

The submergence accident at the tunnel of Kokubugawa River diversion channel 【Matsudo City, Chiba Prefecture, on September 19th, 1991.】

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On September 19th in 1991, because of the heavy rain with the typhoon No.18, the muddy stream flowed to the diversion channel tunnel under construction at Matsudo City in Chiba Prefecture, and seven workers in it died. Since the temporary cofferdam at pit mouth collapsed, the muddy stream flowed in. In the criminal action over this accident, the owner was charged with professional negligence.

1. Event

On September 19th in 1991, because of the heavy rain with the typhoon No.18, the muddy stream flowed to the diversion channel tunnel under construction which had been constructed for discharging the part of the water in Kokubugawa River (Matsudo City, Chiba Prefecture) to Edo River (via Saka River), and all seven workers in it died. The figure 1 shows the details of the site on the day after the accident.

On this day, Chiba Prefecture had heavy rain, and the water which overflowed from Kokubugawa River and Wanagaya Irrigation Canal, flowed into the entrance of the tunnel. The temporary cofferdam at pit mouth collapsed, and the muddy stream flowed in. The water attacked the site under excavation, which was about 1600 meters away from the pit mouth, and seven workers in the tunnel were confined. 7 workers were found drowned to death consequently.



Figure1: The place of Kokubugawa River diversion channel



Figure 2 the aspect of the site on the day after the accident (September 20th, 1991)

(Source: "Construction Accident" (Nikkei B P))

2. Course (ref. figure 2. in the next page, workers A ~ D are correspondent to the figure.)

After 7 a.m. on September 19th in 1991, because of the typhoon, warning of heavy rains and local flooding and thunder, strong wind and high surf warning were announced in the northwest district in Chiba Prefecture such as Matsudo City. **In Matsudo City, there was rainfall of 31 millimeters per hour from 4 p.m. to 5 p.m., just after accident occurred.** There was rainfall of 214 millimeters from the 18th to 5 p.m. on the 19th, and many roads near the construction site were flooded.

In the tunnel in the field, the workers were carrying out the excavation in spite of the heavy rain. While more than a dozen people went up to the ground from the pit after 4 p.m., the other 5 workers continued to carry out spraying concrete work.

[Around 4:30 p.m.]

The report from the chief of the construction section of Chiba Prefecture which said "the water in Kokubugawa River has exceeded the temporary embankment" came to the field of Tobishima Construction who was in charge of construction of the main body of the tunnel. He told the site agent of Tobishima Construction Company over the phone that the staffs of S Construction who was in charge of construction of the temporary cofferdam were piling sandbags. The site agent of Tobishima Construction

directed the employees of the company to escape from the tunnel.

Afterwards, the Kokubugawa River construction section chief of Chiba prefecture told the site agent of Tobishima Construction Company over the phone that he would like the agent to communicate directly with Shimizu Construction Company, and he offered to start spraying the working face. The construction chief and the workers (C in the figure) received this direction, and they went down the pit in order to tell of the change in instructions. The worker C ran farther into the tunnel, and he directed the five workers who were carrying out excavation to leave after the spraying work. At the same time, the construction chief waited at the bottom of the pit.

[Around 4:45 p.m.]

Since the water level had already reached the height of the entrance of the tunnel when the site agent and the worker of Tobishima Construction went to see how it was going, they directed the workers to escape from the tunnel. The worker E at the site went down the pit, and he shouted "Come back at once".

[Around 4:50 p.m.]

As received the evacuation directive, the workers (A, B and C) once returned to the bottom of the pit, and they joined the chief. However, 3 people except for the chief returned again to the back of the pit to call 3 people who were still working.

[Around 5 p.m.]

Moreover, the worker D who had returned from seeing the temporary embankment also went down the pit in order to inform of the danger, and he got past the chief and disappeared into the tunnel.

[Around 5:18 p.m.]

The temporary cofferdam collapsed because of the hydraulic pressure of the muddy stream just after the worker D ran to the back of the tunnel. The flash flood surged ahead with the muffled thump, and the tunnel was submerged. The total of 7 persons consisted of the 3 persons in the back and the 4 workers (A, B, C and D) were drowned. The construction chief was escaped by clinging to the stair and by climbing up it, in spite of the fact that he had been soaked up to the neck in the muddy stream.

[After the accident occurred]

Though the drainage by the pump from the tunnel started at 9 p.m., the water level in the tunnel did not drop very much, and rescue workers could not enter the tunnel and they waited. After midnight when about 7 hours had passed since the accident occurred, a rubber boat and oxygen tanks for diving search were carried in, but the lack of oxygen in the tunnel complicated rescue efforts.

At last, 6 persons were found dead and they were recovered four days after the accident. The remaining one person was also soon found dead.

