

■ R&D Topics : Robotics Technologies

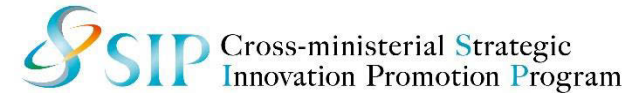
■ R&D Theme : R&D of The Variable Guide Frame Vehicle for Inspection of Tunnel

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R&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 and the method varies according to inspectors. We have proposed a "Variable guide frame vehicle" that is a new maintenance technology.



Tunnel inspection

Subjects

Main Theme

(1) Variable Guide Frame(VGF)

Can change its shape according to the various tunnel geometries and obstacles

(2) Protective Frame Vehicle

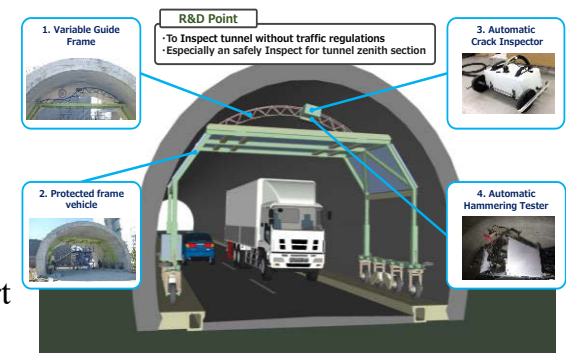
Can protect road users from falling concrete pieces.

(3) Automatic Crack Inspector

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

(4) Automatic Hammering Tester

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



VGF vehicle

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 necessary amount of expansion and contraction of the actuators by inverse analysis.

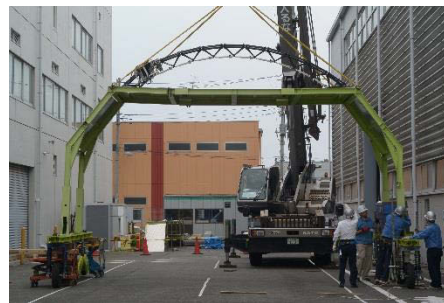
【Topics】

- 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.
- Divide traffic areas and inspection areas for safety work.
- Can be assembled and disassembled on site within a short time.

【Topics】

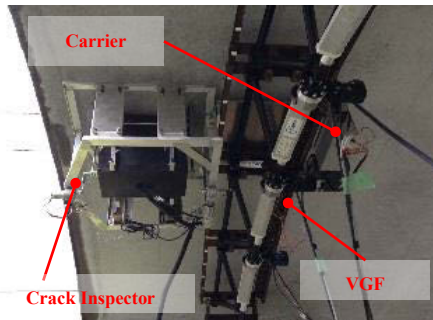
- Performed traveling test on an experimental tunnel
- Performed frame assembling test on a test field

Benefits of the inspection vehicle

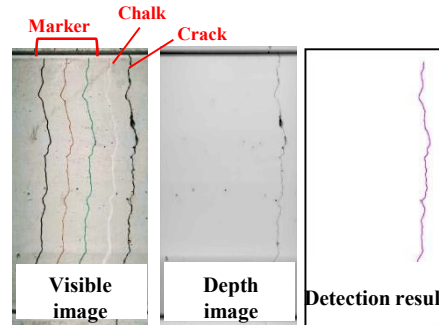
- Can take reaction force necessary for hammering test from the Variable Guide Frame.
- Can realize precise inspection with a little traffic regulation.
- Variable Guide Frame allows us to inspect more tunnels.

Remote control inspection device

Automatic Crack Inspector



Crack Inspector



Acquired image and result

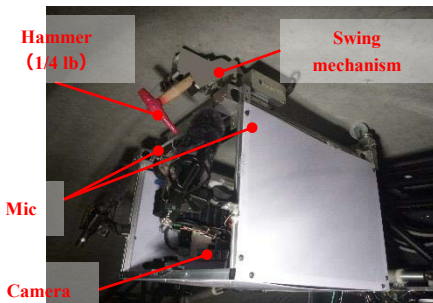
【Overview】

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

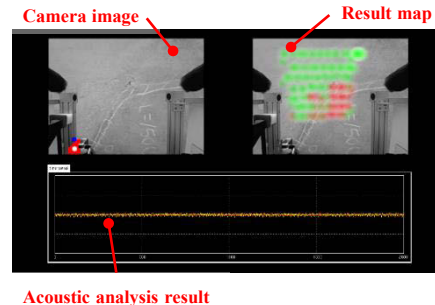
【Topics】

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

Automatic Hammering Tester



Hammering Tester



Deformations map

【Overview】

- Detect concrete flaking instantaneously from visible image and hammering sound.
- Visualize concrete flaking by deformation mapping.

【Topics】

- Detected concrete flaking with experimental tunnel and test pieces.
- Considered on-site calibration method.

Benefits of the inspection device

- Can reduce process time to remove noise such as dirt in images.
- Can quickly find signs such as diagonal cracks that may cause concrete flaking.

R&D Final Goal

Detection accuracy of deformation by
Variable Guide Frame Vehicle

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

Inspection system target

- Road tunnels managed by municipalities having severe issues of a lack engineers

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

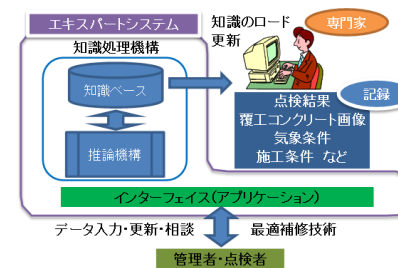
Support for inspection of road tunnels managed by municipalities

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

R&D for practical

Tunnel management support system (under development)

Tunnel management support system draws up inspection record and photo ledgers from inspection data acquired by inspection vehicle, and that presents optimal repair methods, materials, and repair engineers. This system calculates the Life Cycle Cost (LCC) of the tunnel, and will support municipalities having the severe issue of a lack engineers.



Support system image

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