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## R&amp;D of The Variable Guide Frame Vehicle for Tunnel Inspection

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## R&amp;D Objectives and Subjects

## Objectives

- Tunnel maintenance engineers have conducted human-eye based close inspection using mobile elevating work platforms up to this point in time. The conventional inspection method requires traffic regulation for road users. One of objectives of this R&D is to reduce the traffic regulations during inspection works that are convenient to both road users and administrators.
- It takes much time for conventional inspection and hammering tests of wide areas. Besides, conventional depending on inspectors. We have proposed a "Variable guide frame vehicle" that is new maintenance technology.



Tunnel inspection

## Subjects

## Main Theme

## (1) Variable Guide Frame(VGF)

Can be changing shape according to the various tunnel geometries and obstacles.

## (2) Protective Frame Vehicle

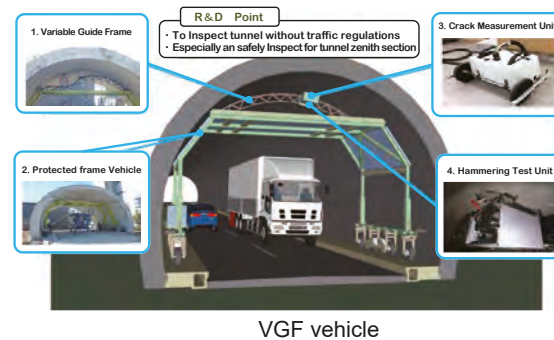
Can protect road users from falling concrete pieces.

## (3) Crack Measurement Unit

Can integrate visible images and 3-dimensional shape depth data (range image) by the light-section method and distinguish between cracks and dirt automatically.

## (4) Hammering Test Unit

Can detect possibility of concrete spall from hammering sounds through machine learning.



## Current Accomplishments (1/2)

## Inspection vehicle for regulation less traffic

## Variable Guide Frame(VGF)



Change frame shape



Guide frame (1unit)

## [Overview]

- Guide frame can deform by expansion and contraction of its actuators.
- It detects obstacle position and determines the quantity of necessary expansion and contraction of the actuators by inverse analysis.

## [Topics]

- Performed operation check on experimental tunnel
- Self-lock and others implemented as safety measures

## Protective Frame Vehicle



Traveling test



Frame assembling test

## [Overview]

- Traveling along a road and inspecting tunnels.
- Dividing traffic areas and inspection areas for safety work.
- Can be assembled and disassembled on-site within a short time.

## [Topics]

- Performed traveling test on an experimental tunnel
- Performed frame assembling test on a test field

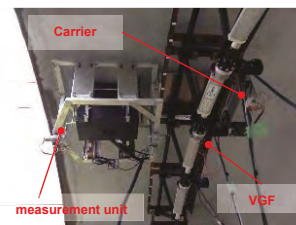
## Benefits of the inspection vehicle

- Can take necessary reaction force for hammering test from the Variable Guide Frame.
- Can realize a precise inspection with a little traffic regulation.
- Variable Guide Frame allows us to inspect kinds of tunnels.

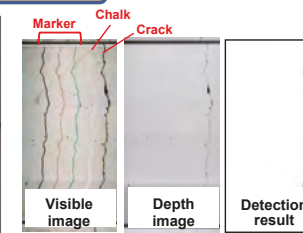
## Current Accomplishments (2/2)

## Remote control inspection unit

## Crack Measurement Unit



Crack measurement unit



Acquired image and result

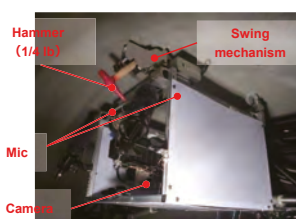
## [Overview]

- Can integrate a visible image and a depth image (range image) obtained by light-section methods and can distinguish between cracks and others.
- Detecting efflorescence too.

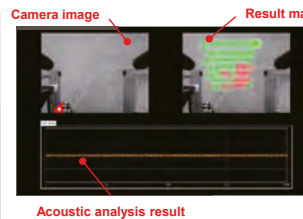
## [Topics]

- Accuracy rate of the distinction between cracks and dirt were over 70%
- Accuracy of the crack detection test rate was over 95%

## Hammering Test Unit



Hammering test unit



Inspection result

## [Overview]

- Detecting concrete spall instantaneously from visible images and hammering sounds.
- Visualizing concrete spall from inspection results.

## [Topics]

- Detecting concrete spall of experimental tunnel and test pieces.
- We considering calibration method on-site.

## Benefits of the inspection device

- Can reduce processing time for removing noise such as dirt in images.
- Can be finding signs quickly such as diagonal cracks that may cause concrete spall.

## Goals

## R&amp;D Final Goal

Detection accuracy rate of deformation with Variable Guide Frame Vehicle

- Cracks: over 80% (width over 0.5 mm)
- Concrete deformations: over 70%

## Target of this inspection system

Road tunnels managed by municipalities severe lack of engineers

Variable Guide Frame Vehicle is applicable to about 55% of tunnels in Japan

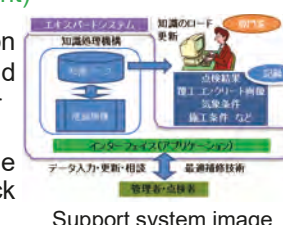
## Supporting inspection of road tunnels managed by municipalities

- We lend out the inspection vehicle and provide technical guidance for local consultants and inspectors. The cost of the inspection vehicle will be lower than a mobile elevating work platform and inspection engineers.
- We will establish an association about inspection vehicle, which will promote diffusion, lending, operator dispatch, support for planning and report preparation.

## R&amp;D for practical application

## Tunnel management support system (under development)

Tunnel management support system draws up inspection records and photo ledgers from inspection data acquired by inspection vehicle, and it also presents optimal repair methods, materials, and repair engineers. This system calculates the Life Cycle Cost (LCC) of the tunnel, and will support municipalities to settle severe lack of engineers.



Support system image

We will make a system to support municipalities to settle severe lack of engineers, and give a basic information of infrastructure.