# Akima Tunnel Construction on Hokuriku Shinkansen Railway Line

1. Construction Project Outline

In the construction project of Hokuriku Shinkansen Railway toward its target completion date prior to the scheduled opening of the Nagano Winter Olympic in 1998, the Akima Tunnel then completed was of 8,305m total length, the longest in the service section between Takasaki Station on the JR Johetsu Shinkansen and Karuizawa Station on the JR Shinetsu Main Line. Construction of the Akima Tunnel was executed by the Extruding Concrete Lining (ECL) Method for its length of 4,335m in the East Work Section and by the NATM for 1,850m in its Central Work Section and 2,120m in its West Work Section respectively.

1) Client Agency :

Japan Railway Construction, Transport & Technology Corporation

2) Time for completion : From March 1990 to September 1997

3) Construction cost: ¥22,482,228,000 in total covering three (3) work sections.

In the East Work Section of Akima Tunnel, as the first attempt of utilizing the man-power saving mechanical system for construction of the long mountain tunnel of a large section, the TEK-ECL Method by use of the world 's largest shield machine was adopted. Furthermore, in order to carry a large quantity of tunnel mucking to be collected as its construction is executed at a rapid pace and transport ready-mixed lining concrete in a safer and more efficient manner, the 'Pneumatic Capsule Liner Mucking Carrier System', which was so devised as to carry in and out by mobilizing- the carrier capsule in a low pressure air current through the conduit line, was employed as the world's first application of this kind. Mention is made hereunder of its construction record solely through the East Work Section of the Akima Tunnel on the JR Hokuriku Shinkansen line where such innovative construction technology was concentrated.

2. Site Topography / Geology

The site geology around the tunnel is featured basically by Itahana and Akima strata in the Neogene-Miocene period, being covered by the stratum of volcanic ash of the Quaternary period fallen and distributed over by the volcanic mountain named Mt. Asama.

With regard to the Akima stratum as the major site geology for the planned construction works, it is composed largely of volcanic fragmental rocks such as volcanic tuff or welded tuff and breccia, though partly wedged by sandstone or conglomerate.

3. Outline of Extruding Concrete Lining Machine

The machine for Extruding Concrete Lining Method is designed for the open type shield. The shield machine is designed for the structure of three (3) separate bodies of 'shells' at front, middle and rear of the whole body so as to allow its continuous operation for both excavation and lining most rapidly and efficiently.

Namely, the front shell body is of excavation and driving mechanism. The middle shell contains the folding device to allow directional correction and performance at any curved sections and

the expansion system to permit trouble-free operation of both excavation and lining at the same time. The rear shell of the shield machine is provided with the changeable framework on the ring so as to operate for continuous concrete placing under pressure to ensure tight concrete lining to the ground. The rear portion of the machine is equipped with the erecttion unit and its traveling beam so as to be able to build up the inner form for concrete lining or to facilitate its removal, relocation and reassembling.

4. Operation of Pneumatic Capsule Carrier System for Tunnel Mucking Disposal

In the East Work Section of Akima Tunnel, daily mucking transportation in a large quantity by dumping trucks was restricted severely by the site environment that the designated disposal yard was located in the spot noted for sightseeing.. For this reason, the pneumatic capsule carrier was used by full- automatic operation for the first time in the world. The pneumatic capsule carrier system is so devised as to remove mucking by use of the running capsule in air current through the partitioned space. The mechanical system referred to herein as the "pneumatic capsule carrier" is composed of the one integral unit system devised to carry promptly the ECL-excavated tunnel mucking over a distance of about 7km from the rear of shield machine to the disposal yard. and is also capable of carrying ready-mixed concrete from its primary mixing plant installed at the tunnel portal to the secondary mixing plant installed inside the tunnel. In other words, it consists of five (5) fundamental design factors, such as capsule, its mobile conduit line and each station on the carriage line to be installed inside and at the tunnel portal and the mucking disposal yard.

1) Design requirements

① Carriage capacity : 100 cubic m per hour for mucking transport,
40 cubic m per hour for concrete transport

② Max. gradient : 10% , Min. radius : 50m

③ Carriage length : 4 km or so inside tunnel, 3 km or so outside tunnel

④ In-tunnel sending/receiving base points :
To be transferable following the progress rate of excavation.

