The Great Tangshan Earthquake of 1976

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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
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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
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

The large coal mines in Tangshan City provided the base for the development of heavy industry, such as locomotive manufacture, cement manufacture, chemical manufacture, etc. All of these industries were damaged by the earthquake and this inflicted a great economic impact on the country. It was of great importance to repair the damaged industries and to restore manufacturing. Because of the need for a speedy recovery, engineers did not have time to thoroughly study the damage and, therefore, an effort was made to document the damage by photographing the most important features.

Many of the inhabitants of Tangshan City and the surrounding area lived in one-story or two-story buildings that had been constructed without benefit of architecture or engineering. These small buildings had low earthquake resistance and most of them collapsed during the earthquake. These collapsed dwellings accounted for the majority of deaths as the earthquake occurred about four o’clock in the morning. The collapse of these structures is not documented in this report but in some of the aerial photographs it is possible to see the destroyed area where these buildings had been located.

The photographs in this volume provide a number of lessons to those concerned about destructive earthquakes. First, it is clear that buildings not designed to resist earthquakes will be badly damaged or will collapse during strong ground shaking; second, the few buildings that had been designed for earthquake resistance performed very much better than the other buildings; third, the relatively few structures that had been retrofitted for earthquake resistance performed better than those which had not; fourth, earthquake engineers looking at these photographs will find it very interesting to try to explain why the damage occurred the way it did; fifth, an engineer while looking at the photographs would find it interesting to try to determine what retrofit could have been undertaken to minimize the damage.

Any reader of this report should ask himself: what would happen to my city if it experienced strong ground shaking? It should be kept in mind that the building code had put Tangshan City in a seismic zone not requiring earthquake design, so that a city which does not require seismic design is not necessarily safe from an earthquake disaster. Even cities that do have modern seismic design requirements in their building code also have a large group of structures that were not designed to resist earthquakes according to modern principles and the experience of Tangshan shows what could happen in the event of strong ground shaking.

George W. Housner
California Institute of Technology
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(Photo: Chen Dasheng)

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61. Originally three stories, an office building of the Hebei Coal Mine Design Institute in the city of Tangshan had its two added stories partly collapse and smash the third story. (Photo: Lei Tongshun)
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(Photo: Institute of Geology, State Seismological Bureau)
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66. A close-up of the central portion of the Third Guest House of the Kailuan Bureau of Mines. (Photo: Seismological Bureau of Hebei Province)

67. One side of an expansion joint collapsed in a power plant office building of the Kailuan Bureau of Mines. (Photo: Earthquake Resistance Group of the Design Administration Bureau, Ministry of Coal Industry)
68. Building No. 4 of the Kailuan Bureau of Mines on Xishan Road in the city of Tangshan was a 3-story brick-concrete structure with flue pipes in the external longitudinal walls. After the earthquake the buttress on the external longitudinal wall of the bottom floor was damaged. (Photo: Zhou Bingzhang)

69. In apartment No. 64 of the Kailuan Bureau of Mines, the upper two stories collapsed and the bottom floor was moderately damaged. (Photo: Zhao Tingjie)
70. The domicile of the Tangshan Coal Mine of the Kailuan Bureau of Mines on Xima Road in the city of Tangshan partially collapsed. (Photo: Ma Fukang)
71. The upper two stories collapsed at the office building of the Kailuan Coal Mine Research Institute. The top photo is a side view of the building. (Photos: Earthquake Research Institute, State Seismological Bureau).
72. Domicile No. 3E of the Kailuan Coal Mine Research Institute on Xinhua Road in the city of Tangshan was a brick and wood structure. The top floor partially collapsed. (Photo: Dong Jinchen)

73. The top floor collapsed of a 2-story office building of the Coal Mine Medical Institute which had inner brick walls, in the city of Tangshan. (Photo: Lei Tongshun)
74. A restaurant collapsed near the Xingeng shaft of the Tangshan Coal Mine, Kailuan Bureau of Mines. (Photo: Earthquake Resistant Group of Design Administrative Bureau, Ministry of Coal Industry)

75. Multistory buildings on both sides of Jianshe Road in the city of Tangshan were seriously damaged. (Photo: Chang Qing)
76. Multistory Gongnongbing buildings on the east side of Jianshe Road in the city of Tangshan. Nine dwellings totally collapsed. (Photo: Wang Cong)

77. A six unit office building on Xinhua Road in the city of Tangshan was a 5-story brick-concrete structure which had reinforced concrete columns in the entrance hall. The first, second and third floors were left standing, the rest of the building collapsed. (Photo: Zhu Yulian)
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79. The top floor of the main building of a 6-story Tangshan Guest House collapsed.
(Photo: Earthquake Research Institute, State Seismological Bureau)

80. The majority of a 5-story side building of the Tangshan Guest House pictured collapsed. The remaining portions were auxiliary rooms such as bathrooms, restrooms and the boiling water room, etc.
(Photo: Earthquake Research Institute, State Seismological Bureau)
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83. The upper two stories of building No. 4 of the First Guest House in Tangshan collapsed. I was a brick, concrete and wood structure. (Photo: Earthquake Research Institute, State Seismological Bureau)
84. The top floor above the entrance of building No. 5 of the First Guest House in Tangshan collapsed. (Photo: Earthquake Research Institute, State Seismological Bureau)

85. Walls cracked under windows of building No. 5 of the First Guest House in Tangshan. (Photo: Earthquake Research Institute, State Seismological Bureau)
86. The northern side of a wall collapsed and columns in a staircase were slightly damaged in building No. 5 of the First Guest House in Tangshan. (Photo: Yang Yucheng)

87. The corner of the top floor collapsed in building No. 1E of the Second Guest House in Tangshan which was a brick, concrete and wood structure. (Photo: Yang Yucheng)
88. Reinforcing bars between the transverse and longitudinal walls were pulled and broken in building No. 3E of the Second Guest House in Tangshan. (Photo: Yang Yucheng)

89. A middle school classroom in building No. 21 on Wenhua Road in the city of Tangshan. The pre-cast floor slab with bond beams mostly collapsed, the wood roof fell down and eaves leaning against a wall supported by a cast iron pipe did not fall. (Photo: Yang Yucheng)
90. At the Tangshan Paper Flower Works the longitudinal wall was damaged.  
(Photo: Lian Zhiqin)

91a. The Wenhua buildings on Wenhua Road in the city of Tangshan were three 3-story brick and concrete dwellings which were constructed identically. After the earthquake, building No. 1 collapsed. (Photo: Qiu Zonglian and Yang Yucheng)
91b. A portion of the bottom story in building No. 2 remained.
(Photograph: Qiu Zonglian and Yang Yucheng)

91c. Horizontal cracks passed through under the window sills.
(Photograph: Qiu Zonglian and Yang Yucheng)
91d. Cracks in the interior transverse and longitudinal walls. (Photo: Qui Zonglian and Yang Yucheng)

92. The spandrel walls below the windows cracked but the building did not collapse. The office building of the Foreign Trade Bureau of Tangshan in the city of Tangshan. (Photo: Yang Yucheng)
93. The office building of the Tangshan Architectural Ceramic Works was identical in construction to the office building of the Foreign Trade Bureau of Tangshan and suffered similar damage. (Photo: Gao Yunxue)

94. External longitudinal walls and a staircase collapsed at the Tangshan Farm Machinery Research Institute. (Photo: Earthquake Research Institute, State Seismological Bureau)
95. The building of physics and chemistry of the Hebei Institute of Mining and Metallurgy collapsed. (Photo: Yang Yucheng)

96. A middle school classroom building of the Tangshan Iron and Steel Company was partially left standing. (Photo: Institute of Geology, State Seismological Bureau)
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100. The corner building east of the Yuejinlou residential quarters in the city of Tangshan cracked but did not collapse. (Photo: Yang Yaling)
101. The corner building west of the Yuejinlou residential quarters in the city of Tangshan. The upper portion collapsed and the store on the bottom floor remained. (Photo: Zhou Bingzhang)

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103. A building at the Yuejinlou residential quarters in the city of Tangshan. A staircase across the longitudinal section collapsed. (Photo: Liao Jishan)

104. A bearing wall collapsed in the south building of Construction Headquarters of the Tangshan Coal Mine. (Photo: Gu Zhiqing)
105. Both southern and northern external longitudinal walls collapsed at a dormitory of the Third Department of the Tangshan Railway Institute. (Photo: Yang Wenzhong and Lian Zhiqin)

106. The bottom story was all that remained of the bachelor quarters of the Douhe Power Plant, which was a 3-story brick and concrete structure. (Photo: Qi Yongqian)
107. An office building of the Douhe Power Plant partially collapsed. (Photo: Qi Yongqian)

108. External longitudinal walls of the bottom floor collapsed at the Guest House of the Majiagou Refractory Material Plant in the city of Tangshan. (Photo: Han Jiagu)
109. The walls between the windows on the bottom floor were seriously damaged at the Beigongfang dormitory of the Jinggezhuang Coal Mine, Kailuan Bureau of Mines. (Photo: Earthquake Resistant Group of Design Administrative Bureau, Ministry of Coal Industry)

