

Highly Integrated Technology: The Construction of KYUSHU SHINKANSEN

Japan Railway Construction, Transport and Technology Agency (JRRT)
 KYUSHU Railway Company (JR-KYUSHU)

1. Introduction

KYUSHU SHINKANSEN (Fukuoka ~ Kagoshima), whose length amounts to 257km, connects two large cities in Kyushu Island, the west part of Japan. Fukuoka is the central city in Kyushu and Kagoshima is the capital city in southern Kyushu. The line has a vital role as the artery of Kyushu Island which is a segment of the national corridor of whole Japan. It is expected to improve the quality of life and activate the economy in local area as an essential infrastructure. In the whole route of it, southern segment between Shin-yatsushiro and Kagoshima -chuo (length: 127km) was decided to be constructed prior to the other part because the conventional railway along the segment has shoddy facilities such as single track and sharp curves. As a result the length of the segment becomes 37km shorter than that of conventional way. The construction authorized for 640billion yen(US\$5.8billion) started in 1991 and inaugurated in March, 2004. Whole of the route is to be completed six years later. This report shows the features of this segment involving the construction methods, effects by its operation, new design concepts, etc.

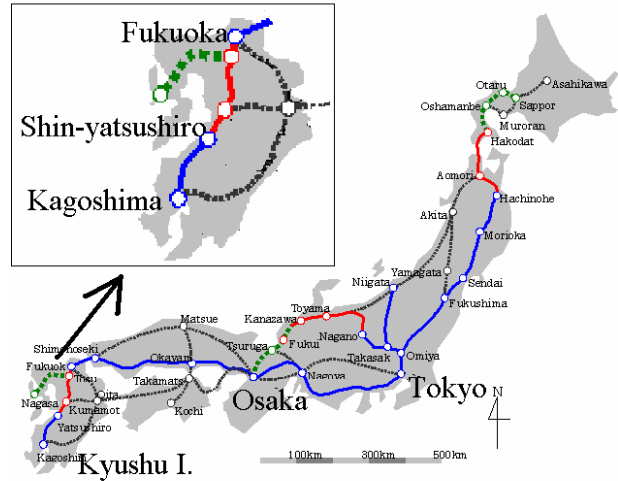


Figure1: Routes of SHINKANSEN
 (Blue: Operating Red: Construction Green: Planned)

2. Features of the route

(1) Tunnel shares 70% of whole route in length.

The conventional railway between Kagoshima and Yatsushiro was constructed along the seashore because inland area is mountainous. Since this segment was constructed with penetrating this mountainous topography, it contains 50 tunnels and the whole length of them amounts to approximately 88km, sharing 69% of whole this segment.

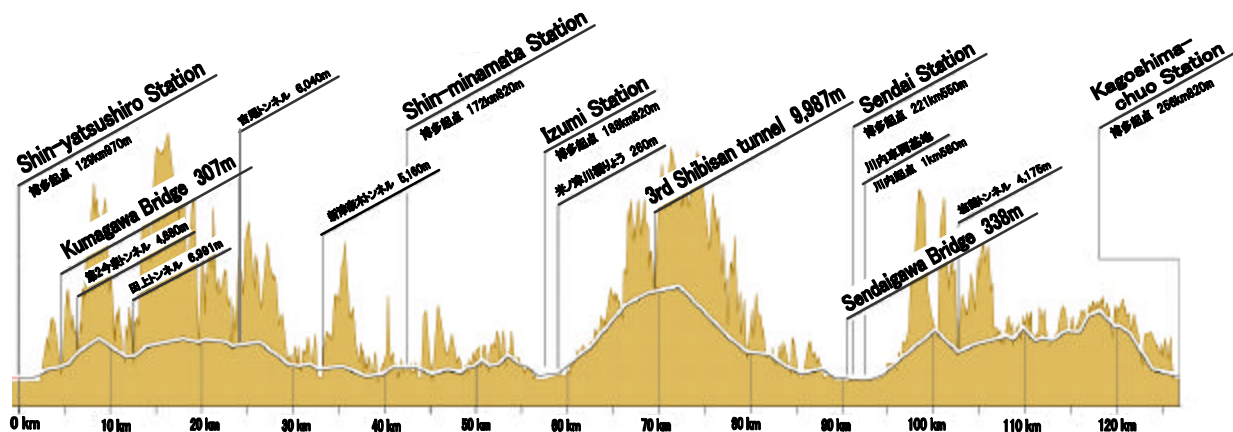


Figure 2: Profile of KYUSHU SHINKANSEN (Shin-yatsushiro ~ Kagoshima-chuo)

(2) Steepest gradient in SHINKANSEN:35‰

The 35‰ gradient is applied as the first case in SHINKANSEN because of both cost-reduction and environmental issue. The steep gradient can reduce the length of boring in water-saturated ground. It is also available to reduce the length of tunnel itself. Although there are many tunnels in KYUSHU SHINKANSEN, the total length is minimized due to the steep gradient.

