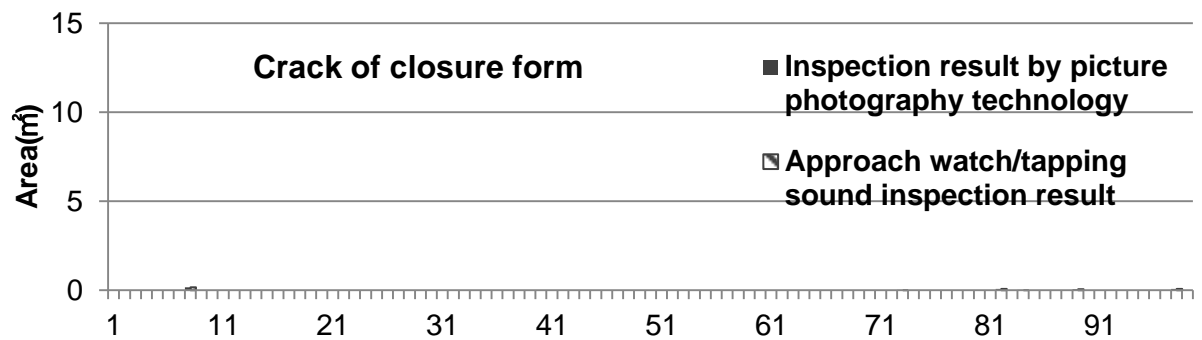
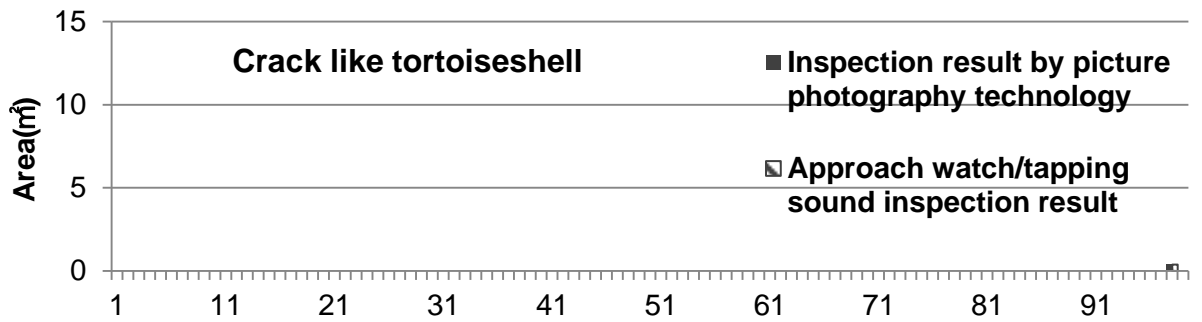
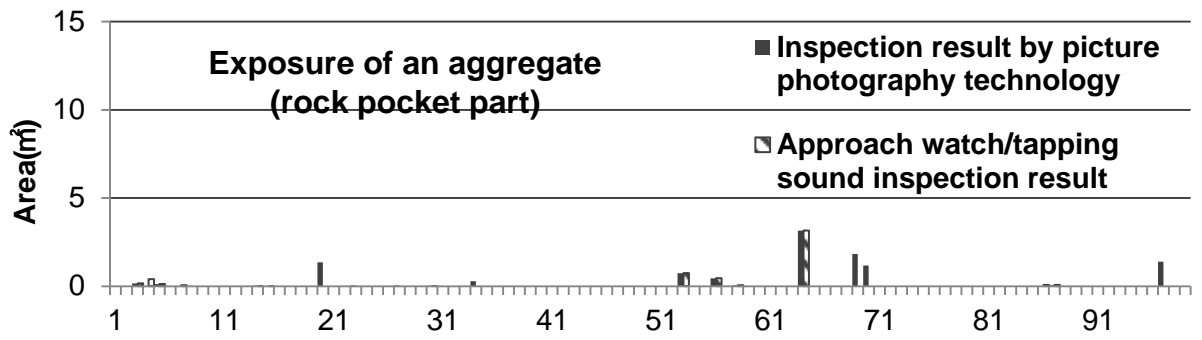
I can think there is a possibility that a change in the state of the lining surface by a leak of water influences a inspection result.