110. External longitudinal walls collapsed at the dormitory of the Guye Maintenance Section. (Photo: Seismological Bureau of Hebei Province)
111. The office building of the Zhaogezhuang Coal Mine, Kailuan Bureau of Mines was a 3-story stone and wood structure. The walls between the windows on the bottom floor suffered damage and the end of the building partially collapsed. (Photo: Earthquake Resistant Group of Design Administrative Bureau, Ministry of Coal Industry)

112. The entrance of the Shaheyi Hospital collapsed. (Photo: Zhang Xiguang)
113. One of two stone buildings remained standing at the residential quarters of the Tangshan Rolling Stock Plant. There were diagonal cracks on the wider walls of the second floor. (Photo: Liao Jishan)
114. Staff residences of the Qixin Cement Plant in the city of Tangshan were slightly damaged. The photo below is the back view of the building.
(Photo: Liao Jishan and Chen Dasheng)
115. The Trade Union Building of the Tangshan Iron & Steel Company was slightly damaged. (Photo: Gao Yunxue)

116. The Beigongfang bachelor quarters of the Tangshan Iron & Steel Company basically remained intact. (Photo: Central Research Institute of Building and Construction, Ministry of Metallurgical Industry)
117. The bachelor quarters of the Tangshan Architectural Ceramic Works basically remained intact. (Photo: Liao Jishan)

118. The guest house of the Douhe Power Plant located in the foothills basically remained intact. (Photo: Dong Jincheng)
119. The dormitory of the Mechanical Plant of Linxi Coal Mine was constructed of stone and concrete and basically remained intact. (Photo: Zhou Bingzhang)

120. External longitudinal walls collapsed, transverse walls from the second floor collapsed to the first floor, and roofing covered the collapsed transverse walls of the Public Health Bureau of Luanxian County. (Photo: Yang Yucheng)
121. The office building of the Baiezhuang Chemical Fertilizer Plant was a brick and wood structure. One end of the building subsided and a wall cracked due to soil liquefaction. (Photo: Yang Deyong).

122. At the Qinghuangdao Seamen's Club, the projecting 4-story building was seriously damaged. (Photo: Earthquake Research Institute, State Seismological Bureau)
123. External longitudinal walls collapsed at the living quarters for staff and workers of the Qinghuangdao Asphalt Felt Works. (Photo: Earthquake Research Institute, State Seismological Bureau)

124a. Many roof tiles on old multistory brick buildings slipped down in the city of Tianjin. (Photo: Institute of Geology, State Seismological Bureau)
124b. The building in the lower right portion of the photo lost its roof tiles. (Photo: Institute of Geology, State Seismological Bureau)

125. In the city of Tianjin, old brick and wood structures were seriously damaged and newer brick and concrete structures were basically left intact. (Photo: Mao Shihong)
126. Brick and wood structures built in the twenties on Lasa Road in the city of Tianjin collapsed. (Photo: Jiang Yongqi)

127. Roofs and external longitudinal walls collapsed on brick and wood structures built in the thirties on Tangshan Road in the city of Tianjin. (Photo: Jiang Yongqi)
128. External longitudinal walls partially collapsed in the brick and wood structures built in the thirties on Heping Road in the city of Tianjin. (Photo: Jiang Yongqi).

129. Corners between longitudinal and transverse walls broke in the brick and wood structures built in the thirties on Jianshe Road in the city of Tianjin. (Photo: Jiang Yongqi)
130. The roof collapsed on a 3-story brick and wood structure on Jianshe Road in the city of Tianjin. (Photo: Jiang Yongqi)

131. The high facade of the Out-patient Department of the Tianjin Public Security Hospital, which was a brick and wood structure, collapsed. (Photo: Jiang Yongqi)
132. A 4-story building expanded from 2-stories on Nanchang Road in the city of Tianjin. The walls of the original two floors cracked. (Photo: Su Shiguang)

133. The corner of the projecting portion of the Railway Telecommunication Building of Tianjin was damaged. (Photo: Jiang Yongqi)
134. The Meiman residential building on South Jiefang Road in the city of Tangshan, which was a brick and wood structure, suffered longitudinal cracks due to ground fissures. (Photo: Yu Yongnian)

135. There were "X" shaped cracks on transverse walls of a 6-story brick and concrete building built in 1975 on Wujiaoyao Main Street in the city of Tianjin. (Photo: Jiang Yongqi)
136. The top floor of an office building of the Hangu Soda Plant in the city of Tianjin, which was a brick and concrete structure, was seriously damaged. (Photo: Li Yihong)

137. The top floor collapsed of the first August Middle School, which was a brick and wood structure, of Tanggu District in the city of Tianjin. (Photo: Institute of Geology, State Seismological Bureau)
138. Tiles fell off of the building of the Ministry of Finance, which was a brick and concrete structure, in the city of Beijing. (Photo: Wang Zhongnan)

139. The Museum of Geology in the city of Beijing suffered cracks at the corner of the third floor. (Photo: Wang Zhongnan)
140a. The building of the Ministry of Materials in the city of Beijing was a brick and reinforced concrete structure. The corner of the 6th floor meeting room, the portion which projected out, was damaged. The photo on the following page is a close-up view. (Photo: Lei Tongshun)

140b. A view from inside the damaged room of the Ministry of Construction building in Beijing. (Photo: Lei Tongshun)
141. A market in the new city district in the city of Tangshan was an inner-frame structure with a single row of poured-in-place columns. The middle 4-story part collapsed; two wings of the third story collapsed but the first and second story remained. (Photo: Earthquake Research Institute, State Seismological Bureau)
142. The Vegetable Sales Department on Wenhua Road in the city of Tangshan was a 3-story inner-frame structure with a single row of poured-in-place columns. The upper portion collapsed and the bottom floor remained standing. (Photo: Zhou Bingzhang)

143. The multiple-producing Workshop of Tangshan, the Fifth Ceramic Plant, was a 4-story inner-frame structure with multiple rows of poured-in-place columns. The upper portion collapsed and the bottom portion remained standing. (Photo: Dong Jincheng)
144. The top floor partially collapsed at the Production Workshop of the Tangshan Porcelain Plant of Arts and Crafts which was an inner-frame structure with a single row of pre-cast columns. (Photo: Lian Zhiqin)

145. The Shaping Workshop of Tangshan at the Ninth Ceramic Plant, a 2-story inner-frame structure with two rows of pre-cast columns, partially collapsed. (Photo: Yang Wenzhong)
146. The Painted Pottery Workshop of Tangshan at the Ninth Ceramic Plant was a 2-story inner-frame structure with a single row of poured-in-place columns. The top floor partially collapsed. (Photo: Han Jiagu)

147. The dining room for staff and workers at the Tangshan Iron & Steel Company partially collapsed. (Photo: Information Station of the Tianjin Architectural Design Institute)
148. The Third Guest House of the Coal Mine Bureau of Kailuan had the column tops of the inner-frame structure on the bottom floor (half basement) seriously damaged. The upper portion of the 6-story brick and reinforced concrete structure collapsed.

(Photo: Zhou Bingzhang)

149. The antechamber of the Linxi Coal Mine Club of the Coal Mine Bureau of Kailuan was a 2-story inner-frame structure. The two ends of the structure collapsed.

(Photo: Chen Dasheng)
150. The Luanxian Department Store collapsed. (Photo: Chen Dasheng)

151a. The Luanxian Xinhua Book Store was a 2-story inner-frame structure with a single row of poured-in-place columns. The front longitudinal walls tilted backward. (Photo: Earthquake Research Institute, State Seismological Bureau and Chen Dasheng)
151b. The Luanxian Xinhua Book Store. The back longitudinal walls collapsed. (Photo: Earthquake Research Institute, State Seismological Bureau and Chen Dasheng)

151c. The Luanxin Xinhua Book Store. The frame columns were damaged. (Photo: Earthquake Research Institute, State Seismological Bureau and Chen Dasheng)
152. The waiting room at the Fengren Bus Station partially collapsed. The bottom floor was an inner-frame structure with a poured-in-place single row of columns. (Photo: Seismological Bureau of Hebei Province)

153. The Hangu Restaurant of Hangu District in the city of Tianjin was an inner-frame structure with two rows of poured-in-place columns. It was a 4-story building but a portion of it was 5-stories; everything collapsed except for the corridors of the first two floors. (Photo: Information Station of the Tianjin Architectural Design Institute)
154. The Tonglou Department Store in the city of Tianjin was a 3-story inner-frame structure with two rows of poured-in-place columns. The upper portion of the brick walls was seriously damaged. (Photo: Dong Jincheng)

155. The Tianjin 764 end product storage building was a 4-story inner-frame structure with two rows of pre-cast columns. The brick walls partially collapsed on the top floor. (Photo: Xu Wei)
156a. The State Council First Guest House in the city of Beijing. The middle section is a frame structure and the two side portions are brick and reinforced concrete. The penthouse is an inner-frame structure which was most seriously damaged. The degree of damage decreased to the lower floor. The photo on the following page shows the damage to a brick wall and reinforced concrete column bottoms. (Photo: Lei Tongshun)

