Amarube Railway Bridge Accident

December 28, 1986 at the Amarube Railway Bridge on the Sanin Main Line in Amarube, Kasumi, Kinosaki, Hyogo

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An outbound train was traveling from Fukuchiyama to Hamasaka on the Sanin Main Line when a strong gust of wind blew it off the Amarube Railway bridge. The maximum wind velocity was 33 m/s at the time. Seven passenger cars fell approximately 41m on a seafood processing factory and residences. The accident killed 1 train operator and 5 female factory workers, and injured 6 people. The conductors did not stop the traffic even though they knew that they should have avoided crossing the bridge during strong winds. Photo 1 is a press photo of the accident.

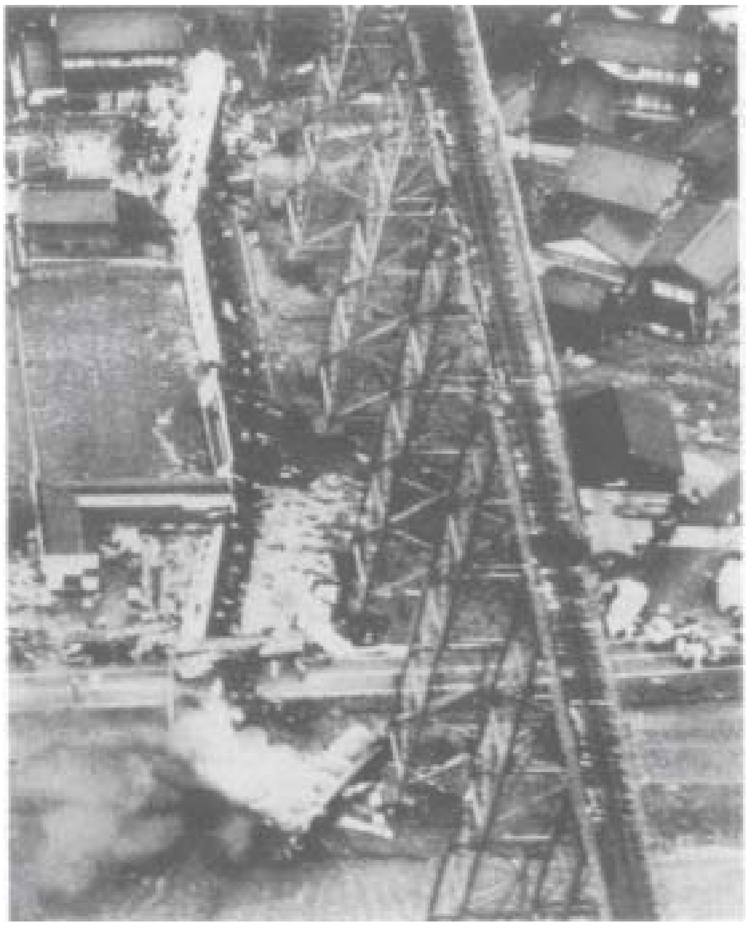

Photo 1. Train was blown off the Amarube railway bridge and caught fire [1]

1. Event

An outbound train was traveling from Fukuchiyama to Hamasaka on the Sanin Main Line when a strong gust of wind blew it off the Amarube Railway bridge. The maximum wind velocity was 33 m/s at the time. Seven passenger cars fell approximately 41m on a seafood processing factory and residences. The accident killed 1 train operator and 5 female factory workers, and injured 6 people.

2. Course

When 1986 was about to end on December 28, the 7-car special train "Miyabi" with sunken kotatsu seats and karaoke was carrying tourists on the "Sanin Shopping Tour" from the Tanigawa Station on the Fukuchiyama line. After unloading 176 passengers carrying lots of seafood products for the New Year's Holidays at the Kasumi Station, the train was traveling without passengers near the Amarube Railway bridge towards Hamamatsu on the outbound line.

The safety regulation specified shutdown of the Amarube Railway bridge during strong winds when the maximum wind velocity was 25 m/s or greater. The railway bridge had automatic wind velocity sensors (anemometers) on both sides around the center. When the wind velocity exceeds the safety limit, the Centralized Train Control (CTC) at the Fukuchiyama Railway Bureau warns conductors with a red flashing light and a wailing alarm. The conductors then must remotely activate the light signal (a pentagonally-shaped signal with 5 red light bulbs that flashes in sequence) to inform danger and stop trains. The Amarube Station located west of the railway bridge was an unmanned station at that time after CTC installation.

At around 13:10, the CTC alarm went off warning a strong wind over the maximum wind velocity of 25 m/s. The control center, which did not have information on the exact wind velocity, contacted the Kasumi Station and found that the wind velocity was about 20 m/s, less than the safety limit. Knowing that no traffic was scheduled to cross the railway bridge at that particular time, the control center decided to take no action.