2) Capsule

① Loading capacity : 1.11 cubic m per unit of mucking
1.0 cubic m per unit of ready-mixed concrete

② Ejection time interval : 120 sec. at minimum

③ Average traveling velocity : 7m per sec.

The capsule should have its top opening for loading of mucking or concrete and the bottom lid plate to be opened for discharging, being equipped with four (4) wheels for loading support and their corresponding guide wheels of equal number, that is, two (2) wheels each at front and rear of the capsule respectively. Each train formation should be made up with three (3) capsules, each being inseparable at any time during operation. Operation of each capsule train is placed under full-automatic remote control at and from the central control

room in the space allocated to the boggy succeeding to the driven ECL shield machine.

3) Conduit line

The conduit line for running capsules should be of cost-saving type and can be installed, wherever possible, in a stable condition inside the tunnel. It must be well bearable with adequate rigidity against running capsules and internal pressure to be incurred during operation. For these reasons, the RC-made two (2)-combined box culverts (90*90 in convergence) were used to meet such requirements.

The steady-moving interval between the loading/unloading bogie and the braking bogie of capsule ejection with the in-tunnel station was moved forward by moving the 'go and return' carriage bogies with capsules on board, then making a daily extension of the conduit line length at a frequency of once a day.

5. Record on Construction Progress

According to the original progress record of construction in the East Section of Akima Tunnel Project, it aimed at 200.4m per month at maximum and 231m at the maximum unit rate on a thirty (30) unit day basis. In reality, however, there often occurred unforeseeable difficulties, as the result of having introduced into the project two innovative construction technologies, such as Extruding Concrete Lining Method with the ECL shield machine for the world's largest sectional area and the Capsule Mucking Carriage Liner System as the world's first application of this kind in the construction sector, we are of firm belief that those new technologies will prove their effectiveness provided that the research and development efforts will further continue to achieve it.

END

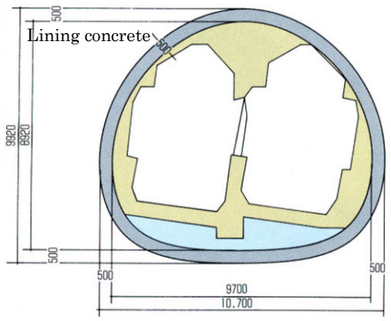
# Introduction to General Outline Of Hokuriku Shinkansen Line

1.Section:Takasaki Station～Karuizawa Station
2.Length:Approx.42km
3.Tunnel length:Approx.25km(About 60% of total length)

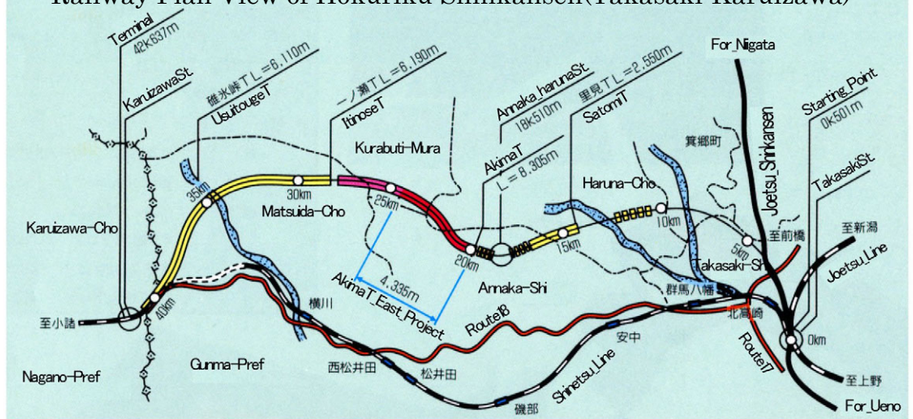
# Construction Outline in East Section

(1)Project name: Akima Tunnel East Section Construction
(2)Soil conditions: Soft rock and semi-hard rock Max.7kN/mm$^2$
(3)Construction length: 4,335m(of total8,305m)
(4)Sectional excavation area: 88.6m$^2$
(5)Lining thickness: 50cm
(6)Tunnel gradient: 30/1000 (up)
(7)Min.curve radius: 3,000m