156b. The State Council First Guest House in the city of Beijing. (Photo: Lei Tongshun)
157. Earthquake damage to the Xinhua Hotel and of its surrounding area on Xinhua Middle Road in the city of Tangshan. (Photo: Li Yaodong)
The Xinhua Hotel in the city of Tangshan. The upper three floors of the two wings which were brick and reinforced concrete structures collapsed. The middle section, an 8-story frame structure with structural columns in the external walls, cracked but did not collapse (above). The fifth floor frame columns were seriously damaged, the column caps yielded and bent, the secondary beam subsided up to 6 cm (below). (Photos: Earthquake Research Institute, State Seismological Bureau and Lei Tongshun)
159. The cold storage at the Cold Storage Plant collapsed, which was a poured-in-place 5-story beamless floor structure. (Photo: Earthquake Resistant Office of the Ministry of Commerce)

160. The upper floor collapsed and the bottom floor remained in a tool shop at the Tangshan Rolling Stock Plant. It was a poured-in-place 2-story beamless floor structure. (Photo: Du Zhaomin)
161. The Library of the Hebei Institute of Mining and Metallurgy was a 4-story beamless floor structure. The bottom floor collapsed and the upper three floors dropped (above). The columns of the bottom floor passed through the floor slab (below). (Photo: Yang Yucheng)
162. The Tianjin Friendship Hotel was a frame and shear wall structure designed according to intensity rating VII. The main structure was basically intact, but bumping from both sides of the expansion joint caused damage (above). The corner columns of the bottom floor and filled walls were damaged (below). (Photos: Institute of Geology, State Seismological Bureau and Zhou Bingzhang)
163. Chenglinzhuang storage of the Tianjin Textiles Company was a 3-story slip-form structure. The slabs and columns were basically intact, the walls of the escalator were seriously damaged and the majority of the wall enclosures collapsed. (Photo: Information Station of the Tianjin Architectural Design Institute)

164. The dormitory for staff and workers of the Tianjin Guest House in the city of Tianjin was a 5-story pre-cast frame and light slab structure (was under construction during the earthquake). The joints of the columns were damaged and the joints between aseismic wall slabs and columns were seriously damaged. (Photos: Dong Jincheng)
165a. The building of the Tianjin Department Store was a poured-in-place frame structure built in the thirties. Since the 1966 Xingtai earthquake the wall enclosure of the tower body was damaged repeatedly. After the 1967 Hejian earthquake external reinforced concrete strengthening was added. During the Tangshan earthquake the main structure was partially damaged and the face brick decoration of the wall enclosure peeled off. (Photo: Xie Yunxiang and Su Shiguang)

165b. The building of the Tianjin Department Store. The part below the tower was seriously damaged. (Photo: Xie Yunxiang and Su Shiguang)
166. The concrete slab structure at Heiniucheng in the city of Tianjin was basically left intact. (Photo: Information Station of the Tianjin Architectural Design Institute)

167. A silicate brick building at Heiniucheng in the city of Tianjin was basically intact except for the crack at the corner of the roof. (Photo: Lei Tongshun)
168. The building of the Beijing Department Store was a 6-story frame structure. The outer wall of the upper two floors was damaged. (Photo: Wang Zhongnan)

169. A five pointed star fell off the top of the Beijing Exhibition Hall. (Photo: Institute of Geology, State Seismological Bureau)
170. In the vicinity of Chongwenmen in the city of Beijing, a cross on the top of a church fell down and the other one broke off. (Photo: Institute of Geology, State Seismological Bureau)
LARGE BUILDINGS

171. The auditorium of the Tangshan Party Committee was a timber structure with bearing brick walls and an asbestos tile roof. The facade collapsed and the back walls were seriously damaged. (Photo: Institute of Geology, State Seismological Bureau)
172. A gable at the arena of the club theater of the Tangshan Architectural Ceramic Works collapsed. (Photo: Chen Guishen)

173. The upper portion of the gable in the audience hall collapsed at the club theater of the Tangshan Power Plant. (Photo: Yang Deyong)
174. The auditorium of the Tangshan Metallurgical Mining Machinery Plant had bearing brick walls, a steel roof truss and an asbestos tile roof. The west end of the building partially collapsed. (Photo: Yang Wenzhong)

175. The Tangshan Exhibition Hall was a single story large brick building with a fairly heavy roof. Horizontal fissures occurred along the longitudinal walls at the bottom of the beam after the earthquake. (Photo: Lei Tongshun)
176. At the Tangshan Oil Pump Plant, later built pilasters collapsed.  
(Photo: Chen Dasheng)

177. The Shiqicun Club of Departments, directly under the Coal Mine Bureau of Kailuan had bearing brick columns and timber roof trusses. The brick walls collapsed and the roof trusses were basically left intact.  (Photo: Institute of Geology, State Seismological Bureau)
178. A large brick building at the Tangshan Chemical Fertilizer Plant was damaged. (Photo: Chen Dasheng)

179. Long span timber trusses, the iron sheet roof and bearing brick columns were basically left intact at the Tangshan Transportation Workers Club. (Photo: Institute of Geology, State Seismological Bureau)
180. A hangar at the Tangshan Airport collapsed. (Photo: Institute of Seismology, State Seismological Bureau)

181. There was damage at the bottom level of the Tangshan Airport which was a large building with bearing walls and columns. (Photo: Lian Zhiqin)
182. The waiting room at the Guye Railway Station totally collapsed. (Photo: Seismological Bureau of Hebei Province)

183. Timber trusses, the iron sheet roof and stone gable were slightly damaged at the club theater of the Zhaogezhuang Coal Mine, Coal Mine Bureau of Kailuan. (Photo: Sun Ming)
184. The gable partially collapsed at a department store in Fengnan County. (Photo: Earthquake Research Institute, State Seismological Bureau)

185. The bearing reinforced concrete columns, arched steel roof trusses, iron sheet roof and main structure were intact but the skylight window frame shifted at the track and field gymnasium of the Tianjin Physical
186. In a small section of Diaoyutaiiin north of Dachengshan Mountain in the city of Tangshan, buildings in some areas totally collapsed and in other areas most buildings cracked but did not collapse. This raises questions about the correlation between damage and site condition. (Photo: Earthquake Research Institute, State Seismological Bureau)
187. A dining room on Fugui Street in the old town district in the city of Tangshan totally collapsed. It was a timber structure with adobe wall enclosures and a flat cinder roof. (Photo: Institute of Geology, State Seismological Bureau)

188. The workers dormitory, of the Coal Mine Bureau of Kailuan on Xishan Road in the city of Tangshan, was a single story flat cinder roof building which totally collapsed. (Photo: Institute of Geology, State Seismological Bureau)
189. An office building of the Tangshan Coal Mine Supply Section of the Coal Mine Bureau of Kailuan was a single story brick reinforced concrete structure. The exterior walls collapsed and the roof fell down. (Photo: Earthquake Resistant Group of Design Administrative Bureau, Ministry of Coal Industry)

190. Walls collapsed and the roof fell down onto an automobile at the garage of the Tangshan Traffic Company. (Photo: Seismological Bureau of Hebei Province)
191. The roof collapsed at the dining room of the Tangshan Coal Mine Medical Institute which was a multiple cylindrical shell structure. (Photo: Yang Wenzhong)

192. One span collapsed, one span was damaged and two spans were left intact of a four span continuous arch bricked roofed building. (Photo: Qui Zonglian)

194. The Laboratory of the Kailuan Coal Mine Research Institute was left intact. (Photo: Dong Jincheng)
195. The gable wall collapsed at a residence at Guiyizhai of Fengren County. (Photo: Yang Deyong and Liu Xiaodi)

196. The Primary School of Wangguanying Commune, Fengren County was a gantry structure with stone columns. The end bay was purlins on gables and the stone gable and wall enclosure collapsed. (Photo: Yang Deyong and Liu Xiaodi)
197. Brick walls collapsed and the cinder concrete roof broke at a supply and marketing cooperative in Luanxian County. (Photo: Wu Chen)

198. A wall partially collapsed and tiles on the roof slid down 1 m on a Chinese style timber truss dwelling in Luannan County. (Photo: Yang Deyong and Liu Xiaodi)
199. The walls were damaged due to different settlements in the basement at a privately owned house in Jiangbao, Luannan County. (Photo: Chen Dasheng)

200. The Maolizhuang Dachedian of Yahongziao Commune, Yutian County was a bearing timber structure with adobe protective walls. The entire structure inclined 16° and a large number of sand boils and waterspouts were inside. (Photo: Institute of Geology, State Seismological Bureau)
201. Tiles laid on the roof slid down at a privately owned house at Lutaizhen, Ninghe County in the city of Tianjin. (Photo: Lei Tongshun)

202. Cracks occurred at the joints of transverse and longitudinal walls in a single story building at Lutaizhen, Ninghe County in the city of Tianjin. (Photo: Lei Tongshun)
203. A single story building with a cinder roof was left intact at Lutaizhen, Ninghe County, in the city of Tianjin. (Photo: Lei Tongshun)

204. A brick structure on Louyuchuanji street in east Hexi District in the city of Tianjin. Before the earthquake the gable was out of vertical 12 cm and was strengthened with steel tie-bars. It was intact after the earthquake. The corner wall, which was not strengthened, was intact before the earthquake but vertical fissures occurred during the earthquake. (Photo: Jiang Yongqi)
205. Transverse and longitudinal walls cracked at a single story building on the 581 sub-farm of Jinzhonghe Farm in the city of Tianjin. (Photo: Seismological Brigade, State Seismological Bureau)