I aimed is the numerous point of the size and the item that a damage was detected. The target in A tunnel is made 70-81 span. The target in a B tunnel is made 5 and 48 spans.

The one with the big size of the damage detected at two tunnels finds out that the item affected by the crack system large is "about 2.0 mm of crack and continuously more than 3 m". But only with this, damage, it wasn't possible to grasp the tendency of the detection.

The detection point of view of the damage of tunnel lining as well as the size of the strange document and a crack are considered from information on the way of the damage here. The point of view of the damage detection and the way indicate the part of the lining development which can be confirmed on figure 5 and 6. Figure 5 indicates the lining development inspection by picture photography technology gives. Figure 6 indicates the lining development approach watch/tapping sound inspection gives. Figure 5 and 6 show the situation of the lining surface of number of 5 spans in a B tunnel. A lining development is made in case of two inspection. The state of the tunnel lining surface was mapped. A list of the damage expressed in a lining development is indicated on figure 7.

When a lining development on figure 5 is seen, I find out that only inspection by picture photography technology is detecting exposure of an aggregate (the rock pocket part). The other spans also analyzed inspection result in a target by a similar way. When it was analyzed about the item of the crack course, progress of a crack was the damage and that detected around the crest in a tunnel, and was here, and developed in the crossing direction, influence was relatively and detection in a margin found out that it's frequently.



