Collapse of the Korea Seoul Seongsu Bridge

〔 October 21st (Fri), 1994 Korea 〕

Masahiko KUNISHIMA (note of 1)

The central section of Seongsu Bridge, totaling over 48m in length which was constructed across the Han River in Seoul, the capital city of Korea, suddenly, collapsed during service. A bus and passenger cars, both in use, fell in Han River under about 20m below, since it was the commuting time in the early morning, and 32 people died, and 17 people were injured on the bridge. Following the investigation after the accident, the actual condition of many "omissions" became clear.

Photo.-1. the situation right after the decay falling accident of Seongsu Bridge.
(Donation: Prof.Yozo Fujino, University of Tokyo)

1. Event

At 07:40 on October 21 (Fri), 1994, 48m of the central region of Seongsu Bridge suddenly collapsed, which across Han River running Seoul the capital city of Korea, urban bus and 6 passenger cars that driving down the bridge fell in river about 20m below one after another. The fallen bridge girder which is upper part of pavement part did not sink in the underwater, since it was the dry season and the water depth was 3-5m, and urban bus and passenger cars which fell in the top wrecked and they became rolling big disaster. The victims were 17 day girls who on the bus and almost the other were workers driving to the office.

Seongsu Bridge have a lot of traffic volume which was a part of key component

of road which connects the Konan district Seoul city heart division which is residential section in the southern in Seoul City. It is said that the traffic jam arose, because especially, it was for commutation attending school hour in the accident-generation, and because the rain fell, and that the rolling stock was crowded.