206. The brick-adobe walls and gable collapsed at a privately owned house in Baodi County in the city of Tianjin. (Photo: Xie Yunxiang)
207. An auditorium at the Xiji Primary School, Tongxian County in the city of Beijing. The girder framed structure, with exterior walls with brick enclosed columns was damaged. (Photo: Institute of Geology, State Seismological Bureau)

208. A privately owned house in the city of Beijing was a girder framed house. The external face of the brick wall broke and peeled off. (Photo: Lei Tongshun)
209. The ancestral temple of Liu's family in the city of Tangshan was built in the Yongle second year of the Ming Dynasty and rebuilt in the Guangxu period of the Qing Dynasty. The protective wall collapsed but the main wood frame was left intact. (Photo: Luo Zhewen)
210a. The reinforced columns were damaged at an octagonal pavilion at the top of Fenghuangshan mountain in the city of Tangshan which was a reinforced concrete imitation of ancient architecture. (Photos: Institute of Geology, State Seismological Bureau and Chen Dasheng)
210b. A close-up view of the damage to the octagonal pavilion on Fenghuangshan mountain.
211. The enclosing wall collapsed at the Niangniangdian Temple of Jingzhongshan, Santunying Commune in Jianxi County (above) but the timber trusses at the Xuyuanci Ancestral Temple remained (right). Photos: Chen Dasheng)
212. The majority of the ancient buildings were basically intact at the Eastern Tombs of the Qing Dynasty in Zunhua County. (Photo: Institute of Geology, State Seismological Bureau).

213. Three gates with colored tile at Xiao Tomb were damaged at the Eastern Tombs in Zunhua County. (Photo: Luo Zhewen).
214. The iron incense burner tilted at the Pulesi Temple in the city of Chengde. (Photo: Cultural Relic Bureau of the City of Chengde).

215. The garret of the Guangyingge was basically left intact at the Dolesi Temple in Jixian County in the city of Tangshan. (Photo: Wei Kejing).
216. Column footings in the southwest portion of the gate tower of the Godly Prowess displaced in a southwest direction and the maximum displacement was up to 4 cm at the Old Palace Museum in the city of Beijing, about 150 km from Tangshan. (Photo: Luo Zhewen).

217. The footings of four columns at Jiaotaidian Hall all displaced. The maximum displacement was up to 2 cm and cracks occurred at many places on the partition wall at the Old Palace Museum. (Photo: Wang Zhongnan).
220. Columns of both the upper and lower layers of the long corridor inclined at the Yongan Temple. (Photo: Wang Zhongnan),
221. The surfaces of the gable and side rooms peeled off at the Puandian Temple on Qiong Island. (Photo: Luo Zhewen).
222. The upper brick wall was damaged at the tower of Deshengment Jianlou Gate in the city of Beijing. (Photo: Institute of Geology, State Seismological Bureau).
223. The brick temporary ceremonial gateway in front of Niangniandian Temple, on Jingzhongshan mountain of Santunying Commune in Jianxi County, was cut in the middle portion. (Photo: Chen Dasheng).

224. A Buddhist monk’s grave at the top Jingzhongshan mountain in Jianxi County collapsed. (Photo: Chen Dasheng).
The Hua tower built in the Liao Dynasty, and the beamless hall built in the Ming Dynasty at Chezhoushan in Fengren County was damaged. (Photo: Luo Zhewen).
226. The beamless hall at Chezhoushan in Fengren County Collapsed. (Photo: Wang Cong).
The Tiangong Temple in the county town of Fengren County was built in the Liao Dynasty. The Dense eave styled brick tower cracked and crumbled. (Photo: Luo Zhewen).
228. The upper portion of the eight tiled pagodas collapsed at the Pulesi Temple in the city of Chengde. (Photo: Cultural Relic Bureau of the City of Chengde).
229. The top of the Tibet styled tower fell down at the Waibamiao Temple in the city of Chengde. (Photo: Cultural Relic Bureau of the City of Chengde).

230. The top of the White Dagoba fell down in Jixian County in the city of Tianjin (left). (Photo: Wei Kejing).
232. A full view of the White Dagoba of the Miaoyingsi Temple in the city of Beijing before the earthquake (above). After the earthquake, the top of the “thirteen days” cracked. The canopy was only supported by eight iron bars and was in imminent danger of collapse (below). (Photos: Archaeological Group on Earthquakes).
233. The southwest tower top fell down at the Zhenjuesi Temple in the city of Beijing. (Photo: Archaeological Group on Earthquakes).

235. The majority of the mill buildings at the Tangshan Rolling Stock Plant collapsed.  
(Photo: Li Yaodong)
236. The Coach Bogie Workshop of the Tangshan Rolling Stock Plant had steel roof trusses. The large roof plates fell down. (Photo: Earthquake Research Institute, State Seismological Bureau)

237. The Coach Body Workshop of the Tangshan Rolling Stock Plant had steel roof trusses. The well-type skylight windows were basically left intact but the roof plates fell down. (Photo: Xu Wei)
238. Roofs collapsed at the Cast Steel Workshop of the Tangshan Rolling Stock Plant. (Photo: Earthquake Resistance Office of Ministry of Machinery Industry)

239. At the Cast Steel Workshop of the Tangshan Metallurgical Mining Machinery Plant, many roofs collapsed but the roof trusses did not collapse where the roof braces were fairly perfect. (Photo: Yang Songlin)
240. The First Metal Working Workshop of the Tangshan Metallurgical Mining Machinery Plant consisted of mill buildings of different heights. The joints of the roof trusses with higher spans and column caps were damaged and roofs collapsed. (Photo: Yang Songline)

241. The Second Metal Working Workshop of the Tangshan Metallurgical Mining Machinery Plant had reinforced concrete columns and steel roof trusses. The gable wall of the main span collapsed and one end of the roof collapsed. (Photo: Yang Songlin)
242. The Fourth Metal Working Workshop of the Tangshan Metallurgical Mining Machinery Plant consisted of buildings of different heights. The joints of the roof trusses and column caps were damaged and roofs collapsed. (Photo: Han Jiagu)

243. A roof truss at the vertical brace of a skylight window frame was damaged at the Tangshan Metallurgical Mining Machinery Plant. (Photo: Zhang Xiquang)
244. At the Cast Steel Workshop of the Tangshan Metallurgical Mining Machinery Plant, the majority of the roof system collapsed but the trussed columns were basically left intact. (Photo: Yang Wenzhong)

245a. At the Metal Working Workshop of the Tangshan Cement Machinery Plant, roofs collapsed and short columns broke. (Photo: Xu Hanbo)
245b. At the Metal Working Workshop of the Tangshan Cement Machinery Plant, roof trusses of pre-cast spans collapsed and a roof plate fell through and hung on the short columns. (Photo: Xu Hanbo)

246. The Weaving Department of the Huaxin Textile Factory in the city of Tangshan had a saw tooth shaped roof. The top of the column at the end portion cracked and the roof collapsed. (Photo: Yang Wenzhong).
247. At the Assembly Workshop of the Tangshan Water Pump Plant the shear bracing at the end span was deformed and the tie buckled. (Photo: Chen Dasheng)

248. The roof collapsed at the Production Workshop of the Tangshan Water Pump Plant. (Photo: Chen Dasheng)
249. The upper columns failed and the roof partly collapsed at the Oxygen Refinery of the Tangshan Iron and Steel Company. (Photo: Zhang Xiguang)

250. The roof partly collapsed at the Oxygen Refinery of the Tangshan Iron and Steel Company. (Photo: Yu Chuncheng)
251. The columns became brittle and cracked and the roof subsided at the Rolled Steel Plant of the Tangshan Iron and Steel Company. (Photo: Han Jiagu)

252. The frame of the skylight and the roof collapsed at the Dross Treatment Workshop of the Tangshan Iron and Steel Company. (Photo: Zhang Xiguang)
253. The roofs collapsed at the Sintering Workshop of the Tangshan Building Ceramic Plant. (Photo: Wang Zhongnan)

254. Roofs collapsed at the Steam Turbine Workshop of the Tangshan Power Plant. (Photo: Earthquake Research Institute, State Seismological Bureau)
255. Roofs collapsed at the Steam Turbine Workshop of the Douhe Power Plant. (Photo: Qi Yongquan)

256. The roofs collapsed except for one span at the Machinery Workshop of the Douhe Power Plant. (Photo: Wang Gongkang)
257. The skylight collapsed and the roofs partially collapsed at the Metal Processing Workshop of the Tianjin Engineering Machinery Plant. (Photo: Liao Shutang)

258. The frames of the skylight were broken off and collapsed at the Foundry Workshop of the Tianjin Engineering Machinery Plant. (Photo: Xu Wei)
259. The roofs collapsed at the Hull Shop of the Tianjin Xingang Shipyard. (Photo: Seismological Brigade, State Seismological Bureau)

260. Almost all the upper columns were broken off at the Cast Steel Workshop of the Tangshan Rolling Stock Plant. (Photo: Zhang Qihao)
261. The joint plates of the x-brace between columns had one pulled off and the other one buckled, at the outdoor span of the Fourth Rolling Mill of the Tangshan Iron and Steel Company. (Photo: Yu Chuncheng)

262a. The concrete at the column joints peeled off and cracked and the reinforcing bars were deformed at the pre-cast reinforced concrete frame, above the gully for unloading, at the Douhe Power Plant. (Photos: Wang Gongkang and Shi Guobin)
262b. A close-up view of the damage at the Douhe Power Plant.