At 13:25, the CTC alarm went off again. The control center contacted the Kasumi Station and found that the maximum instantaneous wind velocity had reached 25 m/s and it was then 20 m/s. The train had already passed the Yoroi Station 2 minutes earlier and was entering the Amarube Railway bridge. The conductors assessed the situation and concluded that it was too late to activate the manual control lever to stop the train. The manual control lever was not activated.

Different accounts report that the conductors were too busy handling another train's failure to strop crossing the bridge crossings.

After checking the unlit light signal located west of the railway bridge, the operator drove the train to cross the railway bridge. The operator reduced the travel speed from 60 km/h (default) to 48 km/h due to the strong wind. In the middle of the railway bridge, the train was hit by a gust of wind of 33 m/s. It was the 4th strongest wind on record during that winter. The middle cars started falling on the south side of the railway bridge (the end cars with power supply weighed more), pulled the rest of the railcars except the engine. Its heavy weight saved the engine. The weight of the falling cars tore the brake pipe, causing automatic brakes to engage (failsafe system). The train operator on the engine looked back to check the rear and found no passenger car.

The Amarube Railway bridge was brought back in service 3 days after the accident, at 15:11 on December 31.

3. Cause

The principal factor responsible for the accident was the conductors' lack of safety consciousness. The conductors should have stopped the train without crossing the bridge when the CTC alarm went off. Ignoring the safety regulation, the conductors took no action to stop the traffic. It was later revealed that they had the customary practice of contacting the Kasumi Station upon noticing the alarm. This was probably because the one of the sensors was not functioning and the other one gave inaccurately lower readings. This practice caused delay in stopping the train while the conductors were contacting Kasumi Station.

4. Immediate Action

Amarube Accident Technical Investigation Commission was established after the accident to investigate the cause of the accident. The investigators performed wind tunnel tests to obtain the threshold wind velocity at which railcars overturn in normal train operation. The results showed that railcars are likely to overturn at 33 m/s of wind velocity (Amarube Accidents Investigation Report).

5. Countermeasure

(1) The warning light signal was directly connected to the wind velocity sensors to automate the alert tripping. Human operation was eliminated as shown in Figure 1.

(2) The wind velocity to stop the train operation was set lower to 20 m/s from the previous 25 m/s.

(3) Windscreens were installed to the railway bridge.

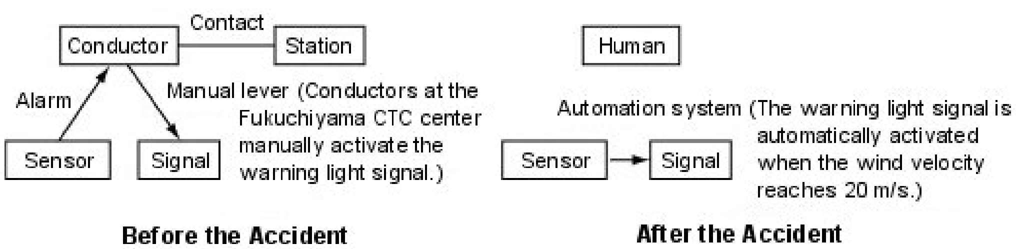

Figure 1. Control Loop of Safety System [1]

6. Summary

Even though the wind velocity sensors (automatic wind velocity sensors) had sent a warning to the CTC center, the conductors did not immediately stop the bridge crossings. The conductors delayed activating the manual lever to confirm the actual wind velocity at that time. Because of the conductors' poor judgment, the train fell off the railway bridge. Human role in the control-loop of the safety system contributed to the accident. Human operators may ignore warning signals. Head-on collision will occur, if train operators ignored a red signal on a single-track line.

It was fortunate that the train was not in service at that time after unloading all 176 passengers at the Kasumi Station. The conductors may have taken stricter safety precautions if the train was carrying passengers, but their lack of safety consciousness would have caused an accident sooner or later.

7. Knowledge

(1) The control-loop of safety system should not include human interaction.

(2) Even though sensors of safety systems trip alarms, human operators may ignore them if they believe that the sensors are not accurate.

(3) Human operators tend to follow generally accepted practice rather than rigorous standards. It is essential for operators to fully understand the reason why they have regulations and manuals to follow.

8. Background

The Amarube Railway bridge opened in 1912 (Meiji 45) after 2 years of construction by 250,000 workers with 330,000 yen of building expense. Seiichi Furukawa, an engineer of the Ministry of Rail Road, and others with advices from American engineers designed the steel trestle bridge (trestle means “mounting”). The trestle material (bridge support) was shipped from the U.S. and barged to the Amarube shore. It was the most difficult construction on the Sanin Main Line. The Sanin Main Line opened after the railway bridge was completed. The 41m-high and 310m-long railway bridge was the biggest bridge in Asia at the time. It is still the biggest trestle in Japan (Excerpt from the guide plate of the Amarube Railway bridge).