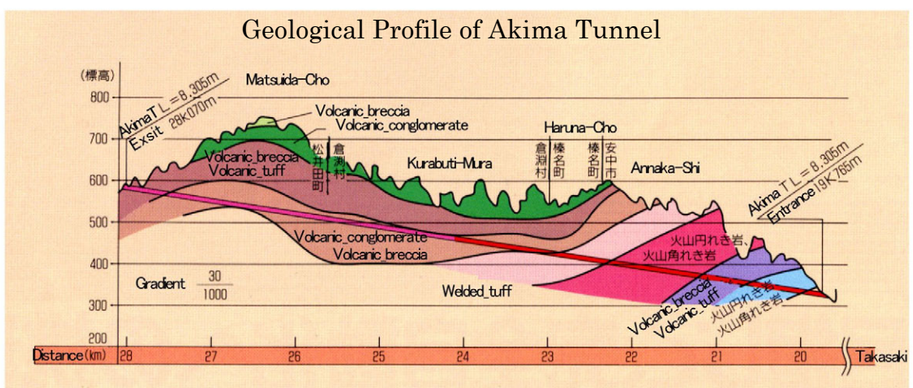
Standard Cross Section of Structure

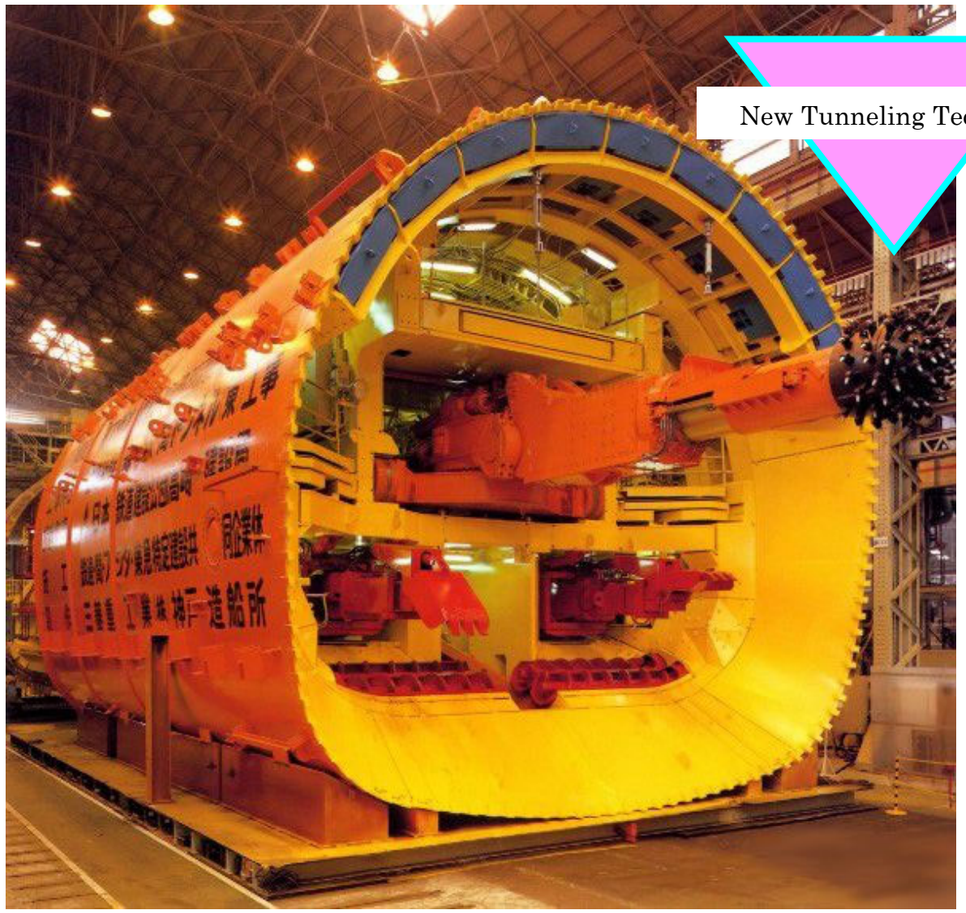



Railway Plan View of Hokuriku Shinkansen(Takasaki-Karuizawa)