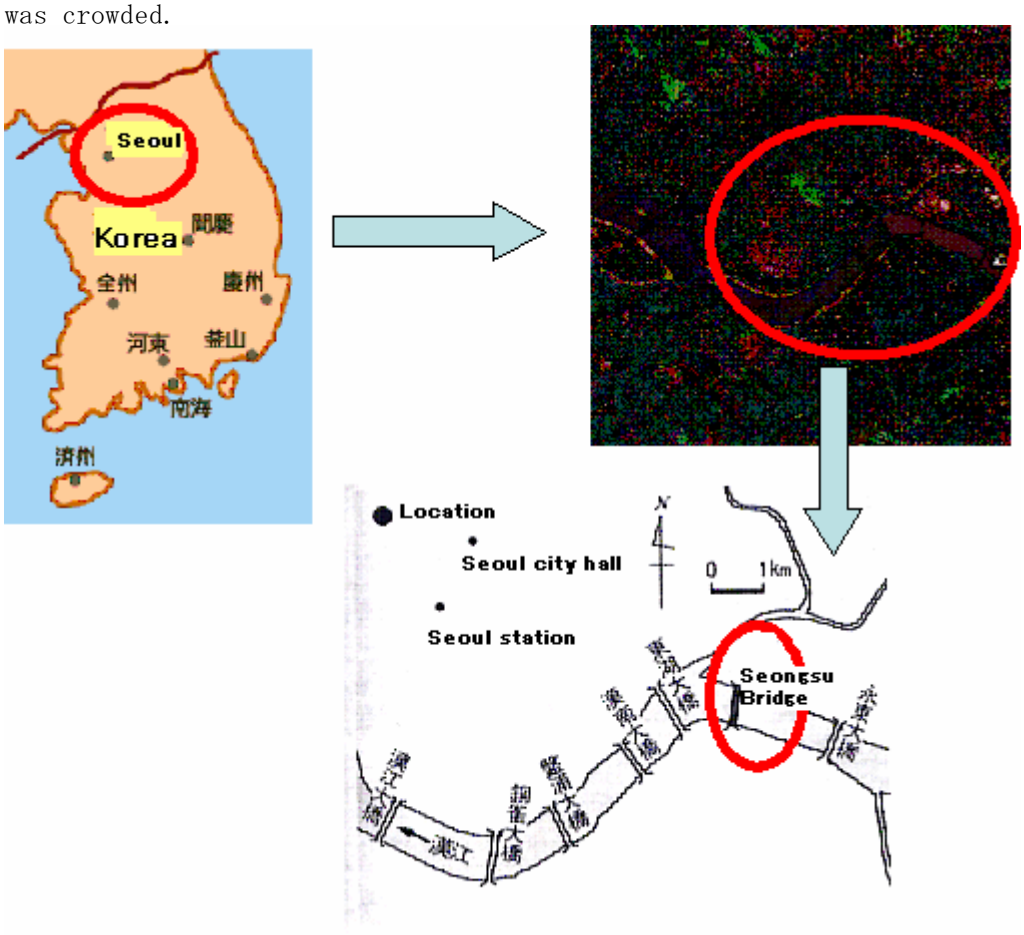

Figure -1: Position figure of Seongsu Bridge.
(Source: Nikkei construction)

2. Course

Seongsu Bridge has four lane (two lanes each way) roads of 1160.8m length and 19.4m width. Construction was started in April 1977, and it was completed in October 1979. In Dong Ah Construction Ind. Co., it was Orderer Seoul City consultant (designer) big consultant builder construction cost about 116 hundred million Won (about 14 hundred million yen). It consists of steel truss digit of the seven spans and simple steel and concrete synthetic column of 16 spans of the before and behind. It is the 672m overall length in the steel truss digit division where the accident occurred. Five spans of the center are also one span 120m on anyway, and the fixing support digit of the steel truss, which issued bridge pier dry pitching of both sides, becomes the Gerber-structure that hangs and supports suspension digit of the center of the 48m length in the vertical member. Collapsing and fallen part was one of the suspension digits of

the center.

Seongsu Bridge it was comparatively new that it went to the 17 bridges to which be built in Han River , and first traffic volume was utilized over the double in the opening beginning, and standard rolling stock load were utilized at not 18 tons expected in the design but 24 tons. In addition, Seongsu Bridge the complaint was placed with that the swinging was intense in the running from a past, and the authorities in Seoul City carried out the repair work of the emergency in the night in accident the previous day.

There was the anxiety that the swinging was intense in the running from a past on Seongsu Bridge. From the citizen, the complaint that the swinging of the same bridge was intense recently was placed, and the authorities in Seoul City carried out the repair work of the emergency in the night in accident the previous day. As a testimony of the taxi-operator, there is some the report that level difference was possible for the joint part (expansion joint) the previous day 20 day and night same road surface 30cm.