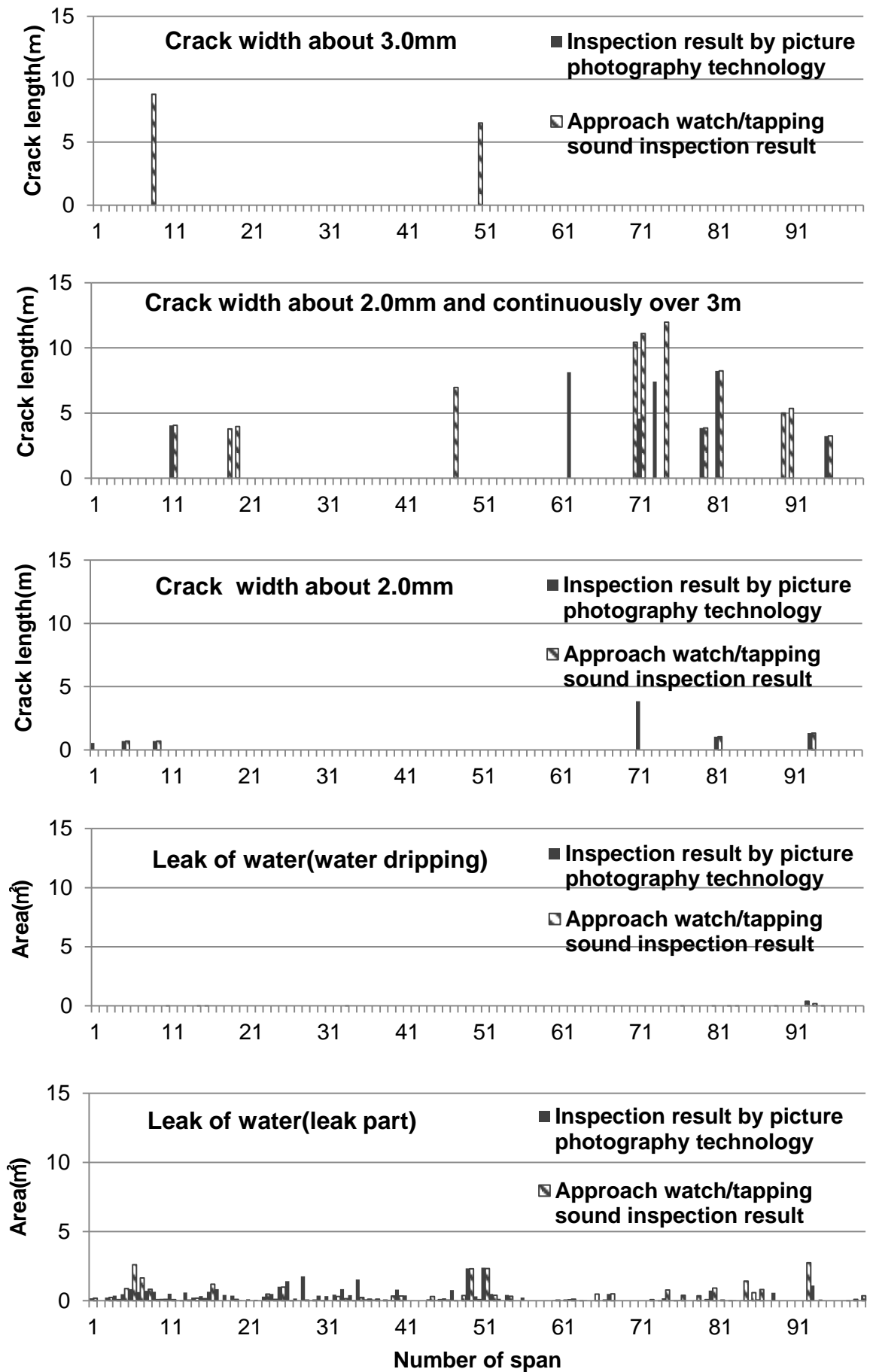
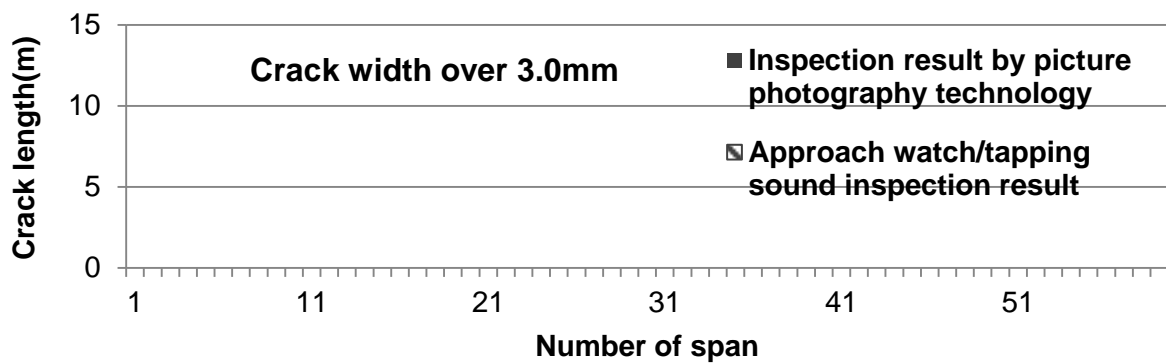
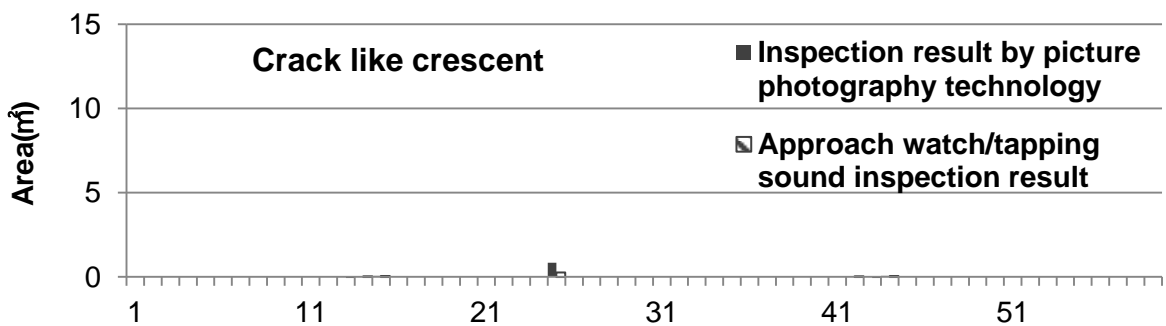
