Bridge girder fell in Hiroshima "New Transportation System" construction site

【On March 14th,1991, Hiroshima, Hiroshima】

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At the Hiroshima City "New Transportation System" construction site, in the course of lowering a box-type bridge girder using the "side-loading and lowering construction method", the jack and its mount supporting the main girder slipped out of place, allowing the girder to fall onto the prefectural road below. As a result, eleven motor vehicles waiting for the traffic signal to change were crushed, injuring and killing a total of twenty-three persons.

Figure 1 shows the outline of the accident field and the "side-loading and lowering construction method"

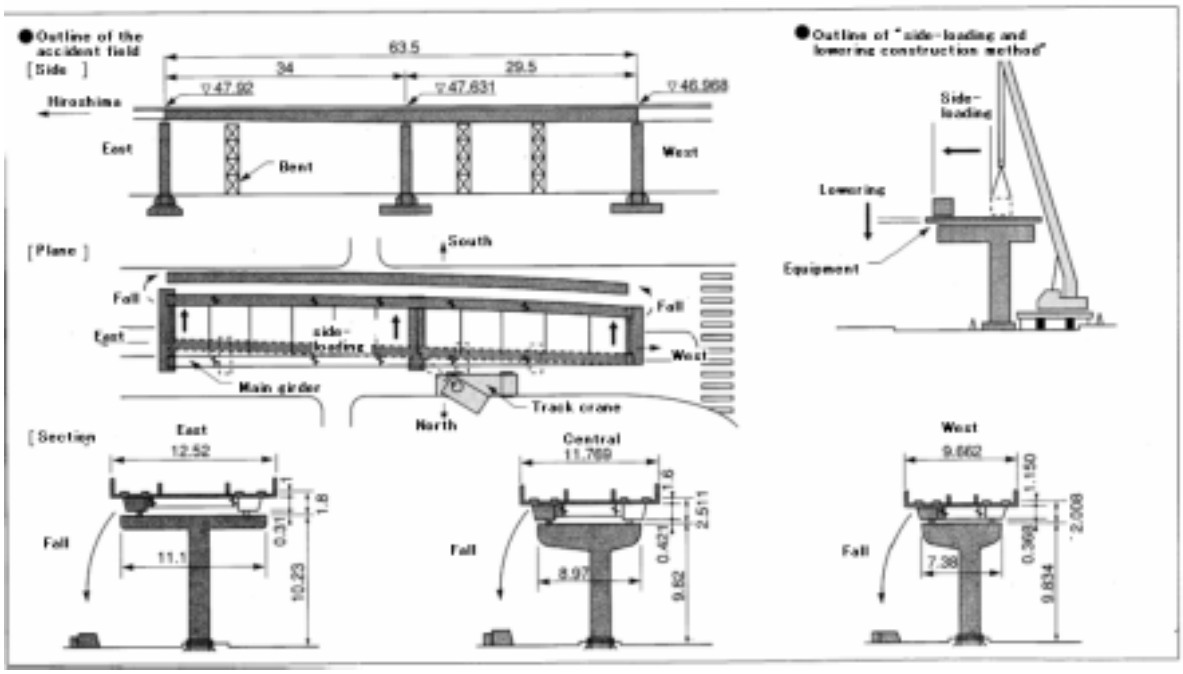


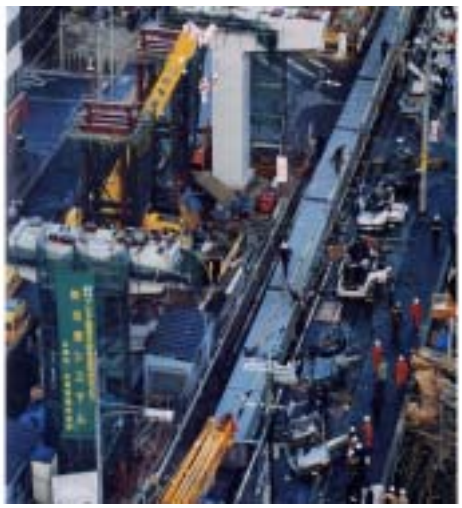
Figure 1: The outline of the accident field and the "side-loading and lowering construction method"
（source: ”Construction Accident” (Nikkei Construction) p16）

1. Event

At around 14:05 on March 14, 1991, at the Hiroshima City elevated rail track "New transportation System" construction site, a steel box girder 63.4 meters long and weighing 60 tons fell to the prefectural roadway below. Eleven motor vehicles waiting for the traffic signal to change were

crushed and ten citizens died. Five workers also died. In total fifteen people died and eight people received serious or slight injuries. It was a big disaster. Picture 1 is taken from the near side and picture 2 is from the sky.