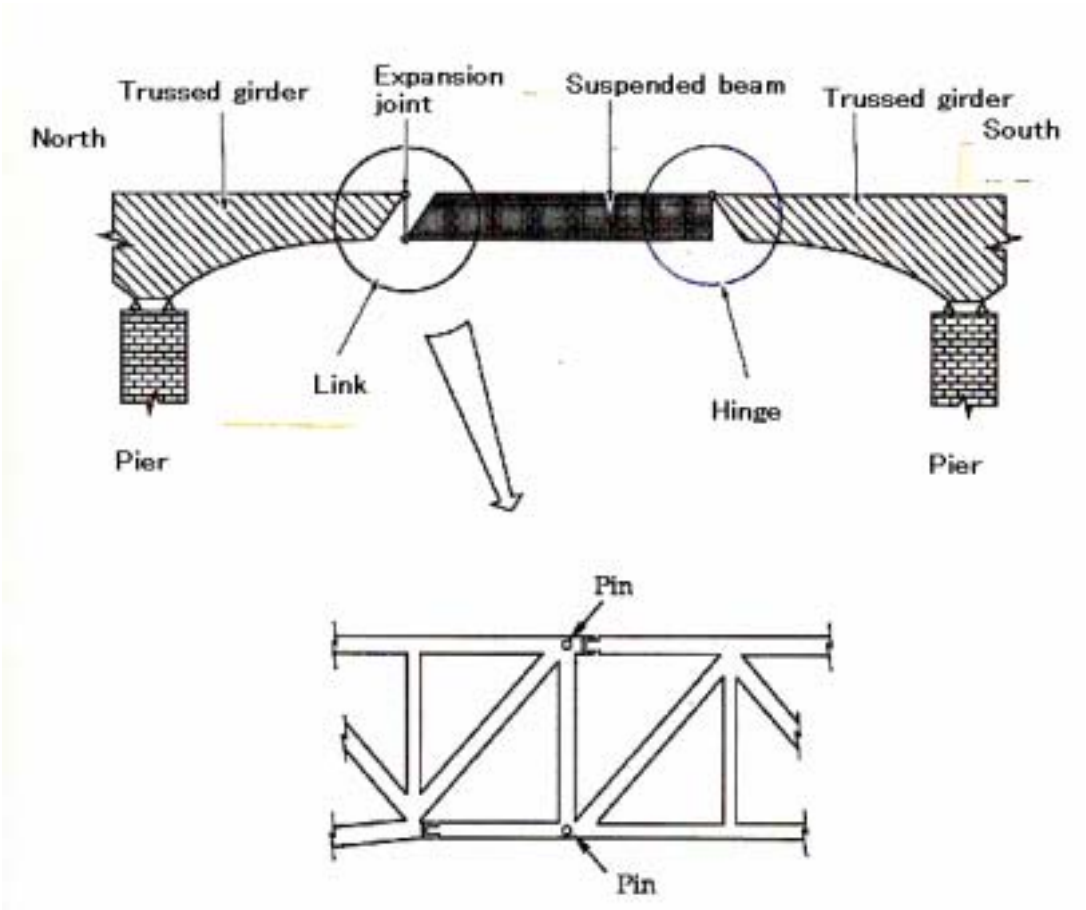

Figure -2: Schematic drawings of structural type of Seongsu Bridge.
(Source: Author made)

3. Cause

(1) Bad welding of the suspension seems to be a main cause which member of the I-type cross section, which was hanging the suspension digit of the center from the steel truss.

That is to say, it was insufficient to carry out the edge preparation of the mate welding, and the except for surface part was the un- welding. Therefore, the fatigue crack developed there, and it seemed to come to the rupture. That is to say, the cause of the accident is not corrode of the member but poor of weld. Then, this is not proven in the visual inspection. Generally, there might be a fault that was important for production and construction management system that it should do the x-ray inspection and could not discover the welding bad why on such weld zone minute.

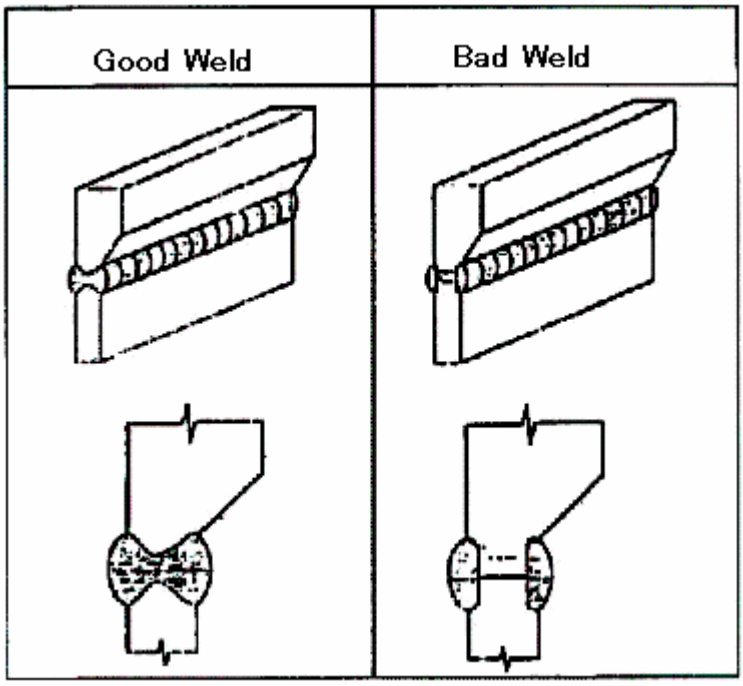

Figure -3: Weld zone minute of the suspension material.
(Source: Author made)

