Damage situations of ground, infrastructures and others

Yasuo Tanaka RCUSS (Research Center for Urban Safety & Security)

Damages caused by GEJET

- <u>Human casualties</u> by tsunami & strong shaking
- Physical damages by strong ground motions & tsunami: Houses, buildings, <u>roads, railways, water,</u> <u>electricity (including nuclear plant)</u> and <u>gases</u> ← tsunami and significantly due to <u>ground failures and</u> <u>liquefactions</u>
- Societal Impacts: Economical, agricultural, <u>environmental, governmental, psychological</u>, etc.



Extremely High PGAs Recorded



Variation in Strong Ground Motion



Comparison of Damages between 1995.1.17 and 2011.3.11

Great Hanshin Awaji (Kobe) EQ	GEJET		
Direct Loss of 10 trillion yen	Direct Loss of 16.9 trillion yen excluding NP		
GDP 489 trillion yen (FY1994) \rightarrow 2%	GDP 479 trillion yen (FY2010)→ 3.5%		
Population older than 65: 17.9 million (14.1%)	Population older than 65: 29.6 million (23.1%)		
No. of Collapsed House 104,906	No. of Collapsed House 112,528		
Death: 6434	Death: 15769 (confirmed), 4227 (missing)		
/ 九 / / / / / / / / / / / / /	圧死・損壊死・その他 4.4% 不詳 2.0% 0		

92.4% drowned

83.3% due to collapsed houses

burnt

Comparison of Damages between 1995.1.17 and 2011.3.11

Great Hanshin Awaji (Kobe) EQ	GEJET
Electricity down: 2.6 million houses	Electricity down: 8.71 million houses
Gas supply down: 845,000 houses	Gas supply down: 420,000 houses, (plus 1,660,000 LP gas)
Water supply: 1.27 million houses	Water supply: 2.29 million houses (including those due to aftershocks)
Sewage line: 260km damaged line in total	Sewage line: 946km damaged line in total, also 48 treatment plants and 78 pumping stations are damaged
Telephone: 478,000 fixed lines dead	Telephone: 1,000,000 fixed lines dead, and 14,800 mobile stations dead

Population	Kobe & other	Iwate	Miyagi	Fukushima
	2.3 million	1.3 million	2.3 million	2.0 million

Different Types of Ground Failure

Due to Strong Ground Motion

- Liquefaction → differential settlement, embankment failure, lateral spread
- Natural Slope failure
- Earth-fill Dam failure
- Failure of Reclaimed Land with Cut & Fill
 Due to mainly Tsunami
- Water Front (Harbor) Facility Failure due to tsunami (& shaking?)

Locations of Ground Geotechnical Failures



Liquefaction Sites in Kanto Region



Tokyo

Urayasu – near Tokyo Disney Land

Cause of Liquefaction

- Near Tokyo (Chiba & Ibaraki), a long duration of shaking with low acceleration at soft ground.
- Near Sendai, a strong ground motion at soft ground.



Liquefaction at Urayasu City





Liquefaction: Differential Settlement and Embankment Failures



Differential Settlement at Urayasu

Road Embankment Failure at Hitachi-Naka Port with LiDar measurement



Natural Slope Failure at Shirakawa

2011 ZENRIN e © 2011 GeoEye Geocentre Consulting

Eart



Failure of Reclaimed Land with Cut & Fill



construction of fill onto the original ground.





Briefing report for ASCE/TCLEE at JSCE on June 13, 2011 http://committees.jsce.or.jp/kokusai/node/5 Examples of lifeline facility failures

From Presentation of Prof. Kuwata

Large diameter pipe damage/ Shiraishi Open channe

River under-passing transmission pipeline $SP \phi 2400$

Lateral sliding 70 cm

After recovery

Briefing report for ASCE/TCLEE at JSCE on June 13, 2011 http://committees.jsce.or.jp/kokusai/node/5 Examples of lifeline facility failures

From Presentation of Prof. Kuwata

Water leak from bellow's type flexible joint

Damage to flexible joint, DIPφ600

Briefing report for ASCE/TCLEE at JSCE on June 13, 2011 http://committees.jsce.or.jp/kokusai/node/5 Examples of lifeline facility failures

Physical damage of No.3 pump house due to tsunami wave loads at Minami Gamo treatment facility

 Structural failure modes by inundation depth of about 8m to 9m
 Deformation of 1m or more in out-of-plane at the RC wall From Presentation of Prof. Shoji

Casualties due to Tsunami



Population in total & inundated area



% of Death in Inundated Area



Process for Recoveries and Reconstructions

March 11th

- 14:46 Earthquake occurred
- 14:50 Emergency Response Offices @ CAO, MoD
- 15:14 the Extreme Disaster Management Headquarters
- 19:03 the Nuclear Disaster Management Headquarters
- April 11 the Reconstruction Design Council (Headed by Prof. lokibe, Emeritus Prof. Kobe Univ)
- June 23 <u>the Reconstruction Headquarters for GEJE</u>
 3 pillars of Headquarters in Central Government. the Reconstruction Design Council presented a recommendation report; "Towards Reconstruction – Hope beyond the Disaster" on June 25th

Reconstruction Design Council

復興への提言 ~悲惨のなかの希望~

Towards Reconstruction "Hope beyond the Disaster"



Prof. lokibe @ Kobe Univ. Symp. on Aug 3



Four Panelist @ Kobe Univ. Symp. on Aug 3

平成23年6月25日 東日本大震災復興構想会議

Towards Reconstruction –Hope beyond the Disaster–

- Our task is to how to derive a solution and implement DRR for such compound disaster.
- The problems that Japan had kept since the World War II lies at the background of such compound disaster
- This disaster reveals the vulnerability of our civilization that overlooked the menace of natural hazards.
- Question may be posed on how our civilization should continue.

Key solution is how to bridge the peoples, communities, regions, and countries.

THANK YOU FOR YOUR ATTENTION