The trestle consists of a number of short spans, supported by vertical steel beams. It is surrounded on three sides by steep mountains, facing the Sea of Japan at its north. The site is often hit by snowstorms and severe winter gales. Located 70m from the coastline, the bridge required frequent rust proofing and replacement of rusted elements. Shortage in maintenance supplies during and after the war severely deteriorated the structure and eventually a 5-year repair plan was carried out from 1956 to 1963. A 8-year maintenance plan in 1968 also replaced all spans to reinforce the railway bridge. In 1976, 64 years after construction, the trestle was reborn as a concrete bridge.

Some argues that the accident was not caused by a strong gust of wind, but by self-excited oscillation, like in the case of Tacoma Narrows Bridge accident, induced by imbalance in the repaired bridge columns (only horizontal elements were replaced). The train derailed traveling on the track warped by self-excited oscillation (Photo 2).

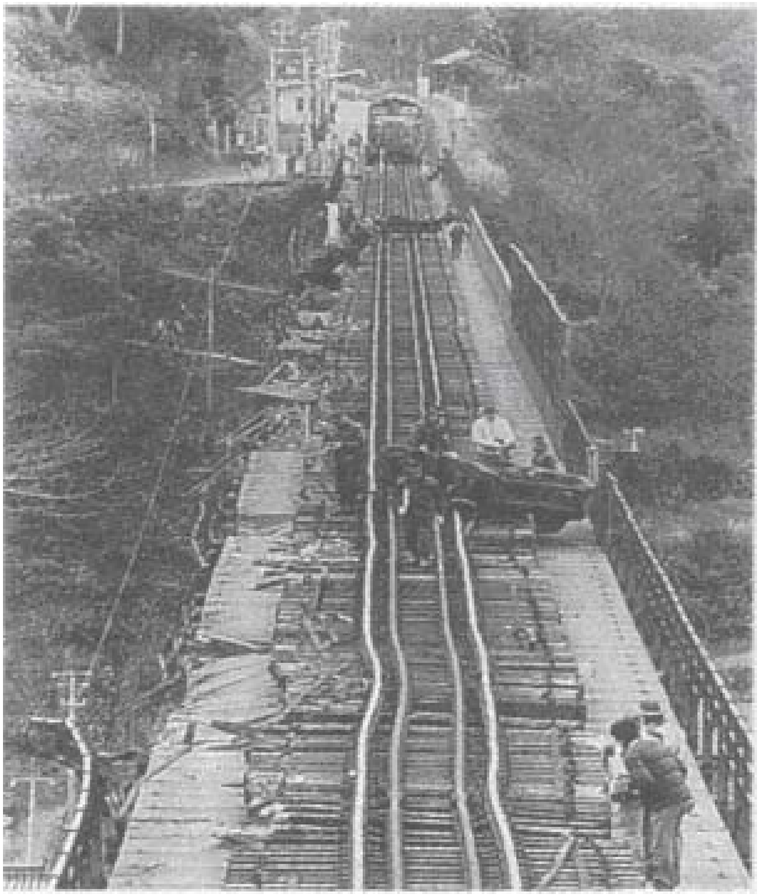

Photo 2. Warped Track (Wind blew from the ocean on right to the mountains on left) (Jiji Press Co.) [1]

The accident took place before the demise and privatization of JNR (April 1, 1987) and the operators tried not to stop the traffic unless it was absolutely necessary because suspending the train service may affect their reemployment.

The new safety regulation that specifies no bridge crossing at 20 m/s of wind velocity results in many delays and suspensions during the winter when crabs are in season. The railways are currently discussing plans to improve the service. The Amarube railway bridge has an incomparable historic value that makes a good local resource for tourism. In order to provide on-time services and landscape improvement, the railway is considering installing a prestressed concrete (PC) rigid-frame (Rahmen) pier. A PC rigid-frame bridge uses reinforced prestressed concrete. Its frame structure has columns and beams rigidly connected at joints to produce extra strength against load. The joint structure is tough against deterioration and decay. (New Bridge Investigation Commission, chairman: Masaru Matsumoto, Professor, Kyoto University)

9. On the Side

Operators who handle a faulty system wind up crying wolf so many times. They will then disbelieve the system and start following an acceptable practice that compensates the unreliability of the faulty system.

As seen in this accident, such a practice of contacting the station aggravates the risk of accidents.

References

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[2] Yasutomi Sasaki, Ryoichi Amiya (1995) *Zoku Jiko-no Tetsudooshi (History of Train Accidents II)*, Nihon Keizai Hyoron, LTD.

[3] "Web News: Teiji Unkoo Kakuho-to Keikan-no Ryooritu-o, Amanobe Tekkyo Kakekae Keikaku (On-Time Services and Landscape Improvement, Reinforcement Plan of Amarube Railway bridge)", *The Kobe Shimbun*, *September 6, 2003*, http:// www.kobe-np.co.jp/