Chapter 1. Introduction

An earthquake struck the central region of Taiwan at 17:47, September 20, 1999 (GMT); i.e., 01:47 AM, September 21 in local time. This earthquake, known as the Chi-Chi earthquake, occurred on the Chelungpu Fault. The epicenter was located at 23.85N and 120.81E, closely north of Chi-Chi in Nantou County, with an epicentral depth of 6.99km. The Central Weather Bureau (CWB), Taiwan, reported a magnitude of 7.3; the USGS, USA reported the moment magnitude to be 7.6.

Statistics of the damage caused by the earthquake are tabulated in Table 1.1. The human casualties were determined from the NCEER (National Center for Earthquake Engineering Research) preliminary report of October 1999. The statistics on building damages reported by Tsai et al. (2000) and highway bridge damages calculated by Chang et al. (2000) are also included.

Table 1.1. Statistics of damage.

City / County	Human casualties		Damaged buildings	Damaged bridges
	Dead	Injured		
Taipei Municipality	71	316	157	-
Hsinchu City	2	4	24	-
Taichung City	113	1112	110	-
Chiayi City	0	11	2	-
Taipei County	39	145	337	-
Taoyuan County	3	84	13	-
Hsinchu County	0	4	15	-
Miaoli County	6	196	348	-
Nantou County	857	2421	4637	95
Taichung County	1135	4886	2815	65
Changhua County	24	387	152	17
Yunlin County	80	423	156	18
Chiayi County	2	5	7	-
Tainan County	1	1	-	-
Ilan County	0	7	-	-
Total	2333	10002	8773	195

- : not reported in original papers

Including the physical loss of buildings, industrial facilities, railways, harbor facilities and highway systems, the total economic loss resulting from this earthquake totaled approximately 11.5 billion New Taiwan Dollars (NTD). The most heavily damaged zones of Nantou County and Taichung County, counties closest to the Chelungpu Fault, sustained approximately 90% of the total building damage.

Following the quake, the Earthquake Disaster Mitigation Research Center, Institute of Physical and Chemical Research (RIKEN), hereafter abbreviated as EDM, immediately initiated the survey, assessment and analysis of the damage caused by the earthquake.

The spatial distribution of the damaged areas during the quake was estimated utilizing DMSP (Defense Meteorological Satellite Program) imagery data. Electric power shut-downs, structural damage to residential buildings, and the stagnation of human activities caused by this hazardous event leads to a reduction in nighttime light within the areas that suffered serious damage. By comparing nighttime satellite images taken after the quake with those taken before the quake, the deviation of lighting image can be determined. Using nighttime

satellite light imaging, we can estimate the spatial distribution of the damaged areas in a remote location without the necessity of on-site evaluation of the damaged areas. The EDM reported the evaluated estimation instantaneously on the worldwide web homepage, included in the Appendix CD-ROM.

The second step is to provide suggestions for recovery and reconstruction procedure, based on experiences of the 1995 Hanshin-Awaji (Kobe) Earthquake disaster. To contribute additional technical advice, EDM groups visited the National Center for Earthquake Engineering Research, NCREE (Director: Prof. C. H. Loh), in Taipei. The group, lead by Hiroyuki Kameda, Director, EDM, and Masanori Hamada, Chair, Committee for Earthquake Disaster Reconnaissance, JSCE, from Waseda University, visited NCREE on September 28 and October 8, 1999. On both visits, the EDM teams offered evaluations of the disaster and reconstruction in Kobe to NCREE; the major issues were briefed and discussed. During the first visit on September 28, an aerial survey by helicopter was conducted in order to capture an overview of the damage. The digital record of this aerial video is included in the Appendix CD-ROM. During the second visit, engineers from the Public Works Research Institute, Port and Harbor Research Institute, and Railway Technical Research Institute explained the reconstruction and code revisions for social infrastructures including highways, railways, and port and harbor facilities, following the Kobe disaster.

The EDM staffs planned reconnaissance activities according to their research specialties working with additional teams dispatched by local engineering associations including the Architectural Institute of Japan, AIJ, and the Japan Society of Civil Engineers, JSCE. Reconnaissance site visits around the Taichung area were performed in the several independent periods from late September to mid October of 1999, summarized in Table 1.2. The analytical results from these field surveys constitute the main body of this report. In addition, the preliminary reconnaissance reports detailing building damages, infrastructure damages and ground failures were made available on the homepage as the data was obtained, included in the Appendix CD-ROM.

Table 1.2. EDM reconnaissance activities.

Member	Date	Main objective
Hiroyuki Kameda (EDM) Hitoshi Taniguchi (EDM) Ryosuke Uzuoka (EDM) Satoshi Tanaka (Kyoto Univ.)	September 27 - October 3	Overview of building and infrastructure damage in the Taichung area.
Hirotada Hasegawa (EDM) Naoki Ogawa (EDM) Osamu Nurao (Tokyo Univ.)	September 29 - October 3	Survey comparing the ground view with the aerial video record by NHK in the damaged area.
Haruo Hayashi (EDM) Norio Maki (EDM) Kei Horie (EDM)	October 5 - 8	Lecture on recovery at NCREE. Inspection of sheltering process.
Hiroshi Arai (EDM)	October 13 - 21	Collecting information about the seismic data. Ground survey on geotechnical aspect. (as a member of AIJ reconnaissance team)
Fumio Yamazaki (EDM) Masashi Matsuoka (EDM) Hisashi Aoki (EDM)	October 16 - 18	Overview of building and infrastructure damage in the Taichung area.

We have included brief reviews of the reconnaissance reports concerning the earthquake, ground motions and structural and ground failures within this EDM report. Our major endeavor is to expand our research works from analysis of the data obtained during our reconnaissance activities of the damaged areas to reduce earthquake damage in the future. The PDF files of this report are also included in the Appendix CD-ROM.

References

National Center for Earthquake Engineering Research, NCERR (1999). "The preliminary report of 921 Chi-Chi earthquake", pp.1-2 (in Chinese).

Chang, K. C., Chang, D. W., Tsai, M. H. and Sung, Y. C. (2000), "Seismic performance of highway bridges", *Earthquake Engineering and Engineering Seismology, Special Issue for 921 Chi-Chi Earthquake*, Chinese Taiwan Society for Earthquake Engineering, Vol. 2, No.1, pp.55-77.

Tsai, K. C., Hsiao, C. P. and Bruneau, M. (2000), "Overview of building damages in 921 Chi-Chi earthquake", *Earthquake Engineering and Engineering Seismology, Special Issue for 921 Chi-Chi Earthquake*, Chinese Taiwan Society for Earthquake Engineering, Vol. 2, No.1, pp.93-108.