

The Great Tangshan Earthquake of 1976

Volume 3

Earthquake Engineering Research Laboratory
California Institute of Technology
Pasadena, California 91125
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FOREWORD

On July 28, 1976, a magnitude 7.8 earthquake devastated the city of Tangshan, China and surrounding regions. Of the 1.5 million people living in the affected area, it was reported that about 242,000 died and 164,000 were severely injured and most of the surviving inhabitants lost their homes because of collapse. This earthquake caused one of the greatest natural disasters in human history.

The great structural, economic, and social impacts of this earthquake made it obligatory to record the seismic effects and also the geological and seismological setting of the earthquake. An effort of six years was made to prepare a report on the Tangshan Earthquake under the leadership of Professor Huixian Liu, the former director of the Institute of Engineering Mechanics (IEM), China Seismological Bureau. The report titled "Damage in the Great Tangshan Earthquake" in Chinese language was published in four volumes including fifteen chapters. Volume I presents the basic information on seismological and geological features relevant to the earthquake; Volume II records real and vivid damage to civil structures and facilities; Volume III describes damage to the lifeline systems, disaster relief and rebuilding of the Tangshan city and Volume IV contains about seven hundred photographs of various typical damages. A unique feature of this report is that all damages collected in the book are described in detail with little subjective explanation so as to insure that the information provided is as objective as possible. This report reflects the whole picture of damages to the various buildings, structures, lifeline systems, etc. distributed in a vast region, ranging from completely destroyed in the near-field to more distant regions where structures suffered only slightly damage. The report provides also basic information on seismic damage for further earthquake engineering research.

The years 1990-2000 have been designated by the United Nations as the International Decade for Natural Disaster reduction (IDNDR). The Decade would be a potent first step in reducing the impacts of natural hazards through coordinated research, data gathering and information sharing. In 1986, four years earlier than the beginning of the Decade, Professor George W. Housner proposed a program to translate the book "Damage in the Great Tangshan Earthquake" into English language after he received and examined a copy of this book. In his letter to Professor Liu Huixian he highlighted "This appears to be an excellent report that contains much information that would be valuable to all earthquake-prone countries in the world. Earthquake engineers and seismologists everywhere could learn from this report how to improve the safety of their cities". This initiation received an active response from Liu Huixian who mentioned in his reply letter that he decided to arrange an English language edition of the Tangshan Earthquake Report. Since then under the sponsorship of the Ministry of Construction and the State Seismological Bureau of China and U.S. National Science Foundation a joint project was finally established and executed in 1991 between the Institute of Engineering Mechanics in Harbin, China and the California Institute of Technology in USA with Professors Liu and Housner as Principal Investigators for the project.

The translation from Chinese to English was done at the Institute of Engineering Mechanics. Many authors who had written the original Chinese report translated many of the chapters. The editing and the publication were done in the United States under the direction of Professor Housner.

Unfortunately, Professor Liu Huixian became ill in 1991 and died on June 24, 1992. Thus, he did not live to see the completion of the report. As his successor, Professor Xie Li-li, who was the director of IEM, has undertaken the responsibility of carrying on the unfulfilled work left by Professor Liu. Through the joint effort since then, the English language version of the report is now completed and published. Undoubtedly, it will be a significant contribution to world earthquake disaster reduction.

On the occasion of the Twenty-fifth Anniversary of the Tangshan Earthquake, we would like to publish and distribute this report in memory of the Tangshan Earthquake and as an expression of sympathy we dedicate it to the victims of this great disaster.