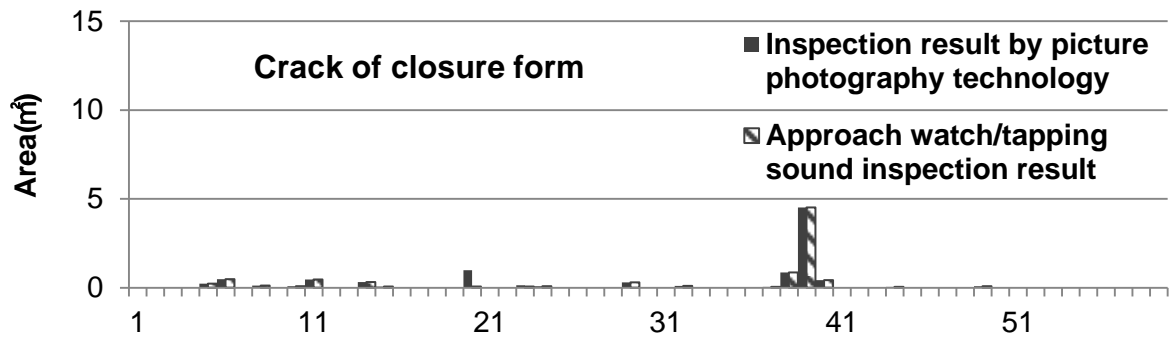
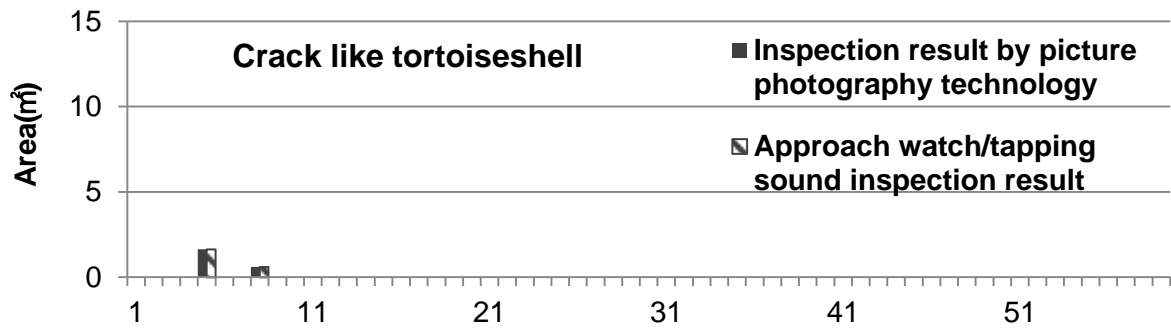
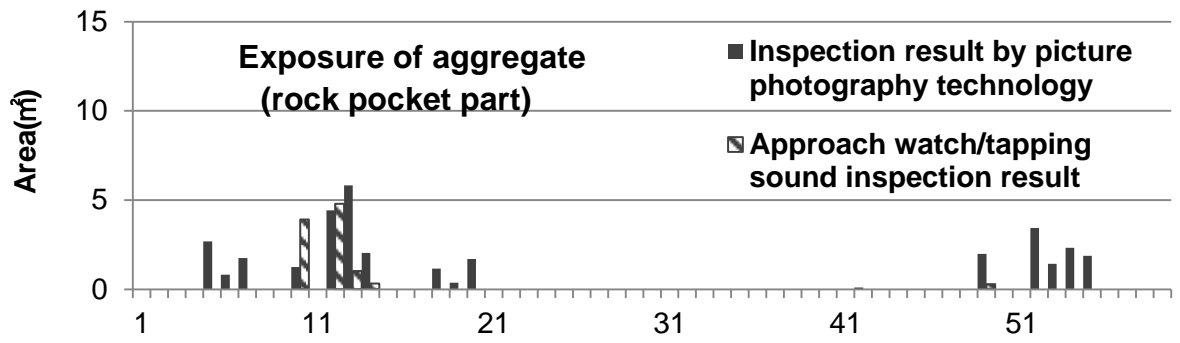


