

Damage Investigation of Sanriku Railway Suffered from the 2011 off the Pacific Coast of Tohoku Earthquake

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ABSTRACT: Instructions for typing papers submitted to the “One Year After 2011 Great East Japan Earthquake - International Symposium on Engineering Lessons Learned from the Giant Earthquake-” are presented. This is an example of how to type manuscripts. The ABSTRACT shall be smaller in width than the main body by 1cm at the left and the right margins. Use Times New Roman in 11pt. The length of the ABSTRACT should not be more than 7 lines.

Key Words: the 2011 off the Pacific Coast of Tohoku Earthquake, transportation infrastructure, Sanriku railway, evacuation facility

INTRODUCTION

At 14:46 JST (5:46 UTC) on March 11th, 2011, an earthquake of moment magnitude 9.0, the largest earthquake ever recorded in Japan, struck off the shore of the Sanriku area in the Tohoku Region. The “mega tsunami” which followed hit deeply indented coastal areas and brought extensive and devastating damage to many cities and villages in this area. Mega tsunami damage was not restricted only to buildings and houses, but the resulting fires destroyed many communities and even nuclear power plant (NPP) facilities have suffered complicated and serious damage due to this mega tsunami. This earthquake was later named “The 2011 off the Pacific coast of Tohoku Earthquake” by the Japan Meteorological Agency (JMA). The total number of dead and missing continues to increase relative to the 1995 Kobe Earthquake due to the large magnitude and killer tsunami of the earthquake. As of August 12th, 2011, the numbers of dead and missing were 15,694 and 4,669, respectively, and that of complete building damage was 112,962. This paper is a quick report on the damage investigation of Sanriku railway by the authors. Due to the large scale of the earthquake damage and issues such as fuel shortage and damage to transportation infrastructure, the investigated area was limited to

just the Tohoku area.

Giant Tsunami destroyed enormous number of buildings and transport facilities such as railway, ports and airport, and enormous number of people is sacrificed. Several infrastructures are damaged by the earthquake and Tsunami. In the aspect of transportation infrastructure, expressway (Fig. 1), railway (Fig. 2), airport (Fig. 3) etc. are suffered from the earthquake and Tsunami. Characteristics of damage are as follow. Expressway and road is suffered from seismic ground motion. On the other hand, railway, airports and sea ports are suffered from Tsunami. Sendai airport which is located coast side of damaged area is attacked by Tsunami. Then, runway, passenger terminal and fuel tank are destroyed. After a few days, Sendai airport began to operate as a base of relief activities which is supported U.S. forces. Then, railway and road network which is transportation route for relief materiel destroyed and suspended by disaster. Then, governments and volunteer in Japan cannot deliver relief goods and aid worker. On the other hand, aviation fields in Japan participate actively in special assistance of damaged area in this disaster. Furthermore, it is possible to deliver goods and person to damaged area by airline.

On the other hand, a lot of railway lines are suffered from earthquake and Tsunami. For example, Jyoban line, Senseki line, Ishinomaki line, Kesenuma line, Ofunato line, Yamada line Senseki line, Ishinomaki line, Yamada line, Iwaizumi line and Hachinohe line are operated by JR East Company. Furthermore Kita riasu line and Minami riasu line are operated by Sanriku railway company. These railway lines have a lot of damage which are not only railway line but also railway stations. Fig.4 shows that railway operations in Tohoku area (as of June 26th, 2011). Black line indicates not operation railway line. That is concentrate coast side of Sanriku region. Many railway lines are not operation due to the huge damage by earthquake and Tsunami.



Fig.1 Damage of Expressway (Joban Expressway)



Fig.2 Damage of Railway line (JR Kesenuma line(left), JR Yamada line (right))



Fig.3 Damage of Sendai Airport (Passenger Terminal (left), Car park (right))



Fig. 4 Status of railway operation in Tohoku area



Fig. 5 Railway system of Sanriku railway

OUTLINE OF THE INVESTIGATION

Authors conducted field survey on March 26th and 27th, 2011 for damaged area which is suffered from the 2011 off the Pacific Coast of Tohoku Earthquake. Field survey areas by authors are coast side of Miyagi prefecture and Iwate prefecture. Furthermore, authors conducted interview survey for president of sanriku railway at main office of sanriku railway which located in Miyako city. Survey items of interview survey are as follows, correspondence during earthquake occurs, damage level, restoration situation and policy in the future for recovery.