(2) Joint part an example showed in figure -3 and photograph -2 (the bolted joint). The surface shape of fillet welding of photograph -2 is spot welding like warty projection, and there is poor welding which is proven in the visual observation that welding rod sufficiently does not dissolve. The splice plate of photograph -2 there is a position where the volt has not been installed in the volt hole of high-tensile bolt in which the position deviated; there was omission construction which was proven in the visual inspection. Construction management and inspection method in the construction of Seongsu Bridge seemed to be remarkably slipshod, it was surveyed.

Photograph-2: Bolted joint minute of the splice plate (there is a position where the volt has not been installed. (Source: Nikkei construction)

(3) Seongsu Bridge was sprayed Calcium chloride of 8 tons every year, which scattered in order to prevent the road surface freezing, chloride ingress for the cracks by poor weld or stress corrosion, and the corrosion of steel product might be promoted.

(4) There is possibility to product unexpected partial crack in the steel surface because in the cross-sectional shape of suspension steel product, cone angle (the relaxation curved surface) for easing stress concentration was insufficient.

(5) Though there is no error at the content for the design, the immature construction level may not be sufficiently assumed. Sophisticated technology, skills, quality control, and inspection are necessary for the welding operation.

(6) There were no technical standards on in service maintenance repair of Seongsu Bridge.

(7) For fiscal resource constraint (budget) of Seongsu Bridge it is in serv ice, the periodic check was not possible.

(8) There were no survey on actual situation and inspecting standard on the change (increase) of traffic load.

(9) There was no technology (inspection) standard on maintenance and welding of the bridge.

(10) There was no tender contract system, which accurately selected the contractor.

(11) There was a social trend that however basic road of Seoul city facilities vigorously early cheaply.

4. Immediate Action

Seoul City was not the last to presume cause of accident was that traffic volume on the bridge increased, passage load became superfluous and the structure was damaged in the storage of the fatigue. On October 22nd, 1994, Seoul City released an interim report about cause of the accident that 1 inside of connection pin of 9 which connected collapsed suspension digit of the center with the fixing support digit of the steel truss broke, and other pins broke in a chain reaction by overload, and the suspension digit part in the center was separated and felt (mechanism reference of collapse and figure -4). The corrosion of this pin and the weld zone was also confirmed. And, investigation headquarters concerned police and prosecutor had grasped the abnormality of the weld zone of the bridge, since the August, 3 times, from the description of ″the repair inspection diary″ done the confiscation from Seoul east construction office.

Same day and the prosecution in Korea arrested director's construction work office staff member of 5 persons of Seoul city road station east construction work office which controlled the same bridge in the involuntary manslaughter injury suspicion in the business. In spite of reporting with ″the danger of the decay is big″, the periodic test of years 4 times for Seongsu Bridge is not sufficiently carried out. And it is broken of the visual inspection in same year February, and the inspection staffs finds corrosion and welding bad position of the connection pin in the junction minute of the same bridge, and this is disregarded, and it is the doubt neglected without taking measures of the safe top which is appropriate accident 8 month close-at-hand.

On October 25th, 1994, the Korea Public Prosecutor's Office arrested road facilities section chief and facilities improvement chief clerk of the Seoul City in the doubt of the involuntary manslaughter in the business.

On October 26th, 1994, Road Bureau length of the Seoul City was false official document preparation, same exercise suspicion by the crime investigation team, and the pre- road facilities section chief was the involuntary manslaughter suspicion in the business, and it was respectively arrested.