Picture 1:The field 1



Picture 2:The field 2

（source: Picture1:"Construction Accident" (Nikkei Construction) p14　Picture2 :same p15）

2. Course

The jack mount had a triple tier of steel H-beams stacked in the same direction (normally each tier would cross the previous one at a right angle). The H-beams also lacked reinforced ribs. As the result, the girder deformed since a non-reinforced section was in direct contact with the jacks. Two of the three jacks supporting the main girder experienced a change of fulcrum force, and at that instant, one of those two was loaded beyond its ability to withstand. As the result, the remaining jack could not support the reaction, so that two jacks collapsed at virtually the same instant. While executing a half turn around the bridge axis, the girder fell to the prefectural road below, crushing eleven motor vehicles that were waiting for the traffic signal to change. Picture 3 shows the H-beams which lack reinforced ribs. Figure 2 shows the situation of how the jacks fell. Figure 3 shows the process of the falling girder.

Picture 3: t he H-beam s which lack reinforced ribs （source ： ”Construction A ccident” (Nikkei Construction) p16)

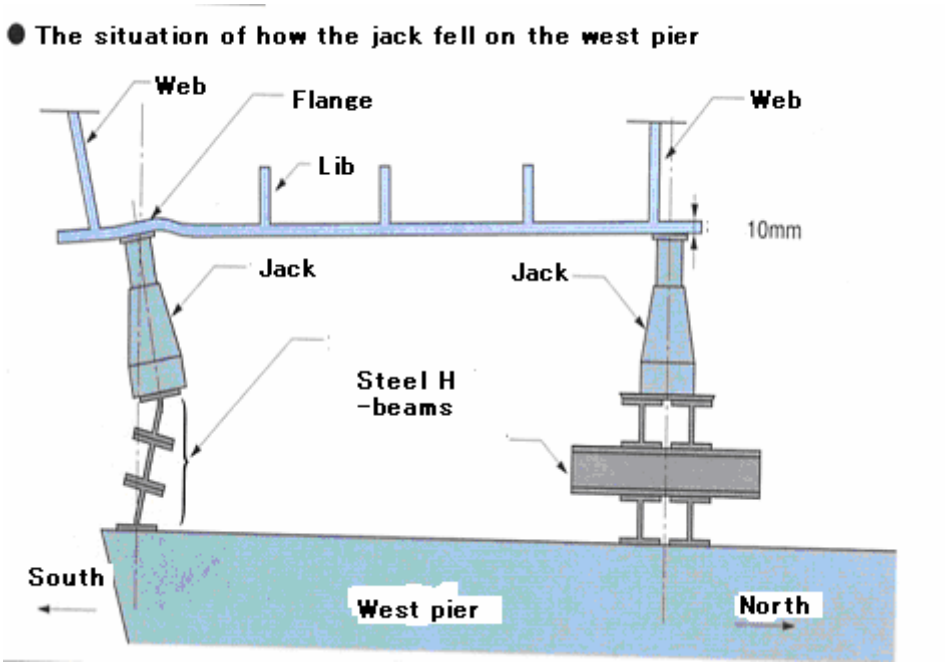


Figure 2 ： The situation of how the jacks fell (source : ”Construction Accident” (Nikkei Construction) p16)