Figure3 Inspection results of A tunnel



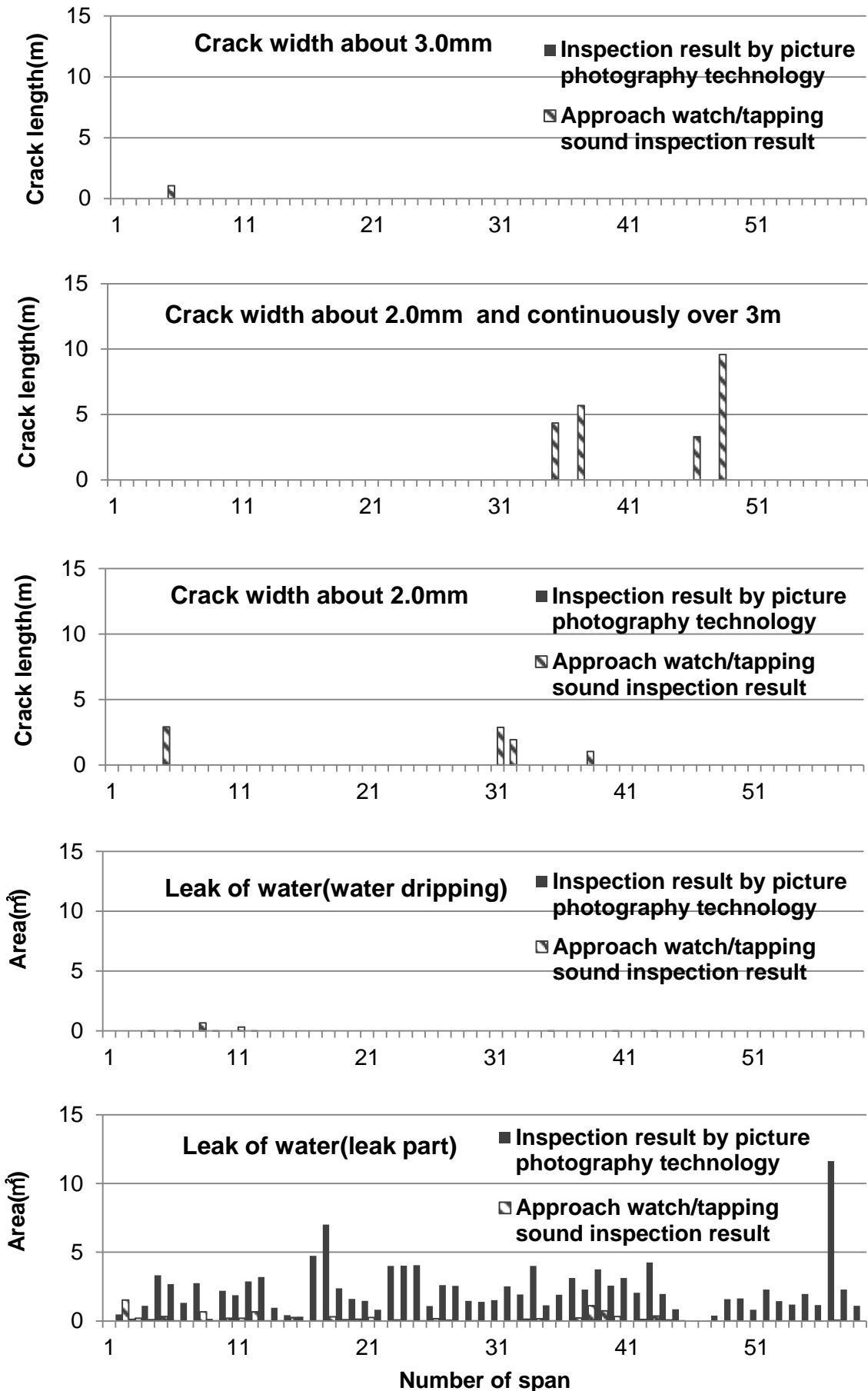


Figure4 Inspection results of B tunnel

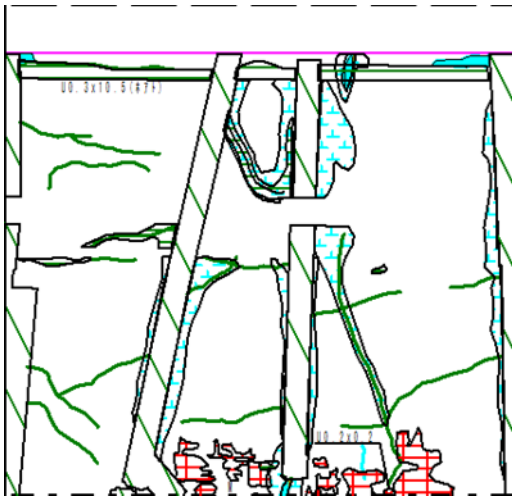


Figure5 Lining development of inspection by picture photography technology

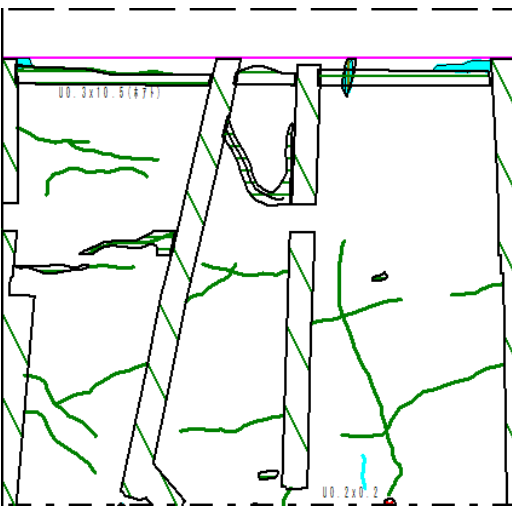


Figure6 Lining development of approach watch/tapping sound inspection

A legend	A mark
Crack width under 0.5mm	Green horizontal line
Crack width about 1.0mm	Yellow horizontal line
Crack width about 2.0mm	Red horizontal line
Crack width about 3.0mm	Blue horizontal line
Crack width over 3.0mm	Black horizontal line
Step	Green diagonal lines
Squashing	Red diagonal lines
Cold joint	Green dotted lines
Stood, Detached	Red diagonal lines
Crack like tortoiseshell	Green diagonal lines
Crack of closure form	Red diagonal lines
Crack like crescent	Green diagonal lines
Separation, Separation tracks	Red diagonal lines
Exposure of aggregate (rock pocket part)	Red diagonal lines
Leak of water (water dripping)	Blue horizontal line
Leak of water (wet point)	Blue horizontal line
Leak tracks	Blue horizontal line
A thing of eluviation	Green horizontal line
Repair	Green horizontal line
Leakage preventive (headrace)	Green horizontal line
Tapping sound inspection to locate	Green horizontal line
Damage of internal facing construction method	Red diagonal lines
Damage of water leakage prevention gutter	Red diagonal lines
Damage of draining facility	Red diagonal lines
Damage of pavement	Red diagonal lines
Damage of tunnel entrance construction method	Red diagonal lines

Figure7 List of the damage expressed in a lining development

6. CONCLUSIONS

It's gathered below that it became clear by this analysis.

(1) There is a possibility that the damage of the system detached around the crest detected by picture photography technology is affected.

(2) When a strange document of the crack system large around the crest detected by picture photography technology and approach watch/tapping sound inspection is included in the crossing direction, there is a possibility that inspection by picture photography technology is affected.

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