Xie Lili
June 30, 2001

PREFACE

At 03:42 (Beijing Time) in the early morning, of Wednesday, July 28, 1976, a strong earthquake of magnitude 7.8 on the Richter Scale hit Tangshan, an industrial city with population of more than one million. The epicenter was located in the southeast part of the city with hypocentral depth of 11 kilometers. After the earthquake a fault rupture running through the city was found. Tangshan was almost entirely devastated to the degree of damage designated as Intensity XI (in the Chinese Intensity Scale, similar to the Modified Mercalli Intensity (MMI) Scale). In the city the building structures were extensively collapsed and only a few survived. The seismic damage was also widely distributed over more than ten countries and Tangshan City, even over some metropolitan regions and big cities such as Beijing, Tianjin, and Qinghuangdao etc., located more than hundred kilometers from Tangshan City. All the infrastructure's such as roads, bridges and public utilities were severely damaged, and therefore, the traffic, communications, supplies etc. to and from other regions outside Tangshan City were all cut off. At 18:45 the same day a strong earthquake of M 7.1 occurred at Shangjialin Town in the Luanxian County about 45 kilometers northeast of Tangshan City, and at 21:53 on November 15 in the same year another strong earthquake of M 6.9 occurred again at Ninghe County in the Tianjin Metropolitan Region. These two strong quakes aggravated in some local areas the seismic damage caused during the main shock. As shown from the statistical data the Tangshan Earthquake claimed the death toll of 242 thousands and heavily injured of 164 thousands. The seismic disaster of the Tangshan Earthquake was so great that it rarely happened in other parts of the world.

With the profound concerns of the Central Committee of the Communist Party and the State Council of China and together with the full support of the people of the whole country, the heroic Tangshan people who have experienced the rigorous trials and faced various crucial difficulties, soon after the rescue and relief works, swept the ruins, recovered daily life and production and started planning and reconstruction of a new Tangshan City. About ten years later, a new Tangshan City is rising from the ruins with increase of population and exciting growth of all kinds of enterprises and has become more prosperous than ever before. Therefore, the lessons learned from the Tangshan Earthquake provided us with earthquake engineering experiences obtained at the price of blood shedding on the one hand, and with experiences of striving against natural disasters for a new, more prosperous Tangshan City on the other hand. These lessons will be always graven on the hearts of the Chinese people and also will stimulate scientists and engineers to develop earthquake sciences and explore new countermeasures for preventing seismic disasters.

Understanding comes from experience. All the existing knowledge of seismic disaster mitigation were learned to a great extent from destructive earthquakes. Recently, there were a series of devastating earthquakes in China. Since two major earthquakes of M 6.8 and 7.2 occurred in 1966 in Xingtai, in succession, an earthquake of M 7.7 hit Tonghai in 1970 and in 1975 the City of Haicheng was also hit by an earthquake of M 7.3. The seismic disasters became more and more severe and reached

its extreme during the 1976 Tangshan earthquake. Chinese scientists and engineers always went to the quake stricken area for reconnaissance and field investigation. Since the Tangshan occurred, there have been many scientists and engineers entering the stricken area for field investigations as well as for relief works. Some of them came to the field on the day of the earthquake and the others followed in quick succession. Even after the normal order in the stricken area was fully recovered, there still were many scientists and engineers, who several times entered the disaster area, continued their studies or checked the data gathered already. They collected therefore a large amount of original data and information which accurately described the features and degree of damage to the various types of civil engineering structures on different categories of sites in areas of various intensity ratings. These could then serve as valuable data for future engineering practice as well as further research towards earthquake disaster mitigation.

However, all these valuable data and information were kept by many different individuals with some of them printed and distributed in informal publications. It really was a matter of regret that so much accumulated data could not be systematically compiled or analyzed further. As a remedy, the former State Capital Construction Commission and the State Seismological Bureau jointly granted a project to the Institute of Engineering Mechanics of the State Seismological Bureau (former Institute of Engineering Mechanics, the Chinese Academy of Sciences) as a responsible unit to organize the other relevant institutions for compiling this huge book. In March of 1980, the Editorial Committee and the Board of Editors for this book were formally organized and started to invite scientists and engineers to prepare their reports and received excellent responses from the relevant experts. With efforts from the experts, an outline of this book was finalized soon and then the preliminary reports were prepared, reviewed, revised and amended. Finally it took several years for this book to be finally prepared for publication. It was indeed a gratifying and significant event in the Chinese earthquake engineering community.