263. The concrete at the joint of the pre-cast reinforced concrete column cracked and reinforcing bars were deformed at a water supply well at the Douhe Power Plant. (Photo: Shi Guobin).
264. Concrete at the joints of pre-cast concrete columns peeled off and cracked at a pump house at the Douhe Power Plant. (Photo: Shi Guobin)

265. The end joint of the roof frame was damaged at the Stamping Shop of the Tianjin Tractor Plant. (Photo: Shi Lulin)
266. The upper chord of the roof truss near the end joint was damaged at the Stamping Shop of the Tianjin Tractor Plant. (Photo: Dong Jincheng)

267. The side column cap broke off at the Machine Repair Shop of the Tianjin Engineering Machinery Plant. (Photo: Shi Lulin)
268. A slab of an I-shaped hollow column cracked (upper) and reinforcing bars at the foot of the column buckled (lower). (Photos: Lei Tongshun and Shi Lulin)
269. The roof beam at the lower span dislocated and concrete at the end cracked at the Founding Shop of the Tianjin Xingang Shipyard. (Photos: Earthquake Resistance Office of the Ministry of Machinery Industry)
270. There were diagonal cracks at the end of the reinforced concrete beam at Xiangang the tenth garage at Tianjin Tanggu. (Photo: Liao Shutang)

271a. A brace between columns buckled at the Hull Shop of the Tianjin Xingang Shipyard. (Photos: Lei Tongshun, Shi Lulin and Liao Shutang)
271b. Vertical cracks along the plate of a column at the Hull Shop.

271c. Cracks at the foot of a column at the Hull Shop.
272. The upper portion of the infill protective wall collapsed and the reinforced concrete ring beam fell down at the Forging and Pressing Shop of the Tangshan Metallurgical Mining Machinery Plant. (Photo: Yang Wenzhong)

273. The gable collapsed and the end span of the roof was suspended in midair at the Heat Treatment Shop of the Tangshan Metallurgical Mining Machinery Plant. (Photo: Yang Songlin)
274. The gable collapsed at the Gas Blower Shop in the new air shaft of the Tangshan Mine, Coal Mine Bureau of Kailuan.  (Photo: Chen Dasheng)

275. The gable collapsed at the Forge Shop of the Tianjin Bicycle Plant.  
     (Photo: Yang Wenzhong)
276. A large portion of a reinforced concrete wall slab basically remained intact (above), but there was some damage at the joints of the wall slab and column (below) at the Second Steel Mill of the Tangshan Iron and Steel Company. (Photo: Central Research Institute of Building and Construction, Ministry of Metallurgical Industry)
277. The gable and eaves of a wall collapsed at the Tangshan Water Pump Plant. (Photo: Chen Dasheng)

278. The gable was out of vertical at the Steam Turbine Shop of the Tangshan Power Plant. (Photo: Qi Yongquan)
279a. At the Water Pumping House of the Douhe Power Plant, the bottom is an open caisson of reinforced concrete and the upper portion is a frame structure with reinforced concrete columns. The gable and a portion of the parapet collapsed. (Photos: Qi Yongquan)

279b. A close-up view of the collapsed gable at the Water Pumping House.
280. The base wall between the windows and columns was damaged at the Watering Pump House. (Photo: Qi Yongquan)
281. A gable and the upper portion of the longitudinal wall collapsed at the Machine Repair Shop of the Jinggezhuang Coal Mine, Coal Mine Bureau of Kailuan. (Photo: Chen Dasheng)

282. A gable collapsed and the end of a span was destroyed at the Shaped Plate Shop of the Xiaoji Iron Plant in Fengnan County. (Photo: Dong Jincheng)
283. The wall was out of vertical at the Forge Shop of Tianjin, the First Machine Tool Plant. (Photo: Earthquake Resistance Office of the Ministry of Machinery Industry)

284. The gable collapsed and the wall was out of vertical at the Foundry Workshop of Tianjin, the First Machine Tool Plant. (Photo: Liao Shutang)
285. A gable partially collapsed at the Sand Treatment Shop of the Tianjin Heavy Machinery Plant. (Photo: Earthquake Resistance Office of the Ministry of Machinery Industry)

286. The upper portion of the longitudinal wall of a multi-span factory building with reinforced concrete columns collapsed at the Metal Assembly Shop of the Tianjin Engineering Machinery Plant. (Photo: Earthquake Resistance Office of the Ministry of Machinery Industry)
287. The wall along with the bond beam collapsed at the Chassis Shop of the Tianjin Tractor Plant. (Photo: Liao Shutang)

288. The upper wall of collapsed and five pieces of the low span steel frame of the roof broke at the New Foundry of the Tianjin Tractor Plant. (Photo: Shi Lulin)
289. Longitudinal and transverse walls cracked and a roll of drawings got squeezed in the crack in an office at the Metal Working Shop of the Tianjin Tractor Plant. (Photo: Dong Jincheng)

290. A large number of the sawtoothed gables collapsed at a factory building at the Wool Sorting Shop of the Tianjin Woolen Mill. (Photo: Xu Wei)
291. Reinforced concrete wind vents (their tops were welded) together with the jointed gable collapsed at the Bench-work Shop of the Tianjin Xingang Shipyard. 
(Photo: Liao Shutang)

292. The reinforced concrete frame structure, the upper portion of the gable and a portion of the roof collapsed at the Forge Shop of the Tianjin Xinhe Shipyard. 
(Photo: Institute of Geology, State Seismological Bureau)
293. The whole structure tilted, bearing reinforced concrete columns, sheet beams and gable collapsed at the Warehouse of Tanggu New Harbor in the city of Tianjin. (Photo: Institute of Geology, State Seismological Bureau)

294. The protective walls partially collapsed at the Production Shop of the Dagu Chemical Works in the city of Tianjin. (Photo: Han Guangzhu)
295. At the Metal Working Shop of Tianjin, the First Machine Tool Plant, column supports which were strengthened before the earthquake cracked but did not fall down.
   (Photo: Liao Shutang)

296. At the beginning of 1976 at the Tianjin Generating Electricity Equipment Plant, gables were strengthened with steel bars and angle steel and were intact after the earthquake.
   (Photo: Li Yihong)
297. The joints between brick columns and concrete beams were strengthened by angle steel and bolts and were intact after the earthquake at the Tianjin Generating Electricity Equipment Plant. (Photo: Tianjin Building Design Institute)

298. The tops of gable walls remained intact at a tall mill, which was strengthened before the earthquake, at the Tianjin Generating Electricity Equipment Plant. (Photo: Information Center of the Tianjin Building Design Institute)
299. The Spinning Department of the Huaxian Textile Mill in the city of Tangshan totally collapsed. (Photo: Earthquake Research Institute, State Seismological Bureau)
300. The bottom of the brick columns was damaged and the end span portions collapsed at the Locomotive Shop of the Tangshan Rolling Stock Plant. (Photo: Tong Maoling)

301. At the Tangshan Chemical Fertilizer Plant the gable wall and the end span of the roof collapsed. (Photo: Chen Dasheng)
302. At the Repair Shop of the Hebei Institute of Mining and Metallurgy in the city of Tangshan, the main span was slightly damaged and the bearing wall and the roof of the auxiliary span collapsed. (Photo: Central Research Institute of Building and Construction, Ministry of Metallurgical Industry)

303. The Calcine and Chomotte Shops of the Kailuan Guogezhuang Alumina Mine collapsed. (Photo: Coal Mine Bureau of Kailuan)
304. The Repair Plant of the Majiagou Mine, Coal Mine Bureau of Kailuan had bearing brick walls and brick columns. One side of the wall and columns broke at the elevation of windowsill, a crane beam collapsed and one side of the light roof fell down with it. (Photo: Sun Ming)

305. A warehouse with brick column bearings collapsed at the Tianjin Chemical Works. (Photo: Liao Shutang)
306. Brick columns broke at the crane beam level at the Belt Conveyer Shop of the Tangshan Metallurgical Mining Machinery Plant. (Photo: Earthquake Resistance Office, Ministry of Machinery Industry)

307. Brick columns at the diagonal brace cracked at the End Product Warehouse of the Qixin Cement Plant. (Photo: Chen Dasheng)
308. The light roof structure and a brick column were damaged at the Air Compressor Shop of the Tangshan Iron and Steel Company. (Photo: Central Research Institute of Building and Construction, Ministry of Metallurgical Industry)

309. The bottom of the columns at a metal material shed was damaged at the Majiagou Mine, Coal Mine Bureau of Kailuan. (Photo: Earthquake Resistance Group of the Design Administration Bureau, Ministry of Coal Industry)
310. The bottom of the columns were damaged at the Vertical Miller Shop of the Tianjin Xinhe Shipyard. (Photo: Dong Jincheng)