Table 1 Member of the investigation

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Tetsuro HYODO	Professor, Tokyo University of Marine Science and Technology
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OUTLINE OF THE SANRIKU RAILWAY

Sanriku railway is private railway company in Iwate prefecture. Sanriku railway operates the Sanriku coast of Iwate prefecture which is Rias coast. Sanriku railway has two railway lines which is Kita riasu line (71.0 km) and Minami riasu line (36.6 km). Kita riasu line operates between Miyako station and Kuji station. Minami riasu line operates between Kamaishi station and Sakari station. Both railway

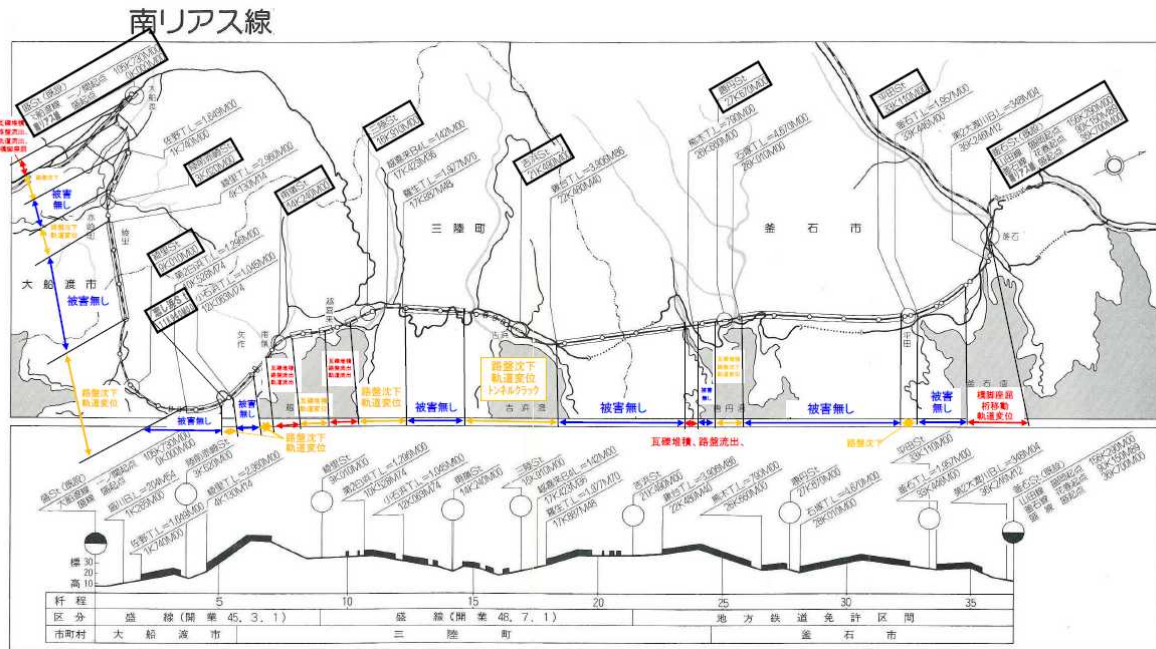


Fig. 6 Damage and railway line (Minami riasu line)

