Damage Caused by the Great East Japan Earthquake and Lessons Learnt

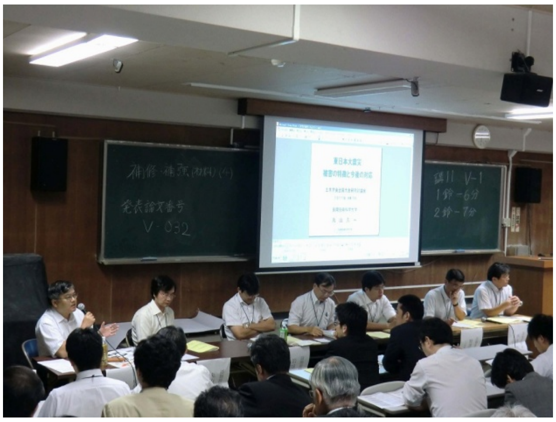
JSCE concrete forum on the Great East Japan Earthquake with respect to concrete structures was organized on 7 September 2011 in conjunction with the annual conference of JSCE at Ehime University.

Chairman:

Motoyuki SUZUKI (Tohoku University), leader of joint survey team dispatched by the Concrete Committee and the Committee on Structural Engineering (the joint survey team)

Panelist:

Kyuichi MARUYAMA (Nagaoka University of Technology), head of general structures in the first survey team of JSCE
Koichi IWAKI (Nihon University), member of the joint survey team
Hiroshi MUTSUYOSHI (Saitama University), chairman of specialized research committee
Mitsuyasu IWANAMI (Port and airport research institute)
Shinichiro NOZAWA (East Japan Railway Company)
Takao KIMIZU (East Nippon Expressway Company Limited)



Chair and panelist

Floor

General Remarks

The March 11, 2011 Great East Japan Earthquake caused the destruction of infrastructure that included railways, roads, and ports. Joint surveys of the damaged area and assessments of the damage were carried out by the Concrete Committee and the Committee on Structural Engineering. This panel is going to discuss the characteristics of the damage, the effectiveness of earlier seismic-retrofit designs

and techniques, the process of recovery, and the lessons learned with regard to maintenance.
Panelists' Topics

K. IWAKI ‘Damage and recovery: railways and roads (except Shinkansen lines and expressways)’
- Damage to structures was relatively light considering the large magnitude (M9.0) and seismic intensity (upper 6 or lower 6 on the Japanese scale) of the earthquake.
- Supporting piers that had undergone seismic retrofitting suffered almost no damage, while some of those not retrofitted exhibited damage around cutoff point of the main reinforcement. As a whole, the substructure of bridges and viaducts remained relatively intact.
- Looking at the superstructure of bridges and viaducts, there was some damage caused by collisions between beams as well as collisions between beams and piers or abutments. However, the superstructure also remained relatively intact in general.
- Most damage occurred at or in the vicinity of the bearings, which means that recovery was delayed.
- Delays in recovery work can depend on the location and degree of damage, the availability of materials, and the support available from other organizations and associations.

S. Nozwa - “Damage and recovery: JR railway structures”
- Core concrete in some piers supporting the Tohoku Shinkansen line was destroyed as a result of the long duration of the seismic motion.
- Piers that had undergone seismic retrofitting suffered almost no damage except peeling of the surface finish.
Q: What is the policy of JR West with regard to seismic retrofitting?
A: Piers that were considered vulnerable to shear-type failure were retrofitted on a priority basis. Further, piers where bending-type failure is expected but which have a bearing capacity of less than 1000 gal were also given priority.

T. KIMIZUYOSHI “Damage to expressways in the earthquake”
- Bridge and viaduct piers designed before 1980 suffered no significant damage because all had been seismically retrofitted.
- Piers designed according to the latest seismic code also suffered almost no damage but fracturing of rubber sue has been found at some bridges.

M. IWANAMI “Port structures”
- Sheet pile quay walls tend to suffer damage such as spillover, but in this earthquake they were hollowed out by the seismic surges. The difference may be in the backwash.
- Some breakwater caissons were washed off their undersea mounds. In the case of Kamaishi bay, this

may have been caused by the extremely high seismic surge of almost 8m.

- The Kamaishi Bay breakwater may have reduced the height of the seismic surge from 13.7m to 8m.
- In future, breakwaters should be made resistant to seismic surges.