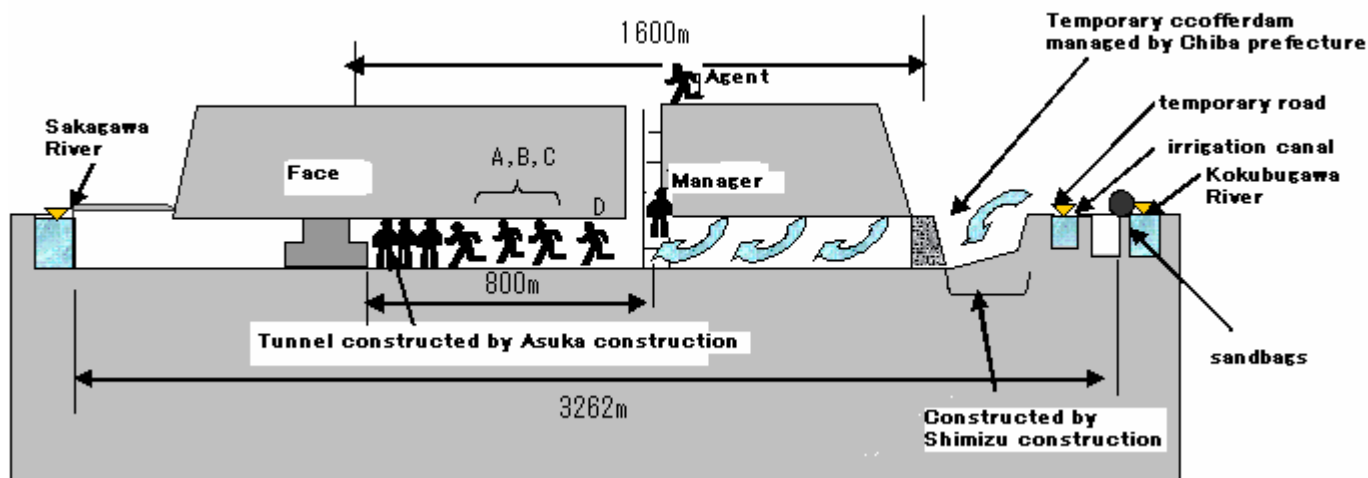


Figure 3 the brief diagram of the temporary cofferdam of the pit mouth

(Described by "Construction Accident (Nikkei BP)" and "Asahi Shin bun, dated on September 22nd, 1991")

3. Cause

1) The construction director made an error of judgment about how dangerous it was.

In spite of the fact that there was the imminent danger, Chiba Prefecture didn't determined to stop the operation, but directed to carry out the operation of spraying the working face. Once the director of the contractor (the site agent of Tobishima Construction Company) directed the workers to stop the operation, he could not go against the instruction of the owner, and he directed them to continue the operation.

2) There was a problem in the information system for risk aversion.

Though the indication of the construction director who was the owner might be changed, in spite of the fact that the first news of the overflow of the river had been announced about 45 minutes before the flood, this information did not reached the field directly. Though there were two telephones which had been linked with the ground at the back of the tunnel besides the bottom of the pit, even the nearest one was 300 meters away from the field. Therefore, running to the back was the only way to inform of the danger. As evidenced by the process of the accident, many people moved in and out within 45 minutes in order to inform of the danger, and the slight difference of their action divided their life-and -death.

And, from another viewpoint, the difference of the contractors between construction of the main body of the tunnel (Tobishima Construction in charge) and construction of the temporary cofferdam (Shimizu Construction in charge) caused the delay of the recognition of the danger and communication.

3) The design of the bolt of the temporary cofferdam differed from the original.

The temporary cofferdam which collapsed in this accident was constructed by putting up the H-shaped steel frame and horizontal sheathing and by piling the sandbags in front of it. (Ref. Figure 3) The lack of intensity of the fixing part at the bottom of the H-shaped steel frame caused the washout. Actually, there

was a difference between the original design of this temporary cofferdam and the result of construction. Because the staff of the consultant did not understand the situation of the field sufficiently and the design condition did not match the situation, Shimizu Construction as the owner changed the design by itself. However, the strength of the bolt became lower than that of the original design. Also, even though the contractor asked the chief of Kukubugawa River construction section of Chiba Prefecture to show the calculation book of the intensity in the design change, this request was rejected.

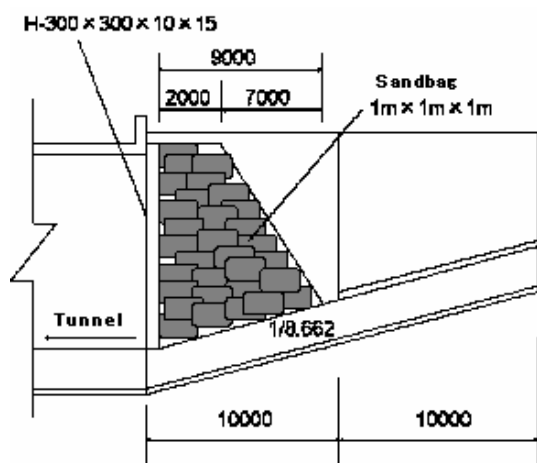


Figure 4 the section of the temporary cofferdam
(Described by "Construction Accident (Nikkei BP)")