3. Effects by the inauguration

- Social and Transportation Impact -

(1) Reducing the traveling time

KYUSHU SHINKANSEN reduced the traveling time between Yatsushiro and Kagoshima to 35minutes from 120minutes by conventional railway. Equivalently, the time between Fukuoka and Kagoshima was reduced to 2hours 10minutes from 3hours 40minutes. Moreover, when whole of the route is completed, it is scheduled to be reduced to 1hours 20minutes.

Reducing the traveling time expanded the sphere of the action from Fukuoka by centering on the station of KYUSYU SINKANSEN. Population of region that can arrive from Fukuoka within three hours increased greatly from 130,000 to 980,000 people.

(2)Increasing the passengers

The number of passengers goes up to 3.22 million people in one year increased by 128% compared to the previous year. Sightseeing and the



Photo1: The day of inauguration in Kagoshima

business occupy the majority to the purpose of the traveling. On the other hand, Passenger to commute or to go to school increased greatly by a factor of about six compared with the previous year. In a word, they have been selected as daily transportation. It seems that the SHINKANSEN brought the revolutionary change to the transportation in Kyushu Area. Sequentially, it is expected to bring more positive effects to whole Kyushu area by its extension to Fukuoka.

(3)Economic effect according to the inauguration

When Kagoshima Prefecture is made an example, the increase by the economic effect according to the inauguration to the prefecture is provisionally calculated as about 16.6 billion yen*. This is more significant than about 4.9 billion yen* that flows out to other prefectures by the ‘straw effect’ (It means the maintenance of traffic that connects a two great city brings a long-term decline to various cities located on the way of both cities).By inaugurating the southern segment of Kyushu beforehand, the economic effect was partially generated at the early stage.

*)source: The Kagoshima Regional Economic Research Institute

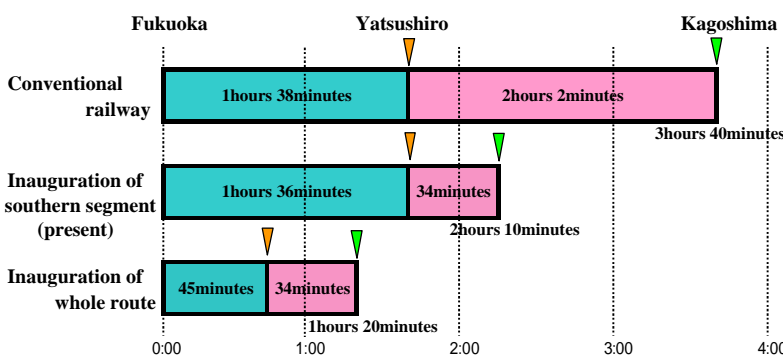


Figure 3: Comparison of arrival time

4. Specific design for KYUSHU SHINKANSEN

(1) Main Concept and Issues

KYUSHU SHINKANSEN was constructed under the concept of 'Cost-reduction' and 'Accessibility to the passengers in cooperation with the locals. Especially for the stations, user-oriented designs such as 'Universal Design' were applied as the direct interfaces with the locals.

For the cost-reduction, the construction management of tunnels was a vital issue. Specifically, tunneling in the 'Shirasu', which is weakest volcanic loam, was the toughest one.

(2) Accessibility to the passengers

➤ Face-to-face transferring

Since the southern segment was inaugurated earlier, passengers must transfer at Shin-yatsushiro Station when they go through both SHINKANSEN and conventional railway. For easing this troublesome transfer, both of platforms were set as face-to-face. This is the first case in SHINKANSEN. In the background that this equipment becomes possible, the transfer line of orbital vehicular from conventional railway is planned to this station, and it has been diverted to riding in conventional railway. As a result, face-to-face transferring was to have achieved it without cost-increase.

➤ Universal Design

Universal Design considers the accessibility not only for disables but also for all station users such as screen door.

For the design of stations, we held the public hearings and showed the model of facilities such as multi-functioned restroom to get various opinions. Moreover, we took the local traditional concepts into account to make stations the symbol of the area in cooperation with locals.

(3) Tunnels with newly developed structures

Since tunnel shares 69% of whole route, it is



Photo2: Transferring at Shin-yatsushiro Station

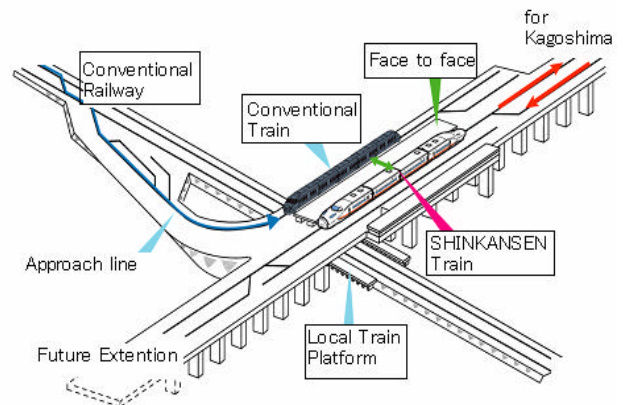


Figure4: Transferring at Shin-yatsushiro Station



Photo3: Screen door



Photo4: Multi-functioned Restroom

most critical for managing the cost and schedule of whole construction. As the standard tunneling method, NATM (New Austrian Tunneling Method) was applied with some auxiliary supporting method around the faults. Especially in the volcanic loam ‘Shirasu’ where totally 14km length of tunnel was planned, 7km length of it was bored in the water-saturated ground. In this condition, repeating impacts from the train make mud-pumping even through invert concrete and erode the ground. For solving this issue, the invert concrete was replaced by the permeable slag subgrade which was newly exploited and has enough strength to support the track and train. Ground water is drained through the subgrade to the center drainage and it prevents excess pore water pressure which causes mud-pumping.