Like other great earthquakes in history, the Tangshan Earthquake had its own features which provided us with knowledge and inspiration: (1) Tangshan was a city with no defense against earthquake disaster. It should be pointed out that the main reason why the Tangshan Earthquake caused so much destruction was that almost all buildings in the city, although they were constructed in the recently years, were designed with no construction of earthquake resistance. This mistake originated from an underestimation of the seismic hazard in the Tangshan area. This reminded us that by existing knowledge we still could not make an accurate assessment of future seismic hazards and, therefore, any civil engineering design should provide structures with a necessary and adequate margin for safety. In this respect the Tangshan earthquake is an excellent example for engineers for in-depth studies. (2) A startling feature of seismic damage during the Tangshan Earthquake was that all structures (including the ancient and modern ones) were widely collapsed in the meizoseismal area, resulting in a large number of casualties and destruction of facilities. It further indicated that it was necessary to take some measures in design to prevent collapse of the buildings against an earthquake of unexpectedly high seismic intensity. The lessons learned from the Tangshan earthquake were likely to provide some clues in the light of which buildings

could be designed as collapse-prevent structures with only some simple measures. (3) Since the Tangshan area is located along the sea coast with lands of coast alluvium, liquefaction was widely distributed and constituted one of the prominent factors contributing to the damage from this earthquake, such as fallen bridges, cracked earthdams, sunk or inclined buildings, inundated farmland with sand, silted irrigation system and so on. All those phenomena, although they have long been studied, provided once again a natural laboratory to engineers for further studies. (4) In the Tangshan area there were also many underground coal mines on a grand scale and this earthquake was really a natural test of seismic behavior of underground structures. It showed that, in comparison with the severe damage to the mining facilities on the ground surface, the underground mine structures were damaged not very heavily, however they were drowned by underground water after the quake for a long time, which caused coal production to be interrupted. The data and information on the performance of underground structures during the strong earthquake were very valuable to engineers since little could be learned from past quakes. (5) Break down of the public facilities was largely caused by the collapse of buildings that in turn caused working staffs to be injured and other installations damaged. It again showed that investment in buildings for earthquake resistance is essential to the safety of staffs and facilities and should not be grudged and neglected. (6) The Tangshan Earthquake also featured an abnormal distribution of intensity, for examples, the higher intensities assigned to the area around the Dacheng hill and Fenghuang hill located inside the Tangshan city proper, as well as the lower intensity assigned to the Yutian County. In addition, the Tianjin Region belonged to a high abnormal intensity zone. One explanation of the abnormal intensity distribution referred to the local site conditions, and further studies are needed. (7) The relief work after the quake was also a very tough task. Such a large industrial city with population of more than one million was destroyed to a field of debris in an instant. It could not be imagined how hard it would be to cope with rescue, medical treatment, water and food supplies, sheltering, sanitation, and epidemic prevention, and also the follow up work of recovery and reconstruction would be huge and difficult. Fortunately, all these problems have been completely solved. No other earthquakes in history could provide such valuable experiences in this aspect. In summary, the Tangshan earthquake provided us with a wealth of significant experiences, which should be explored and summed up at a wide angle.

Based on the backgrounds and features of the Tangshan Earthquake, this book was divided into four volumes. Volume 1 includes five chapters presenting mainly the background information about the earthquake and sites, such as seismicity and tectonic background, distribution of intensity and ground failures, engineering geology conditions, strong motion instrumentation and soil and foundation; volume 2 describes the seismic damage to buildings and structures and is composed of four chapters: residential and public buildings, ancient buildings, mills and factories, and industrial equipments and structures; volume 3, consists of six chapters presenting seismic damage to the lifeline systems including railway, highway, water reservation, irrigation and water transportation, public utilities, etc.. A brief description about the rescue, relief as well as reconstruction of the city of Tangshan is also included in volume 1.

Volume 3 is an album of photographs. It is intended to give the readers a clear picture of the real damage. It should be noted that this book is a documentary report. The objectives of this book are to reflect systematically as many raw materials of real damage as possible, to serve as a basis for further detailed research and to remain as historical records. Explanations of seismic damage, including theoretical analyses as well as experimental researches are not within the scope of this book. However, with respect to some specific topics (for example, geological background) different authors usually had different points of view and derived different judgments or conclusions. According to the Principle of "Contention of A Hundred Schools of Thought," all the points from different experts were in parallel presented in this book. Additionally, in order to assure the accuracy of all data included in this book the authors adopted the units originally used in tests or measurements and all these units had been converted into universal unit system in footnotes, where they appeared at the first time in the book.