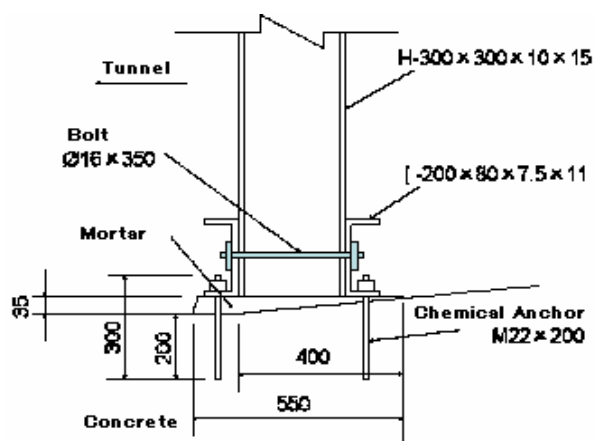


Figure 5 the fixing part at the bottom of the H-shaped steel frame
(Described by "Construction Accident (Nikkei BP)")

4. Immediate Action

In this accident, the construction director (the chief of Kokubugawa construction section of Chiba Prefecture) was charged with professional negligence, and he was given prison sentences of 2 years-imprisonment with a suspended sentence of 3 years. (In May, 1998, the defendant appealed, but the Supreme Court rejected)

Tokyo High Court indicated that the accident was caused by not taking measures to make the workers evacuate urgently. The court judged that the fault was not directing work continuation, but ignoring the emergency and not telling workers to leave the site. As there was the risk of washout, the High Court indicated that Chiba Prefecture had a duty to make people in the tunnel evacuate urgently and the defendant who was in charge of installation and management of temporary cofferdam actually had this duty.

Tobishima Construction and the site agent of this company were sent to the public prosecutor's office for violation of Industrial Safety and Health Law, and a fine of 200000 yen was imposed in September, 1994.

5. Countermeasure

1) The countermeasure to the unusual weather

- During unusual weather such as typhoons, abnormal situations may come about. It is necessary to install the system which directs workers to stop work under abnormal situations and to deal with it.
- When abnormal situations come about, what should be done immediately are pulling the workers off the site and securing their lives. Even though the work must be carried out, it should not be done until the abnormal situation finishes.
- The unusual situation which might occur should be assumed in advance and the countermeasures should be examined.

2) Measures to distribute information

- Measures to distribute information should be secured beforehand so that the field and the construction director can communicate closely each other in an unusual situation.
- In order to distribute the information quickly to the field since the unusual situation is confirmed even when multiple construction contractors engage in one construction, the measures of communication should be confirmed in advance.

3) The consideration in designing

- Though bolts are often used in the design of temporary structures, there are many cases that the structures built temporarily collapse since the actual conditions in the field does not always meet the design intent (to make it resist by shear stress) and the bending moment might be applied, if it is designed to resist by shear stress. The design of temporary structure such as this cofferdam requires not only accuracy of calculation process, but prudent consideration for safety on the basis of the site situation. And, information such as the calculation process of designing and conditions for calculation should be showed all the time.
- The unusual situation which might occur should be assumed in advance and design with safety margin should be examined.
- In the case of changing the design condition, when there is a drastic change in the design conditions and loading conditions in the process of the change should be confirmed.

6. Knowledge

- In the construction field which might be damaged by a natural disaster, the prior investigation and preparation such as investigations of the flood career of the river and precautions for heavy rain at the upper river basin should be sufficiently carried out. (For example, investigations of the flood career of the river and precautions for heavy rain at upper river basin etc.)
- It is necessary to prepare for unusual situation and countermeasures should be examined. It is also important to carry out the virtual exercise and to confirm the criterion of risks.

- The construction director should grasp the situation of the field accurately in the emergency. Risk should be assessed calmly, and instructions should be given in order to take measures to avert the risk in an early stage.
- Even when there is difference of judgment of the situation among the construction director, the site agent and workers, protection of the workers' lives should be prioritized.
- The field director should secure the measures to communicate in order to contact closely with the construction director and with the outside in unusual situation.
- Assuming the case that information is transmitted via some traders, the simulation and field exercise should be carried out in advance.
- The designer should grasp the situation of the field and carry out the designing with sufficient consideration to the safety. In the case of changing the design, the information should be shared among contractors, the designer and the owner, and safety should be secured from the planning stage.

7. Sequel

Early on the 20th, the day after the accident, a second accident occurred when the drainage work had been carried out in the tunnel. The city road of Matsudo just above the edge of the tunnel caved in, and a big hole of 8m diameter appeared was got in the road. It was caused by a reduction in the strength against the pressure of the tunnel because of the drainage work. As a result, the nearby inhabitants evacuated immediately. The inhabitants also showed an general doubt to the construction itself because a "accident caused by others" occurred.

<Reference>

- "Construction accident"(Nikkei Construction published by Nikkei BP)
- Asahi Shim bun edited on 20th (evening), 22nd and 23rd September in 1991.
- Mainichi Shim bun edited on 20th (morning and evening), 22nd and 24th September in 1991.
- The law reports of the Supreme Court : <http://courtdomino2.courts.go.jp/schanrei.nsf>

(The case of professional negligence resulting in death, the year of 1998, (あ) 677th, judged at second petty bench on 7th February in 2001.)

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