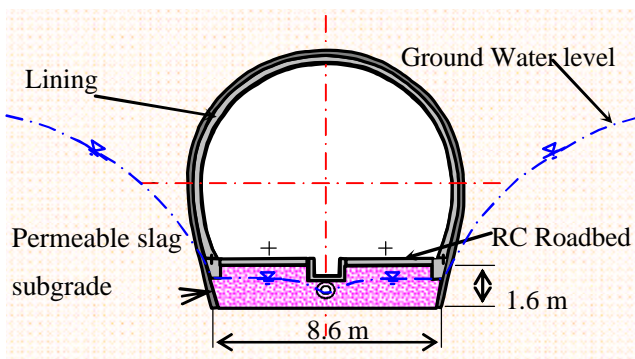


Figure 5: Permeable slag subgrade

(4) Bridges and Stations

➤ Reduction of construction time

For the rapid construction, we applied the prefabricated compound substructure for the first case in SHINKANSEN. The construction period was curtailed by the survey of ruins buried around the site in Yatsushiro. In the limited period, the prefabricated composite substructure enabled rapid construction. This method applies the prefabricated concrete boxes. The substructure is built by placing the H-steel and concrete into the boxes. This method drastically reduced the required time for the site work by six months.



Photo5: Prefabricated composite substructure

➤ Economical design

There are many over-crossings with sharp degree along the KYUSHU SHINKANSEN. In such a case, light-weight steel-concrete composite girder was applied for the economical and easy erection. This composite girder has seismic and economical advantages as a continuous girder. Additionally it is expected to reduce the maintenance cost by using anti-weathering steel. For reducing the height of piers, portal frame subgirder was combined with main girder. It can also reduce the maintenance cost because of decreasing the number of bearing supports



Photo6: Portal frame subgirder

➤ Combination of Civil works and Architecture (So-called ‘Hybrid Structure’)

Conventionally, the large part of station structure contains massive civil works, but ‘Hybrid Structure’ consists of many architectural works. Compared to conventional station structures, Hybrid Structure has many advantages. For instance, the

design of the station obtains degree of freedom. Moreover, the safety of the passengers getting on and off improves, because so many pillars on the platform are defused, and the visibility is improved.

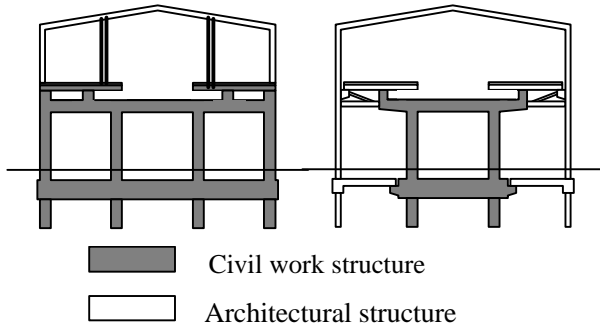


Figure 6: Hybrid Structure(Right), Conventional(left)



Photo 7: Station construction by Architecture

(5) Track and electric installation

The continuous welded rail and the concrete slab track were positively adopted from the viewpoint of the reduction of maintenance and running stability. Joint elimination was promoted more by adapting ‘IJ’ (glued insulated joint) to the rail insulated joint needed as signal equipment, and it became economical. Moreover, as part of the cost reduction, the frame type concrete slab track was adopted for not only tunnel section up to now but also open section completely.

In the electric installation, safety and a high-speed improvement and the cost reduction are attempted by adopting high-speed overhead line (simple catenary method) and digital automatic train

control.



Photo8: Frame type concrete slab track

5. Conclusion

KYUSHU SHINKANSEN was constructed by JR TT and is operated by KYUSHU Railway Company (JR-KYUSHU). Both JR TT and JR-KYUSHU have teamed up in good relation to carry out the project. While supplying good services for passengers such as face-to-face transferring facility and Universal Design, newly developed technologies enabled the constructions in the tough conditions and reduced the cost of both construction and maintenance.

The number of passengers of KYUSHU SHINKANSEN is steadily increasing since its inauguration. We are convinced that KYUSHU SHINKANSEN can generate the large effects and activate the economy in KYUSHU Island in the future.



Photo9: SHINKANSEN Train ‘TSUBAME’

Point of Contact Person: HIDEHIRO Mizuide (Assistant
Director, Planning Section Kyusyu Shinkansen construction
bureau)

Telephone: 092-283-9609

Facsimile: 092-283-9592

e-mail:h.mizuide@jrtr.go.jp