Geological Profile of Akima Tunnel



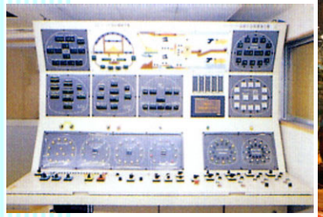



New Tunneling Technology

## Extruding Concrete Lining Method and Capsule Liner Mucking Carrier System

Hokuriku Shinkansen Akima Tunnel East Project

# Concentrated Tunneling Technology toward High-speed & Manpower Saving Construction Practice



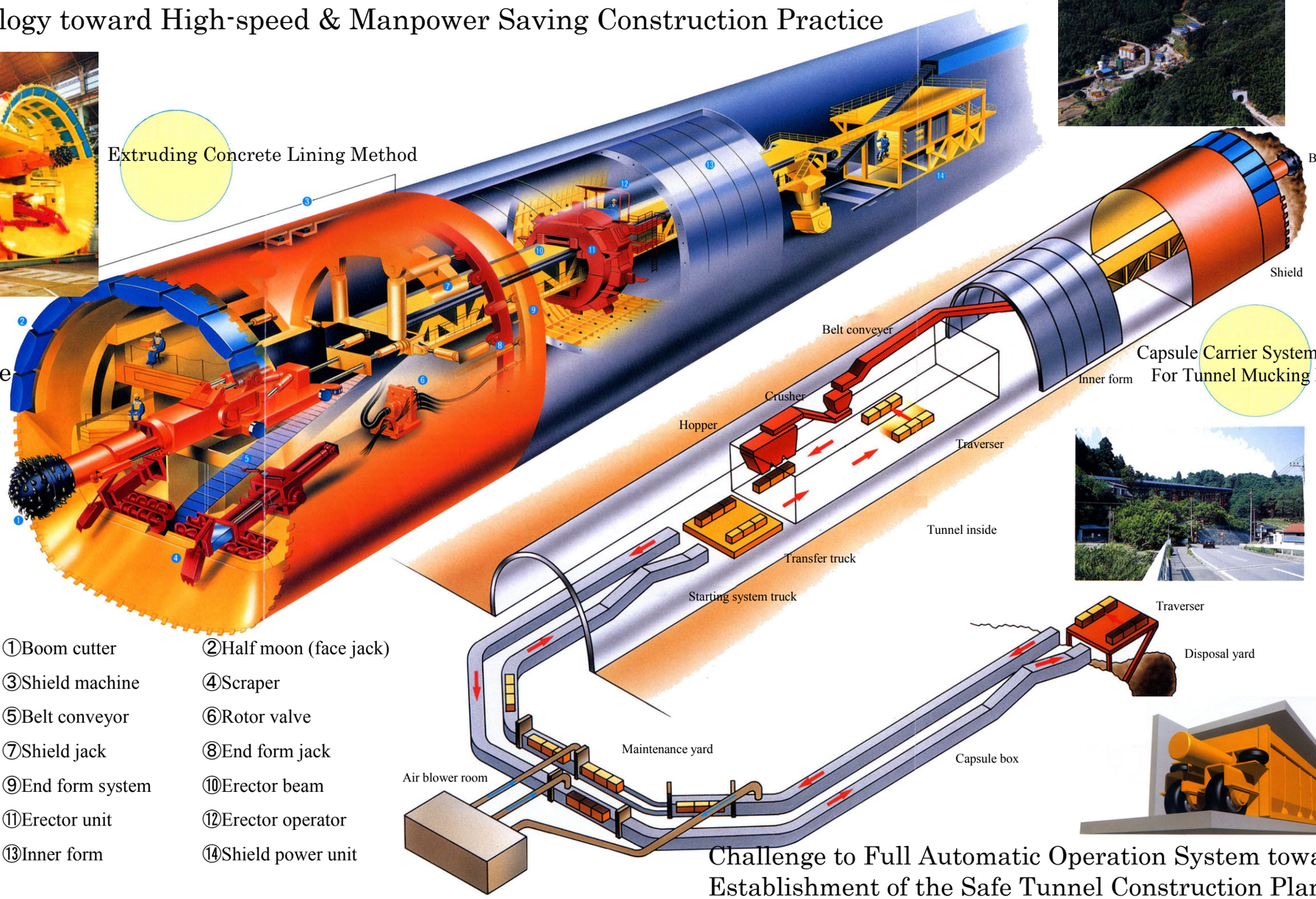
Operation Panel

## Completion of All Works at or near Facing Zone

The Extruding Concrete Lining Shield Method (Tek-ECL Method) was in use for construction of the Akima Tunnel (East Work Section).

This method is reasonably applicable to any tunnel construction to achieve the lining concrete structure of high quality in closest tightness with the ground. The method is, indeed, better rationalized for tunneling construction, owing to framing of inner forms for concrete placing under constant pressure in parallel with face cutting by driving the shield machine. Upon a sequential removal of the tailing inner form to move one step forward after concrete has gained its required strength, then all the works for tunnel construction have come to their completion.

## Extruding Concrete Lining Method




①Boom cutter ②Half moon (face jack)
③Shield machine ④Scraper
⑤Belt conveyor ⑥Rotor valve
⑦Shield jack ⑧End form jack
⑨End form system ⑩Erector beam
⑪Erector unit ⑫Erector operator