311. The brick columns below the windowsills collapsed at the Tianjin Xinhe Shipyard. (Photo: Liao Jishan)
312. Brick columns were damaged at a warehouse at the Ethylene Chloride Monomer Pitcher of the Dagu Chemical Works in the city of Tianjin. (Photo: The Sixth Design Institute, Ministry of Chemical Industry)
313a. The powdering building of the Tangshan Flour Mill was a 5-story poured-in-place frame structure which basically remained intact. The wheat barn to the right of the building was a 5-story brick masonry structure. The top floor collapsed and the brick columns on the bottom floor were broken off, seated in the initial place and tilted. This was caused by bearing capacity failure likely associated with liquefaction. (Photos: Hei Deyong and Institute of Geology, State Seismological Bureau)
313b. Back view of the powdering building and wheat barn.
314. The projecting portion of the top floor collapsed at the Winnowing Coal Dust Shop of the Jixin Cement Plant in the city of Tangshan. (Photo: Chen Dasheng)

315. The limestone vibrating screening building of the Tangshan Iron and Steel Company was a 4-story poured-in-place frame structure. The columns on the second floor broke off and the third and fourth floors settled down onto the first floor. (Photo: Central Research Institute of Building and Construction, Ministry of Metallurgical Industry)
316. A full view of damage of the main mill building at the Douhe Power Plant. (Photo: Shi Goubin)

317. The light roof plate collapsed at the Douhe Power Plant. (Photo: Qi Yongquan)
The fifth floor toppled down at a pre-cast 5-story frame structure between the Deoxidizing Shop and Coal Bunker at the Douhe Power Plant. (Photo: Shi Goubin)
319. Portions of the upper posts were broken off at the Turbo Generator Shop of the Douhe Power Plant which was a pre-cast frame structure. (Photo: Wang Gongkang)

320. The frame columns broke off and collapsed at the Deoxidizing Shop and Coal Bunker at the Douhe Power Plant. (Photo: Shi Guobin)
321. Poured-in-place reinforced concrete coal bunker at an elevation of 30 m fell down to an elevation of 8 m at the Douhe Power Plant. (Photo: Wang Gongkang)

322. The frame structure was seriously damaged and the protective brick walls collapsed at the Turbo Generator Shop of the Douhe Power Plant. (Photo: Shi Guobin)
323. There were cracks at the joint between the longitudinal pre-cast frame beam and column at the Douhe Power Plant. (Photo: Wang Gongkang)

324. The end column of the assembly frame was shattered. The main reinforcing bars deformed and hoop reinforcements were broken at the Douhe Power Plant. (Photo: Shi Guobin)
325. The majority of the in-fill walls collapsed at the coal crusher room at the Douhe Power Plant. (Photo: Shi Guobin)
326. The in-fill wall was damaged at the Deoxidizing Shop and Coal Bunker at the Douhe Power Plant. (Photo: Shi Guobin)

327. The in-fill wall was damaged at the main mill building of the Douhe Power Plant. (Photo: Shi Guobin)
328. An acetylene station at the Kaiping Chemical Works in the city of Tangshan was a 4-story frame poured-in-place structure. The joints between the beam and column were seriously damaged. (Photo: The Sixth Design Institute, Ministry of Chemical Industry)
329. The Mirabilite Shop of the Kaiping Synthetic Chemical Plant in the city of Tangshan was a poured-in-place 4-story frame structure with filled walls. The columns of the third floor broke, the fourth floor fell to the third floor and was displaced to the north. (Photo: Seismological Brigade, State Seismological Bureau)

330. The beams of the frame broke at the synthetic tower at the Guye Chemical Fertilizer Plant. (Photo: Zhan Xinxin and Bai Chungzhang)
331. At the Guye Chemical Fertilizer Plant the top floor of the frame structure was brick. After the earthquake the brick masonry at the top floor collapsed and the poured-in-place roof was destroyed. (Photo: The Sixth Design Institute, Ministry of Chemical Industry)

332a. There were brick walls on the top floor and an open story at the bottom floor at the dress-room building of the Linxi Coal Mine, Coal Mine Bureau of Kailuan. After the earthquake the column caps of the bottom story were damaged. (Photos: Yang Derong)
332b. A close-up view of a damaged column cap at the dress-room building.

333a. The pithead room of the Fangezhuang main pit, Coal Mine Bureau of Kailuan was a 5-story poured-in-place frame structure. The skip store house located at the top collapsed. (Photos: Earthquake Resistant Group of Design Administration Bureau, Ministry of Coal Industry and Coal Mine Bureau of Kailuan)
333b. A full view of the collapse at the Fangezhuang main pit.

334. The shaft at the Coal-Dressing Shop at the Zhaogezhuang Mine 406 inclined. At the time of the earthquake the third floor was under construction; the shutterings on the second floor were not removed; and column caps were sheared and damaged. (Photo: Earthquake Resistance Group of Design Administration, Ministry of Coal Industry)
335. The frame structure was intact at the alumina material-supply system of Guogezhuang Alumina Mine, Coal Mine Bureau of Kailuan. (Photo: Zhang Xiguang)

336. The Titanium Chloride Workshop at the Tianjin Chemical Works had a reinforced concrete frame. The bottom story was slightly damaged and the brick masonry structure on the upper floor collapsed. (Photo: The Sixth Design Institute, Ministry of Chemical Industry)
337. The 666 Workshop at the Tianjin Chemical Works was originally a 4-story poured-in-place frame structure with a fifth story added later. The upper two stories were seriously damaged during the earthquake. (Photo: Information Station of Tianjin Building Design Institute)

338a. The Beicang Ceramics Warehouse of the Tianjin Handicraft Export and Import Company was a pre-cast 3-story frame structure with column capitals and tall columns. The front of the structure was basically intact. (Photos: Information Station of the Tianjin Building Design Institute)
338b. A joint between a beam and end column and gable wall was damaged at the Beicang Ceramics Warehouse.

338c. Frame columns were also damaged at the Beicang Ceramics Warehouse.
339. The corner column broke off at the middle south building of the Second Wool Mill in Tianjin. (Photo: Liao Shutang)

340. The steam absorption building of the Tianjin Caustic Soda Plant was a poured-in-place 13-story frame structure. The floors above the seventh floor collapsed. (Photo: Mao Shihong)
341a. A reinforced concrete shaft tower at the Xinfeng shaft of the Tangshan Coal Mine, Coal Mine Bureau of Kailuan was 40.25 m in height. It broke at the bottom, subsided, and the tower tilted in a N60°E direction with an angle of 6°25'.
(Photos: Seismological Brigade, State Seismological Bureau and Chen Dasheng)
341b. A close-up view of the bottom portion of the shaft tower at the Xinfeng shaft.

342. A foundation of a diagonal rack cracked, one foundation bolt out of 50 was sheared and three others were pulled out at the steel head-frame of pit No. 3 at the Tangshan Coal Mine, Coal Mine Bureau of Kailuan. (Photo: Sun Ming)
343. A steel shaft tower at the Tangshan Coal Mine, Coal Mine Bureau of Kailuan was basically remained intact. (Photo: Chen Dasheng)

344. A steel shaft tower for ventilation No. 2 at the Tangshan Coal Mine, Coal Mine Bureau of Kailuan basically remained intact. (Photo: Chen Dasheng)
345. The assembly reinforced concrete head-frame at the Guogezhuang Alumina Mine 17.5 m in height was slightly damaged. (Photo: Coal Mine Bureau of Kailuan)

346. The steel structure parts were basically intact and the brick columns supported by steel frames cracked at the mixed head-frame of pit No. 3 at the Tangjiazhuang Coal Mine, Coal Mine Bureau of Kailuan. (Photo: Coal Mine Bureau of Kailuan)
347. At the Fanggezhuang Coal Mine, Coal Mine Bureau of Kailuan, the steel head-frame of the main pit was 44.64 m high and was slightly damaged. The elevator house collapsed and the base of the elevator partially cracked 4 cm wide. (Photo: Coal Mine Bureau of Kailuan)

348. The column cap and column footing on the bottom floor were damaged at the cooling tower of mechanical ventilation at the Tangshan Iron and Steel Company. (Photo: Liao Jishan)
349. Both edges of a pillar on the bottom floor were damaged at the newly built cooling tower of the Second Steel Works of the Tangshan Iron and Steel Company. The photo to the right is a close-up view of the pillar damage. (Photos: Du Zhaomin)
350. The end of a frame beam was damaged and concrete at a column footing peeled off and reinforcing bars were bent out at the cooling tower at the Qixin Cement Plant in the city of Tangshan. (Photos: Chen Dasheng)
351. The cooling tower of the power plant at the Qixin Cement Plant in the city of Tangshan was slightly damaged. (Photo: Seismo-geological Brigade, State Seismological Bureau)
352. At the cooling tower of the Linxi Power Plant, Coal Mine Bureau of Kailuan, the jalousie cooling plate surrounded by screen at the lower portion fell down and joints between the beam and column of the frame were cracked. (Photo: Coal Mine Bureau of Kailuan).