During the process of preparing and editing this book the Capital Construction Commission of Hebei Province, the Capital Construction Commission of Tianjin Municipality, the Earthquake Resistance Office of Beijing Municipality, the Earthquake Resistance Headquarters of Tangshan City had provided with their strong supports; the Ministry of Railways, the Ministry of Coal Industry, the Ministry of Metallurgical Industry, the Ministry of Water Resources and Electricity, the Ministry of Communications, the Ministry of Chemical Industry, Ministry of Machine-building Industry and other organizations had offered valuable assistances; the authors of each contribution, the reviewers and the editors and the staff of the publishers as well as those who had generously provided the data, photos, materials etc. contributed much to this book. The Editorial Committee would like to express its sincere thanks to all of them.

Editing of this book was a very serious task. However it was inevitable that there were some mistakes or shortcomings and any comments and suggestions from readers will be highly appreciated and they will be significant and valuable to improve this book for reissue.

Liu Huixian

Chairman, Editorial Committee

Feb. 1985

(Translator: Xie Li-Li)

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A large effort was put into the first English translation by those persons whose names appear under various sections that they translated and their efforts are greatly appreciated. The efforts of Professor He Duxin and Ms. Zhong Nanping made important contributions to the success of the translation. Professor Liu Huixian and his successor as Director of IEM, Xie Lili, provided valuable guidance. The support provided by the Institute of Engineering Mechanics and the grants from the Earthquake Resistance Office of the Ministry of Construction and the Earthquake Science United Foundation of the State Seismological Bureau of China were important elements in the translation project.

A grant from the US National Science Foundation provided funds for the translation work done at California Institute of Technology and the support of Dr. Shi-Chi Liu, at NSF, is acknowledged. The Earthquake Engineering Research Laboratory at the California Institute of Technology contributed funds to complete the translation and to publish the English language report.

To insure that the technical meaning in the Tangshan earthquake report was translated correctly it was necessary that the first draft of the translation should be reviewed by persons knowledgeable in the particular technical subject: geology, seismology, geotechnical engineering, structural engineering, performance of structures during earthquakes, and also knowledgeable in both the English and the Chinese language. The following persons volunteered to do this technical review:

Dr. Frank K. Chang	U.S. Army Engineer-Waterways Experimental Station, retired
Professor Nien-Yin Chang	Department of Civil Engineering, University of Colorado
Professor Zhikun Hou	Department of Mechanical Engineering, Worcester Polytechnic Institute
Dr. Moh-Jiann Huang	Office of Strong Motion Studies, California Division of Mines and Geology

Sharon Beckenbach, Denise Okamoto, Carolina Sustaita and Leslie Ann Crockett carried out the final editing and the preparation for publication at the California Institute of Technology.

The valuable work by all of the foregoing persons contributed greatly to a successful translation and publication of the report "The Great Tangshan Earthquake".