Q: It is said in general that the height of a seismic surge increases as the water depth decreases. Is there any possibility that the reduction in water depth that results from construction of the undersea mound for a breakwater leads to a higher surge?

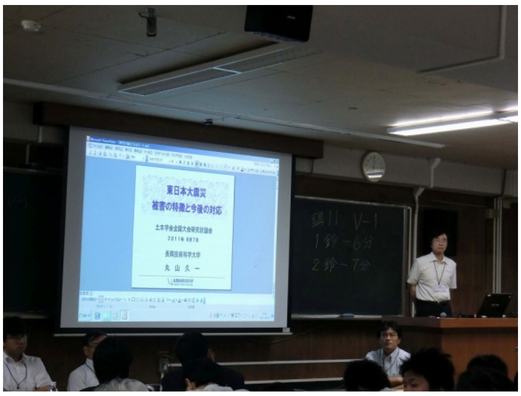
A: This would not increase the surge height because the mound is just few to 10 m wide.

H. MUTSUYOSHI "Damage to structures caused by the seismic surge"

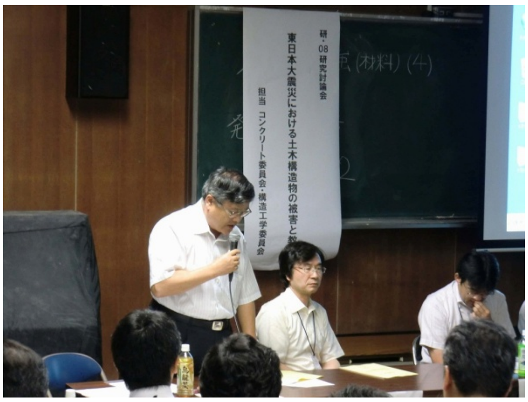
- Among the 1504 bridges belonging to the Tohoku regional bureau of the Ministry of Land, Infrastructure, Transport and Tourism (MILT), 815 bridges (54.2% of the total) were shattered due to several reasons. The seismic surge caused damage to 140 bridges (9.3% of the total).
- The superstructure of the Utazu bridge in Minami Sanriku town (PC bridge carrying national route 45) collapsed due to the seismic surge. The mechanism of its collapse will be investigated.
- Bridges in general have hardly any resistance to the lifting force of a seismic surge. The need for a joint system resistant to lifting forces will be discussed.

K. MARUYAMA "Characteristics of earthquake damage and future strategy"

- The Concrete Committee has set up a subcommittee to evaluate the effect of seismic surges on bridge structures with a remit lasting two years. The 31 members listed on the subcommittee include four specialists in seismic surges, four specialists in structural engineering, and five specialists in other fields.
- Some bridges were lost in the seismic surge but others are not even in the surge. The aim of the subcommittee is to categorize the structural characteristics of all concrete bridges that were hit by the surge with regard to surge height and surge velocity, and also to evaluate the forces acting on the bridges. Ultimately, the resistance of existing bridges against seismic surges will be evaluated.



Presentation of Prof. Maruyama



Prof.Suzuki

Discussion

The process of recovery:

- Even before this earthquake, the policy of JR West was to retrofit bridges to ensure that no superstructure collapse would occur and that they do not suffer shear type failure in the ultimate state.
- As for Tohoku Shinkansen line, bridge and viaduct piers that would suffer shear type failure will be retrofitted in future, while piers that could fracture with bending type failure but which have a bearing capacity of less than 1000 gal will also be retrofitted. Fortunately, many of the shinkansen bridges have roads alongside that could be used to easily bring in repair materials. This helped to achieve a quick recovery.
- One bridge designed in 1996 and belonging to NEXCO East suffered the fracture of a rubber bridge sue due to seismic deformation. A research committee will be organized to determine the cause of this, looking into the material as well as the forces acting on it. Bridges in local streets should be retrofitted soon.

Seismic design against expected earthquakes in Central and South Central areas of Japan:

- It is clear that the performance of bridges against seismic forces has improved owing to code revisions in the wake of the Great Hanshin earthquake, but what can be done against “unexpected” earthquakes?
- A definition of “unexpected forces” should be developed. - The increase of expected forces may lead to higher construction costs. However, technical innovation can be expected to reduce costs.
- The worst possible situation should be assumed in seismic design and an optimum solution should be developed in consideration of technology and cost. Furthermore, the design process and its results should be published to make people aware of this.