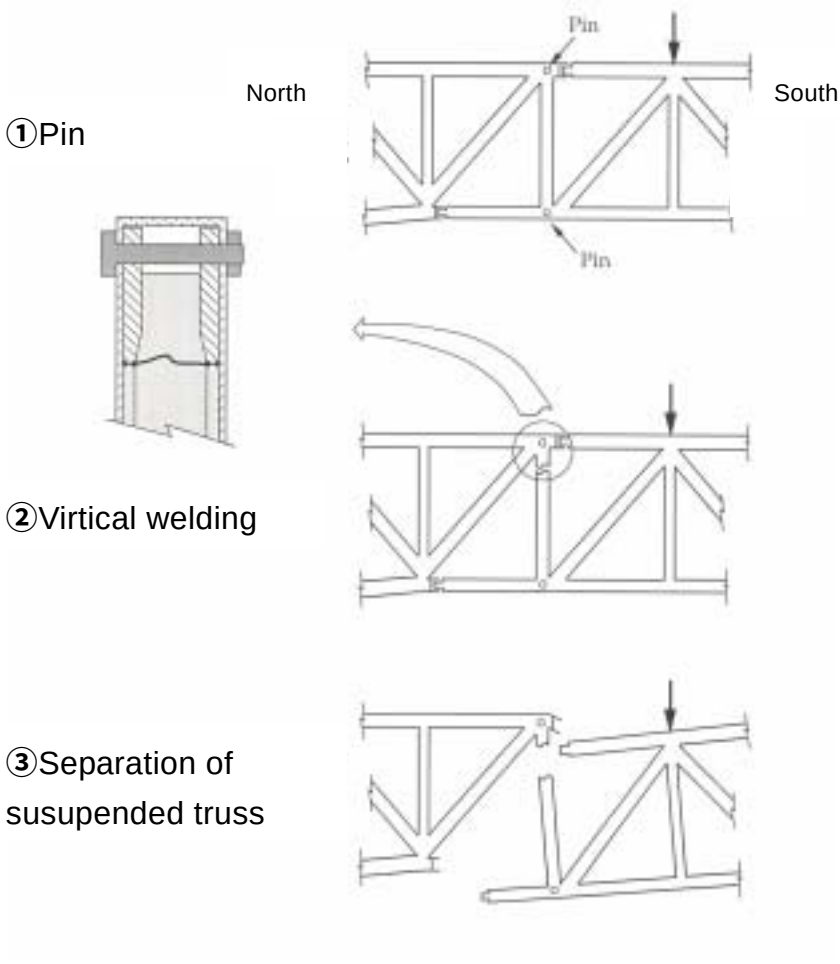

Figure -4: The mechanism of a collapse

(Source: Nikkei construction)

5. Countermeasure

At this opportunity accident of Seongsu Bridge, the Korea nation got angry and demand countermeasure to omission construction that spread in Korea.
It was decided that President Kim Young-Sam ordered general checkup of national roads and bridges and appointed the foreign special enterprise on the Korea government for some main civil engineering works.
A consultant in the United Kingdom, Rendell Palmer and Triton (RPT) Co. made successful bid the contract on integration and technical advice of the remedial work of Seongsu Bridge.

And, it was redesigned (that existing concrete floor system is exchanged for the steel plate floor, etc.) in order to suit the design load that removes and increased the suspension digit part in the center after the accident-generation of Seongsu Bridge for the inspection, in May, 1995, the Modern Construction Co. received order at about 22 hundred million yen. In addition, the construction began, and Seongsu Bridge was opened in July 1997 again for service.

6. Generalization

Collapse accident of the Korea Seoul Seongsu Bridge which arose on October 21st(Fri), 1994, the central region of the bridge suddenly collapsed over the 48m length in service, and bus and passenger car under passage fell in Han River under about 20m in respect of the bridge, and 32 persons died, and 17 persons got injured. By the investigation after the accident, the actual condition of weld zone the construction and construction management of bolted joint, and that inspection method is remarkably slipshod and much omission became clear.