353. The columns of the frame were broken at the sand tower of the Cast Steel Workshop of the Tangshan Rolling Stock Plant. (Photo: Xu Changjiang)
354. A brick cylindrical tube collapsed and a reinforced concrete funnel turned over at the precipitating tower at the Coal Dressing Plant of the Tangshan Coal Mine, Coal Mine Bureau of Kailuan. (Photo: Chen Dasheng)
STORAGE

355. Steel columns buckled and collapsed at the dolomite steel storage at the Second Steel Mill of the Tangshan Iron and Steel Company. (Photo: Central Research Institute of Building and Construction, Ministry of Metallurgical Industry)
356. Column caps of reinforced concrete columns on the bottom floor were broken off and the bunker settled on wagons at the elevated bunker at the Second Steel Mill of the Tangshan Iron and Steel Company. The photos are a close-up view of the broken column caps. (Photos: Central Research Institute of Building and Construction, Ministry of Metallurgical Industry)
357. The cover of a cylindrical cement container displaced 2 m at the Qixin Cement Plant in the city of Tangshan. (Photo: Seismo-geological Brigade, State Seismological Bureau)

358a. Reinforced concrete columns 5 m high were broken off and the cylindrical containers settled at the Qixin Cement Plant in the city of Tangshan. (Photos: Earthquake Research Institute, State Seismological Bureau and Han Jiagu)
358b. The damage condition of the lower ring beam of a cylindrical container at the Qixin Cement Plant.

358c. The damage condition of cylindrical containers which hit against each other at the Qixin Cement Plant.
359. The native-style cylindrical container for grain storage in the city of Tangshan was constructed of reed framework, straw, mud and lime hemp-fiber plastering. The circular roof of the empty container was damaged and the containers full of grain were basically intact. (Photo: Hei Deyong)

360. A brick structure on the top of a cylindrical cement container at the Guye Refractory Material Plant was damaged. (Photo: Xu Hanbing)
361. A cylindrical brick barn at the Guye grain depot, which was constructed with cement mortar, was slightly damaged. (Photo: Hei Deyong)

362. Four units on the left side of an expansion joint collapsed at a coal bunker supported by reinforced concrete columns at the Zhaogezhuang Mine, Coal Mine Bureau of Kailuan. The brick and wood structure at the top of the right side collapsed. (Photo: Earthquake Resistant Group of the Design Administration Bureau, Ministry of Coal Industry)
363. At the Zhaogezhuang Mine, Coal Mine Bureau of Kailuan, the brick structures on the top of a cylindrical silo collapsed while the barn remained basically intact. (Photo: Earthquake Research Institute, State Seismological Bureau)

364. Site soil liquefied and columns of screening and loading coal bunker were damaged at the Xujialou new shaft of the Tangjiazhuang Mine, Coal Mine Bureau of Kailuan. (Photo: Coal Mine Bureau of Kailuan)
365. Five units on one side of an expansion joint collapsed and three units on another side were seriously damaged at a cylindrical barn at the Fangezhuang Mine, Coal Mine Bureau of Kailuan. (Photo: Chen Dasheng)

366. Reinforced concrete cone funnels fell down and broke at the Fangezhuang Mine, Coal Mine Bureau of Kailuan. (Photo: Coal Mine Bureau of Kailuan)
CONVEYORS

367. At the loading passageway at the Second Steel Works of the Tangshan Iron and Steel Company, the protective brick wall collapsed and roof covers fell down (above) and column caps were damaged (left). (Photos: Yu Chuncheng and Han Jiagu)
368. The chord and web members buckled at a steel support structure at the Second Steel Works of the Tangshan Iron and Steel Company. (Photo: Han Jiagu)

369. A reinforced concrete support cross beam was damaged at the raw material passageway at the Iron Works of the Tangshan Iron and Steel Company. (Photo: Han Jiagu)
370. Short columns cracked at the horizontal conveyor at the Tangshan Mine, Coal Mine Bureau of Kailuan. (Photo: Zhang Qihao)

371. The horizontal conveyor at the top of a cylindrical silo at the Kailuan Guogezhuang Alumina Mine collapsed. (Photo: Zhang Xiguang)
372a. A conveyor building at the Kailuan Guogezhuang Alumina Mine broke off. (Photos: Central Research Institute of Building and Construction, Ministry of Metallurgical Industry)

372b. A close-up view of the damage at the Kailuan Guogezhuang Alumina Mine.
373. A conveyor and transfer building collapsed at the Kailuan Guogezhuang Alumina Mine. (Photo: Gu Zhiqing)

374. The protective brick wall collapsed and a span fell down at a conveyor of the Majiagou Mine, Coal Mine Bureau of Kailuan. (Photo: Chen Dasheng)
375. The protective wall totally collapsed at a conveyor belt of the Linxi Mine, Coal Mine Bureau of Kailuan. (Photo: Coal Mine Bureau of Kailuan)

376. The brick wall and top of the transfer structure collapsed at the conveyor of the Xujialou new shaft of the Tangshan Mine, Coal Mine Bureau of Kailuan. (Photo: Coal Mine Bureau of Kailuan)
377. The brick wall collapsed at the conveyor of the newly built Coal-Dressing Plant of the Zhaogezhuang Mine, Coal Mine Bureau of Kailuan. (Photo: Chen Dasheng)

378. The upper portion of a brick wall at a belt conveyor, supported by a brick arch at the Zhaogezhuang Mine, Coal Mine Bureau of Kailuan, was damaged. Only one side of the brick arch was seriously damaged. (Photo: Earthquake Resistant Group of the Design Administration Bureau, Ministry of Coal Industry)
379. A coal yard conveyor at Fangezhuang Mine, Coal Mine Bureau of Kailuan, had its protective brick wall collapse. The top cover slabs fell down and the supports differentially settled and dislocated. (Photo: Chen Dasheng)
380. A steel structure conveyor at Lujiatuo Mine, Coal Mine Bureau of Kailuan, collapsed due to damage of the brick supports. (Photo: Sun Ming)

381. The conveyor to deliver coal and the coal washing building at the Maoershan Chemical Fertilizer Plant in the city of Tangshan both collapsed. (Photo: Han Jiagu)
382. The conveyor at the Tianjin Caustic Soda Plant in Tanggu District in the city of Tianjin subsided 15 cm. The photo below is a view of the damaged joint support.

(Photos: Liao Shutang)
383. The brick cylinder wall collapsed and a water tank dropped at the Tangshan Oil Pump Plant. (Photo: Chen Dasheng)
384. The brick cylindrical wall of a water tank collapsed and the water tank dropped at the Tangshan Measuring and Cutting Tools Plant. (Photo: Chen Dasheng)

385. During the earthquake a water tank on a masonry tower at the Steel Mill of the Tangshan Iron and Steel Company was empty. After the earthquake horizontal ring cracks were found at the bottom portion of the brick cylindrical wall but the water tank remained intact. (Photo: Central Research Institute of Building and Construction, Ministry of Metallurgical Industry)
Diagonal cracks occurred on the cylindrical brick wall of a water tower at Kaipingzhen in the city of Tangshan. (Photo: Lei Tongshun)
387. The reinforced concrete wall of a cylindrical water tower, which had a 300 t capacity, was slightly damaged at the Tangshan Railway Station. (Photo: Liao Shuqiao)

388. X-shaped cracks occurred on the cylindrical brick wall of a water tower in Zunhua county town. (Photo: Chen Dasheng)
389. The lower portion of cylindrical support at a water tower at the Lutai Railway Station, Ninghe County in the city of Tianjin, was constructed of stone 8 m in height and the upper portion was brick masonry 9 m in height. After the earthquake the cylindrical brick wall collapsed and the steel water tank dropped down onto the stone cylindrical support. (Photo: Beijing Railway Bureau)

390. A water tower of the Tianjin Course Bureau was 35 m high with a 60 t capacity. The cylindrical brick wall fell apart and the water tank dropped vertically. (Photo: Tian Yuqing)
391. The cylindrical support of a 50 t water tower at the Tianjin Chemical Plant was 15 m high and the water tank was 5 m high. The cylindrical brick wall collapsed at the bottom. (Photo: Li Yihong)

392. The cylindrical brick wall cracked at a 200 t water tower at the Tianjin Engineering Mechanical Plant. The photos show the front and back views. (Photos: Earthquake Resistant Office, Ministry of Machinery Industry)
393. The base of a water tower at the Tianjin Xinhe Shipyard was horizontally dislocated while the upper portion basically remained intact. The photo below is a close-up view of the dislocation at the base. (Photos: Xinhe Shipyard)
A large piece of brick masonry collapsed at a water tank at the Xiji Supply and Marketing Cooperative, Tongxian County in the city of Beijing. X-shaped cracks occurred on the back of the water tank (below). (Photos: Earthquake Resistant Code Group of the Beijing Design Institute of City Planning and Tong Xingzhen)
395. The upper portion of a brick chimney at the Tangshan Rolling Stock Plant collapsed and the middle portion cracked at various levels. (Photo: Qian Peifeng)
396. A brick chimney at the Tangshan Power Industrial Bureau collapsed at the base and the upper portion dropped. (Photo: Chen Dasheng)

397. A brick chimney at the Tangshan Exhibition Hall was horizontally displaced at the bottom and the middle portion sheared. (Photo: Shanghai Design Institute of City Planning)
398. The upper portion of a brick chimney collapsed and the middle and lower portions were sheared at the Cast Steel Workshop of the Tangshan Iron and Steel Company. (Photo: Han Jiagu)