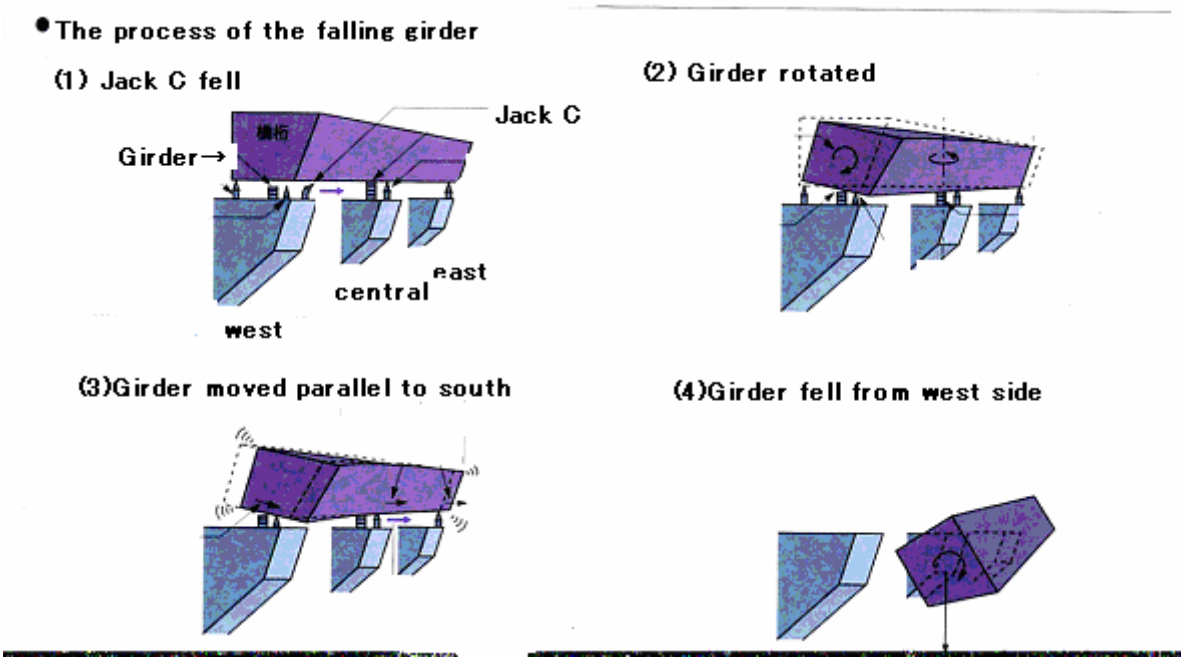


Figure 3: The process of the falling girder (source : "Construction Accident" (Nikkei Construction) p17)

3. Cause

As to why the girder fell, the following is considered.

＜The direct cause＞

（１） Three tiers of steel H-beams stacked in the same direction were used as temporary jack mounts.(Fatal cause)

（２） Materials where load force was concentrated were not reinforced with sheer reinforcement ribs, and jacks abutted sections that were not reinforced with sheer reinforcement ribs.

（３） Wires were at tached to prevent the girder from falling during side-loading; however, this countermeasure was not in place during the lowering operation.

＜The indirect cause＞

（４） The supervisor had little experience of the method and was not accustomed to this work.

（５） The center of gravity of the girder was biased because the landscape was thought important.

（６） A work plan of the lowering operation was not made.

4. Immediate Action

Since the roads around the site carried traffic of 15,000 vehicles per day, construction was being carried out without the total interruption of traffic; however, after the accident a detour was arranged and the prefectural road at the erection point was totally closed to traffic, with guard rails installed to create an exclusive truck lane. After the accident, the Ministry of Labor (now, the Ministry of Health,

Labour and Welfare) instituted the accident special investigation committee. By experiment and analysis, the cause of the accident was investigated.

5. Countermeasure

（1） Do not stack steel H-beams in the same direction for supporting loads.

（2） Install sheer reinforcement ribs on components bearing concentrated loads.

（3） Attach wires to prevent girders from falling during the lowering operation

6. Generalization

This accident was televised and the effect on the society is not measured, while the slipshod management system on construction sites was exposed. That stacking steel H-beams in the same direction is very dangerous was taught. The improvement in the consciousness for the safety management in the construction field is required.

7. Knowledge

（1） The "flow of the force" of hypothesis structure which supports heavy goods such as timber support and frame, or the insight which perceives whether it smoothly transmits the force is necessary for the practicing engineer in respect of the estimation method.
Figure 4 shows how the very slight slippage ((e) in the figure) causes the deformation of the estimation outside, and how tipping over and collapse are brought about.

（2） Safety is "culture". Safety is the result of daily attention to details.

（3） Not to repeat the same mistakes, the construction field should seriously consider this failure, hand it down as a fact of the common awareness, and educate about it.