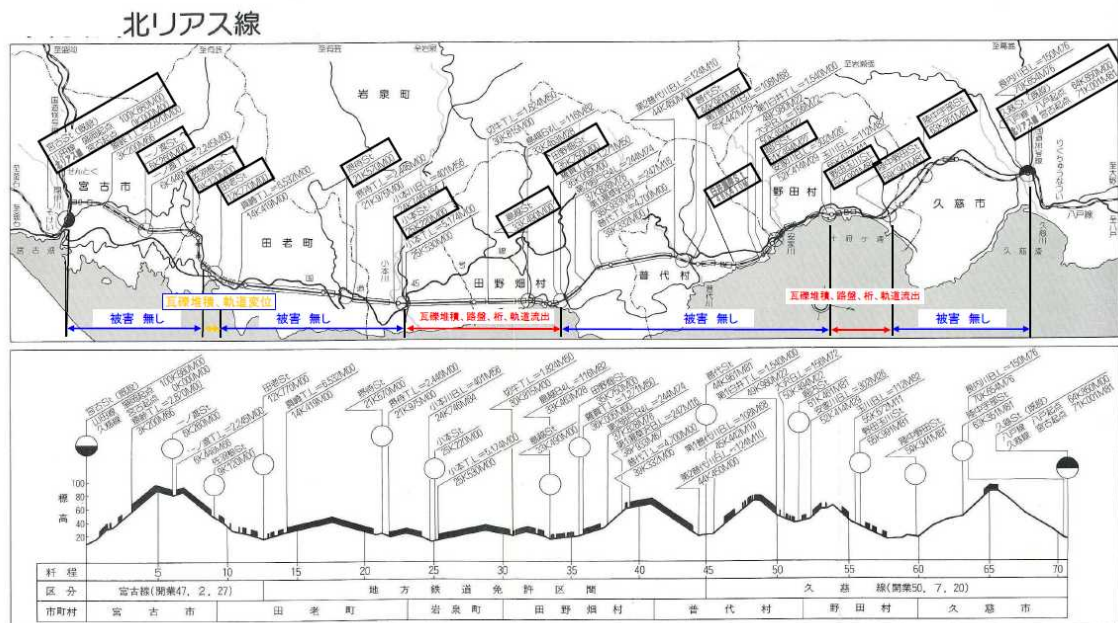


Fig. 7 Damage and railway line (Kita riasu line)

line are used for resident who live in Sanriku coast area. Sanriku railway has many roles for resident which are commute, hospital access and shopping and so on. Sanriku railway starts to operate in April 1st, 1984. Sanriku railway has some construction policies which are strong embankment, strong tunnel and station on the bridge. Then, The Sanriku railway has strong infrastructure against the earthquake and Tsunami. But this earthquake and Tsunami destroyed many railway infrastructures which are railway line, railway stations and embankment. Kita riasu line is destroyed by earthquake. Minami riasu line is destroyed by earthquake and Tsunami.



Fig. 8 details and place of damage



Fig. 9 Shimanokoshi Sta.



Fig.10 Washout of Shimanokoshi Sta.



Fig. 11 Shimanokoshi Sta. (before)



Fig. 12 Shimanokoshi Sta.



Fig. 13 Taro Sta.



Fig. 14 Taro Sta.

DAMAGE OF SANRIKU RAILWAY

Fig. 6 and Fig. 7 shows that damage and railway location in Sanriku railway. Blue line indicates no damage. Yellow line indicates roadbed subsidence, displacement of railway line and crack of tunnel which are not too a serious damage. Red line indicates washout of railway line, road bed, embankment and station which are serious damage. Almost stations locate in cove of riasu coast without Sakari station, Rikuzenakasaki station and Ayasato station. Then damage concentrate in the colony.

There is several of damage in Sanriku railway. Sanriku railway suffered from Tsunami damages which are washout of railway, bridge, embankment and stations. Fig. 8 shows details and place of damage. Whole damage of Sanriku railway is 317 points. About 40% of whole damages are washout of bridge and embankment which is civil infrastructures. About 42% of whole damages are washout and displacement of railway line which is railway structure. Finally, about 13% of whole damages are communication line, railway signal and electronic machine which are electronic infrastructures. Authors conducted field survey of Sanriku railway. Fig. 9 and 10 show damage of Sahimanokoshi station which located Kita riasu line. Fig. 11 and 12 show Shimanokoshi station which is photo of before earthquake and Tsunami. Fig. 14 and 15 show Taro station which does not have serious damage. So, Taro station starts to operate on March 20th, 2011.

INTERVIEW SURVEY

Authors conducted interview survey for Sanriku railway on May 10th, 2011. Sanriku railway has two seismometers which are located in Kuji station (Kita riasu line) and Sakari station (Minami riasu line). Both seismometers detect restriction value of the manual. Then trains are stopped. Trains can communicate to commander of railway operation using disaster priority mobile phone. Sanriku railway have emergency manual. The driver did the correspondence along the manual, and corresponded by the driver's judgment. Furthermore, some stations are used for evacuation space which is Okirai station and so on. Sanriku railway infrastructures are destroyed by earthquake and Tsunami, but the whole of damage grasp was postponed because damage was extensive in the Sanriku railway, the priority level was decided, and it of each section was restored. As a result, Taro is restoring on March 29 on March 20 March 16 between Omoto and Kuji between Miyako and Taro, though all are the Kita riasu line sections.

CONCLUSIONS

Authors conducted field survey and interview survey of Sanriku railway. As a result of field survey, we became clear that Sanriku railway have serious damage which is washout of railway line and embankment. And, As a result of interview survey, we become clear that Sanriku railway have two seismometers, but earthquake early warning (EEW) system is not installed in Sanriku railway operation. Sanriku railway on March 11th, 2011 operates two trains. However, damage did not occur to the railway users.

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