7. Knowledge

(1) Site welded by hands often warns well it. Don't trust it as a principle.
(2) Penny wise and pound (human life) foolish. The infrastructure (the social foundation facilities) works in the back.
(3) The omission of the inspection is fatal.
(4) The civil engineering structure issues the signal, before it falls through. Don't miss it.
(5) Slack off civil engineer is end of all.

8. Background

In the Seoul City, during Korean War most part of bridges spanning the Han River was destroyed. In 1988, mainly the Seoul Olympic Stadium new high-rise collective residential building street rapidly increasing, rolling stock passage with the Seoul city also increasing, and enlargement demand of society for the bridge which spanning Han River and 2 bridges were carrying out construction in those accident days.

17 bridges have been built over Han River, but in the investigation by the Korea society of Civil Engineers 1992, it says that the problem of the strain coming out in concrete degradation of the underwater concrete part of the bridge pier, in the bridge in 11 inside in the whole bridge, had been indicated. The schedule, which starts the repair work by putting in the Seoul City, on the total amount of 4 billion Won in 1995, has been made.

9. Sequel

In Korea, the collapse accident of the bridge occurs after 1970's at eight times.
A collapse of the bridge, which is built in this inside in Han River of the Seoul City, is 3 times. In Korea, the accident of Seongsu Bridge became the past maximum bridge accident. There is just an accident in which construction, bridge piers of 10 and bridge girder part about 800m of the new fortune state Long

Bridge recently collapsed in July 1992. In the accident investigation which made Seongsu Bridge which occurred for the stage in Korea this time frequently to be a beginning, the many people who make civil engineering technology (engineering) and bridge technology (engineering) a specialty participated. It is said that who left sense of crisis in the head of accident investigation and throw oneself into the breach were the elder people that studied and acquired civil engineering technology and bridge technology of Japan, even if there are various and historical history to it. It is having told that the energetic investigative action undermined the health and that the way of the some person died with the completion of the accident investigation report from overwork.

10. On the Side

By self-confidence to 1990 ages in the part in our country Japan, the degree faced telling technology and myth of the absolute safety for the engineering had been faced such as Hanshin Earthquake, sodium leak nuclear fuel cycle Monju, JCO criticality incident, and overlapping H2 rocket launch failure. Afterwards, the following would be advocated: Technology and engineering based at last by extending twenty-first century that exceeded 2000 from the viewpoint of modesty attitudes such as failure science and sociotechnique.

Decay falling of Seongsu Bridge was under usual common use condition in which large swinging (vibration) by the natural condition (disaster) which remarkably differs from the normal by the effect of strong wind by earthquake or typhoon did not work. It was safely designed, as that for the accident, many engineers of Japan are on the bridge in Japan in 1994 usual common use condition, and that it goes and consists, and that the decay falls is absolutely nonexistent, and it commented, when the strict quality control had been done. It was not a mistake, until Toki-Messe communication deck bridge in Niigata City, August 2003 28 NISSIN lagoon Prefecture suddenly fell.

However, the accident in which it was homogeneous even in telling our country with this accident by self-confidence did happen.

The rupture by welding bad which was the accident cause of Seongsu Bridge is generated cases in the temporary structure of construction site.

“It is a method for being convenient for the welding joining the steel product together. So, sufficiently warn just it on the construction of the welding. Especially that it is remarkably different from the case in which environmental condition was controlled of the factory and is forbidden to trust the strength of the joint at all, as long as it does not watch it by often warning the whole story well, change of human factor are big construction site, and they weld it

by hands (not automatic welding).” The author who was a student with the bad performance constructs it in the steel in 1968. It was only matter by teaching in the lecture of Professor. Yoshie OKUMURA who is a big teacher of a field steel structure, will be never forget (it has been learned).

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