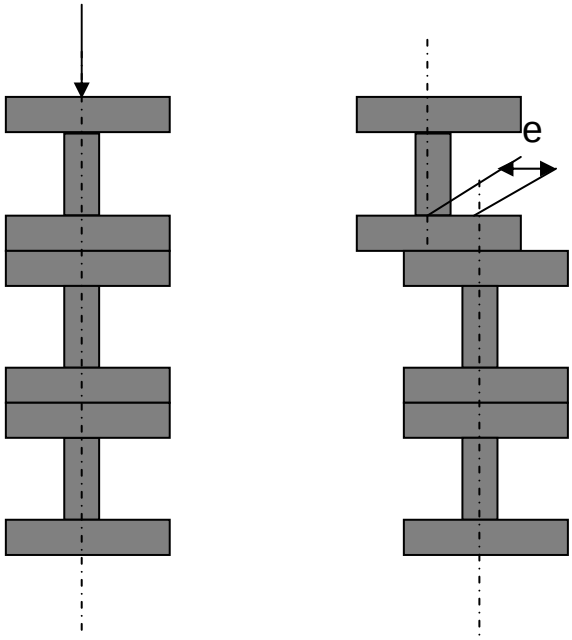


Figure 4:slippage of the H-beam (Source: Author made)

8. Background

Sloppy safety management is seen as a crucial problem behind this accident. First, the selection and oversight of the subcontractors were sloppy. The first subcontractor had never contracted for construction of elevated structures, and although almost half of the workers on this project were veterans with twenty years or more experience, they had virtually no prior experience in construction of an elevated bridge, and no advance instructions were given by the prime contractor. Among the problems with the construction management system, no employees of the prime contractor were providing supervision atop the bridge pillars, and the overall supervisor was a clerical employee of the first subcontractor. Also, according to the construction plan prepared by the prime contractor, insufficient deliberation of work procedures was carried out, and concerning the "side-loading and lowering method" there was merely the inscription "3(d) Side-loading" in the "Election Guidelines" of the attached diagrams. Employees of the secondary subcontractor that installed four of the five jack mounts in this accident had more than thirty years' experience as scaffolding men; however, they had no prior experience with the assemblage of mounts in high places. This construction work began on February 20, 1991; however, until March 1 scaf folding men scheduled to work either arrived late, or failed to show up at all on consecutive days, and as a result the work was behind schedule. After March 2, the workforce was mostly stabilized; however, many of the workers had no prior experience working in high places. At other work sites, in the morning meeting prior to commencement of the day's work, the day's work was reviewed and explained, and through danger forecasting activities the key points for danger for ecasting activities were conducted except for an

explanation of work procedures immediately prior to the side-loading of March 13. Also, morning meetings were never held.

9. Sequel

Litigation concerning indemnification to the families of the victims saw the prime contractor, the first subcontractor and the owner of the construction project (Hiroshima City) admit their negligence in the Hiroshima District Court on March 24, 1998, and the court ordered payment of damages. In the judges' decision, the Hiroshima District Court affirmed both foresee ability and precautionary obligations on the part of the Hiroshima City, and awarded damages on the basis of negligence of precautionary obligations. For the ruling of this Hiroshima district court, the Hiroshima City appealed as an objection. However, bereaved families who desired the early solution by receiving the full amount of the indemnity from the main contractor company gave up a demand for the Hiroshima City, and the appeal did not become the substantial trial. By the demand rejection, it became that the part on the Hiroshima City lost the influence in the original trial. On the other hand, in criminal proceedings, the prime contractor's site manager was sentenced to two years and six month's imprisonment, while the director of the bridge construction division and the site manager's assistant were given two years' imprisonment with probation of four years, respectively. The prime contractor was banned from government contracts as an administrative penalty, and ordered to suspend business.

10. On the Side

After the accident occurred, the safety and health related laws were amended as a part of the countermeasure to prevent the reoccurrence of same accident. The main content of these changes was the addition of requirements that a person in charge be appointed for dangerous elevated erections, and advance notification be given of construction plans.

＜Reference＞

"The Failure Knowledge Database" (http://shippai.jst.go.jp/fkd/Search)

"Construction Accident" (Nikkei Construction, Nikkei BP)

"Analysis and database construction report of failure knowledge in the 2001 fiscal year construction field" (Failure knowledge database development project construction field research council)

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