⑬Inner form ⑭Shield power unit





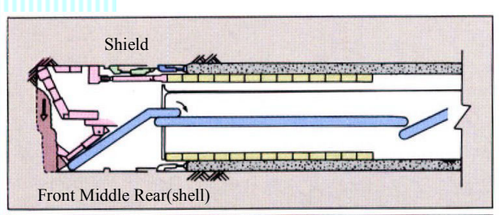


## Capsule Carrier System For Tunnel Mucking Disposal

Muck excavated out of the tunnel face is carried back to the rear hopper and is heaped into stock. From the hopper on, the stock is loaded into the capsule liner devised to run by air current and carried for dumping into the disposal yard located about 3km off from the tunnel portal. Then, the empty capsule is returned into the tunnel. A train consists of three (3) capsule bogies and is operated automatically by computer on a round-the-clock basis.

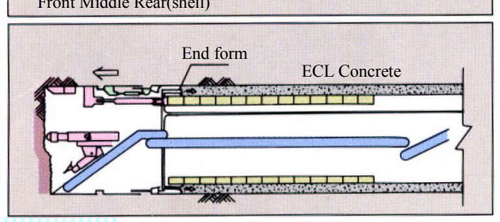
## Challenge to Full Automatic Operation System toward Establishment of the Safe Tunnel Construction Plant

## Sequential Order of Works



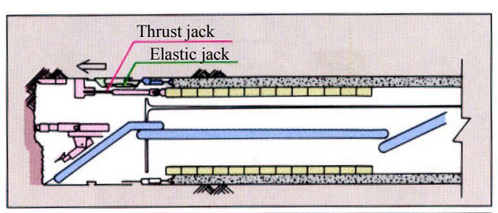

① Start of Excavation

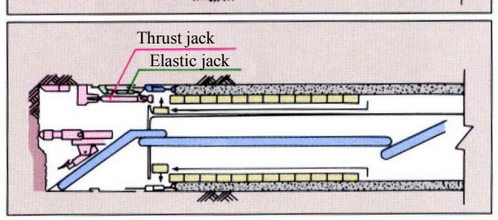
1.Finish of inner form framing
2.Concrete mixing
*Firm concrete pressurizing




② Shield Driving and Concrete Placing

1.Shield driving by utilizing inner form as reaction force
2.Concrete placing by and from shield rear shell while driving forward




③ Finish of shield Driving and Concrete Placing

④Inner Form Stripping and Re-assembling

1.Inner form striping at tail
2.Inner form moving by erector

Conduit Line
(RC-made 2 combined box culvert)

Section