George W. Housner
Li-Li Xie

TABLE OF CONTENTS VOLUME III

	PAGE
CHAPTER 1: RAILWAY ENGINEERING	
DAMAGE TO RAILWAY ENGINEERING	1
CHAPTER 2: HIGHWAY ENGINEERING	
EARTHQUAKE DAMAGE TO ROAD SUBGRADES AND PAVEMENT IN THE TANGSHAN AREA	60
EARTHQUAKE DAMAGE TO ROAD SUBGRADES AND PAVEMENT IN TIANJIN CITY.....	70
EARTHQUAKE DAMAGE TO GIRDER BRIDGES	80
EARTHQUAKE DAMAGE TO ARCH BRIDGES	122
EARTHQUAKE DAMAGE TO THE SHENGLI BRIDGE	144
EARTHQUAKE DAMAGE TO THE YUEHE BRIDGE AND THE NUZHIZHAI BRIDGE	154
EARTHQUAKE DAMAGE TO THE SHAHE RIVER BRIDGE IN LEIZHUANG VILLAGE.....	161
EARTHQUAKE DAMAGE TO THE ZHUACUN BRIDGE.....	166
EARTHQUAKE DAMAGE TO THE LUANHE RIVER BRIDGE IN LUANXIAN COUNTY	175
EARTHQUAKE DAMAGE TO THE LUTAI BRIDGE	185
EARTHQUAKE DAMAGE TO THE HANGU BRIDGE	200
EARTHQUAKE DAMAGE TO THE YUJIALING BRIDGE	209
EARTHQUAKE DAMAGE TO THE BADAOGU BRIDGE.....	220
LIGHTLY DAMAGED BRIDGES IN THE HIGH INTENSITY EARTHQUAKE ZONE	231
CHAPTER 3: HYDRAULIC ENGINEERING	
EARTHQUAKE DAMAGE TO HYDRAULIC STRUCTURES IN THE TANGSHAN PREFECTURE ..	243
DAMAGE TO HYDRAULIC STRUCTURES IN TIANJIN CITY.....	347
EARTHQUAKE DAMAGE TO HYDRAULIC STRUCTURES IN BEIJING CITY.....	412
DAMAGE TO HYDRAULIC STRUCTURES IN LANGFANG PREFECTURE	425
DAMAGE TO HYDRAULIC STRUCTURES IN LUTAI RANCH	437
DAMAGE TO HYDRAULIC STRUCTURES AT HANGU RANCH.....	454
DAMAGE TO THE DOUHE RESERVOIR.....	472
DAMAGE TO THE BAIHE MAIN DAM AT THE MIYUN RESERVOIR.....	521

TABLE OF CONTENTS VOLUME III (CONTINUED)

CHAPTER 4: ENGINEERING FOR WATER TRANSPORTATION

EARTHQUAKE DAMAGE TO SEA HARBOR AWHARVES AND SHORE SLOPES	534
DAMAGE TO SHIP LOCKS.....	555
EARTHQUAKE DAMAGE TO DOCKS ON THE BANKS OF THE HAIHE RIVER	582
EARTHQUAKE DAMAGE TO BANK SLOPES AT THE MOUTH OF THE HAIHE RIVER	621

CHAPTER 5: PUBLIC WORKS

DAMAGE TO WATER SUPPLY AND SEWER WORKS.....	631
DAMAGE TO THE UNDERGROUND WATER SUPPLY NETWORK IN THE TANGSHAN URBAN DISTRICT	649
DAMAGE TO THE SEWER SYSTEM IN THE TANGSHAN URBAN DISTRICT.....	679
DAMAGE TO 4,000 T FABRICATED PRESTRESSED CONCRETE CYLINDRICAL WATER TANKS IN TANGSHAN.....	696
DAMAGE TO GAS AND HEATING INSTALLATIONS.....	701
DAMAGE TO GAS INSTALLATIONS IN TIANJIN CITY	712
DAMAGE TO UNDERGROUND AIR-DEFENSE SHELTERS	732

CHAPTER 6: EARTHQUAKE RELIEF AND RECONSTRUCTION OF TANGSHAN

DISASTER RELIEF AFTER THE TANGSHAN EARTHQUAKE	747
THE REPAIR AND RESTORATION OF THE KAILUAN COAL MINE	765
EARTHQUAKE RELIEF WORK IN THE TIANJIN URBAN DISTRICT.....	776
REPAIR AND RECOVERY OF THE DOUHE RESERVOIR.....	781
EMERGENCY AT THE BAIHE RIVER MAIN DAM OF THE MIYUN RESERVOIR	787
EMERGENCY REPAIR OF RAILWAY BRIDGES FROM BEIJING TO SHANHAIGUAN	792
REPAIR OF HIGHWAYS AND RELIEF TRANSPORTATION	806
REPAIR OF THE TANGSHAN MUNICIPAL WATER SUPPLY SYSTEM AND RECOVERY OF THE WATER SUPPLY	819
REPAIR OF ELECTRIC SYSTEM POWER.....	823
REPAIR OF THE POSTAL AND TELECOMMUNICATIONS SYSTEMS IN TANGSHAN.....	830
DEALING WITH EMERGENCIES AND REPAIRS FOR THE PRODUCTION TECHNOLOGY OF THE TANGSHAN STEEL AND IRON CORPORATION.....	835
REPAIRING THE CERAMIC KILNS IN TANGSHAN CITY	841
REBUILDING TANGSHAN	845