399. A brick chimney at the Tangshan Printing and Dyeing Mill, 35 m high, broke into five sections. The maximum displacement was 30 cm. (Photo: Seismo-geological Brigade, State Seismological Bureau)
400. The upper portions of the brick chimneys at the Tangshan Architectural Ceramic Works were damaged. (Photo: Chen Guishen)

401. A brick chimney at the Tangshan Fifth Ceramic Works broke at the base and bricks were scattered around. (Photo: Han Jiagu)
402. A brick chimney at the Tangshan Railway Institute collapsed at the bottom.  
(Photo: Chen Dasheng)

403. A brick chimney at the Fengnan Chemical Fertilizer Plant toppled over.  
(Photo: Chen Dasheng)
404. The brick chimney at Gaozhuangzi Commune collapsed. (Photo: Institute of Geology, State Seismological Bureau)

405. A brick chimney collapsed to one side at the Phosphate Fertilizer Plant of Leting County. (Photo: Zhang Qihao)
406. The upper portion of a brick chimney, 37 m high, cracked and tilted at the Chemical Fertilizer Plant of Sanhe County. (Photo: Institute of Geology, State Seismological Bureau)
407. The upper two thirds of a brick chimney at the Hangu Salt Works in the city of Tianjin collapsed and also broke at the base. (Photo: Xie Yunxiang)

408. The upper portion of a brick chimney at the Tianjin Metallurgical Materials Plant collapsed. A small section sat on the top of the un-collapsed portion. (Photo: Dong Jincheng)
A chimney at Shigezhuang Commune, Baodi County in the city of Tianjin, which was 37 m high, dislocated at the upper 10 m portion.

(Photo: Institute of Geology, State Seismological Bureau)
410. A brick chimney of the Beijing Institute of Foreign Trade, 34 m high, dislocated at the upper 8 m. The displacement was roughly 7 cm with clockwise torsion. (Photo: Institute of Geology, State Seismological Bureau)
411. The upper portion of a brick chimney cracked and partially toppled down at Sanlihe in the city of Beijing. (Photo: Lei Tongshun)

412. The upper portion of this brick chimney, at the Grape Garden residential quarter on Zhanlan Road in the city of Beijing, shows crisscross fractures. (Photo: Lei Tongshun)
413. The upper portion of a brick chimney collapsed at the Xiaotangshan Sanatorium of Changping County in the city of Beijing.
(Photo: Institute of Geology, State Seismological Bureau)
414. The upper strap-strengthened portion of a square chimney remained intact and the middle portion cracked at the Majiagou Fireproof Material Works in the city of Tangshan. (Photo: Han Jiagu)

415. Stovepipes on a roof were broken with clockwise torsion in Fengren county town. (Photo: Seismo-geological Brigade, State Seismological Bureau)
416. The lower half of a chimney constructed of low-grade mortar was seriously damaged while the upper half made with high-grade mortar (50 grade) remained intact at the Beijing Municipal Engineering Bureau. (Photo: Lei Tongshun)

417. A chimney with a water tower at the Baigezhuang Farm Chemical Works was basically left intact. (Photo: Yang Deyong)
418. A chimney with a water tower basically remained intact at the Baigezhuang Chemical Fertilizer Plant. (Photo: Yang Deyong)

419. A reinforced concrete chimney at the Tangshan Rolling Stock Plant remained intact. (Photo: Ma Fukang)
420. Reinforced concrete chimneys and cooling towers at the Tangshan Power Plant basically remained intact. (Institute of Geology, State Seismological Bureau)

421. A reinforced concrete chimney 180 m high at the Douhe Power Plant broke and toppled over at an elevation of 130.5 m. (Photo: Shi Guobin)
422. The upper portion of a brick chimney collapsed while steel chimneys with tension stays basically remained intact at the Casting Works of the Tangshan Iron and Steel Company. (Photo: Zhang Zhaoxiang)

423. At the Xinfeng Shaft of the Tangshan Mine, Coal Mine Bureau of Kailuan, one of the steel chimneys with tension stays broke off and the other remained intact. (Photo: Chen Dasheng)
FURNACES AND KILNS

424. A lime kiln at the Raw Material Works of the Tangshan Iron and Steel Company collapsed. (Photo: Zhang Zhaoxiang)
425. The pellet sintering vertical kiln at the Iron Works of the Tangshan Iron and Steel Company was a poured-in-place reinforced concrete structure. It had no filled walls on the bottom floor and during the earthquake the reinforced concrete columns broke and the vertical kiln collapsed. (Photo: Central Research Institute of Building Construction, Ministry of Metallurgical Industry)

426. The end of a platform of a coking furnace at the Tangshan Coking Plant collapsed. (Photo: Han Jiagu)
427. The furnace wall of a coke oven carbonization room at the Tangshan Coking Plant partially peeled off. (Photo: He Guangfu)

428. At a coke oven at the Tangshan Coking Plant, the upper and lower joints of a side column of a base frame burst apart. (Photo: Han Jiagu)
429. A lift pipe on the top of a coke oven tilted at the Tangshan Coking Plant.  
(Photo: Han Jiagu)

430. The upper portion of kiln No. 8 collapsed at the Qixin Cement Plant in the city of Tangshan.  
(Photo: Earthquake Research Institute, State Seismological Bureau)
431a. The columns of a frame broke at a rotary kiln at the Kailuan Guogezhuang Alumina Mine. (Photos: Han Jiagu and Zhang Xiguang)

431b. A furnace collapsed at the Kailuan Guogezhuang Alumina Mine.
431c. A roof cover fell down and hit a rotary kiln at the Kailuan Guogezhuang Alumina Mine.

431d. A rotary kiln remained intact at the Kailuan Guogezhuang Alumina Mine.
432. A cast iron support of a gear wheel of a cooling drum tilted outward and broke at the Kailuan Guogezhuang Alumina Mine (above). The kiln body dislocated and the gear wheel was displaced (below). (Photos: Han Jiagu)
Columns of the frame of a vertical kiln were slightly damaged (above) and the concrete of the column top of a base frame cracked horizontally (below) at the Kailuan Guogezhuang Alumina Mine. (Photos: Han Jiagu)
434. An end platform of a coking furnace collapsed at the Maoershan Chemical Fertilizer Plant in the city of Tangshan. (Photo: Han Jiagu)

435. A lime kiln at the Tianjin Dongsheng Resin Works collapsed. (Photo: Liao Shutang)
436. The brick protective wall collapsed at a steel oil tank of 500 cubic meters but the oil tank remained intact which was in the city of Tangshan. (Photo: Earthquake Resistance Office, Ministry of Commerce)
437. Three vertical oil tanks of 100 cubic meters remained intact in the city of Tangshan. (Photo: Earthquake Resistance Office, Ministry of Commerce)

438. An oil tank of 1000 cubic meters had the joint between the wall and the bottom of the tank crack, in the city of Tangshan. (Photo: Earthquake Resistance Office, Ministry of Commerce)
439. A vertical oil tank at the Tangshan Fat Depot remained intact.  
(Photo: Yang Wenzhong)

440. A group of elevated tanks collapsed at the Tangshan Oil Depot.  
(Photo: Earthquake Resistance Office, Ministry of Commerce)
441. Slight horizontal cracks were found on the support of the elevated tanks at the Tangshan Oil Depot. (Photo: Earthquake Resistance Office, Ministry of Commerce)

442. An outside oil depot remained intact at the Douhe Power Plant. (Photo: Shi Guobin)
443. Brick walled oil tanks, partially underground, remained intact at the northern oil depot of the Tangshan Iron and Steel Company. (Photo: Central Research Institute of Building and Construction, Ministry of Metallurgical Industry)

444. Oil tanks, partially underground, remained intact at the Tangshan Rolling Stock Plant. (Photo: Yang Wenzhong)
445. An underground horizontal oil tank covered by soil remained intact in the city of Tangshan. (Photo: Earthquake Resistance Office, Ministry of Commerce)

446. The bottom of a 1000 cubic meter oil tank buckled at the Tianjin Chemical Plant. (Photo: Yu Zufan)
447. The bottom wall of a 1500 cubic meter oil tank buckled in the city of Tianjin.  
(Photo: Earthquake Resistance Office, Ministry of Commerce)

448. A 1000 cubic meter steel oil tank remained intact in the city of Tianjin.  
(Photo: Earthquake Resistance Office, Ministry of Commerce)
The floating deck at the Tangshan Chemical Fertilizer Plant tilted (above) and the pilot wheel broke (left). (Photos: Chen Dasheng).
450a. The brick base of a dust remover was damaged and the cylindrical body of reinforced concrete settled and tilted at the Douhe Power Plant. (Photos: Shi Guobin)

450b. A close-up view of the broken base of the dust remover at the Douhe Power Plant.
451. A dust remover at the Douhe Power Plant tilted and the joint of a flue pipe and expansion section were pulled off. (Photo: Wang Gongkang)
An ion converter at the Douhe Power Plant was totally displaced and toppled over. The photo below is a close-up view of the damaged bottom. (Photos: Wang Gongkang)
453. The west side of the vault peeled off and a beam used to set up lines was bent at garage No. 4, the ninth horizontal tunnel of the Tangshan Mine, Coal Mine Bureau of Kailuan.
454. At the north lane of the eleventh horizontal tunnel of the Tangshan Mine, Coal Mine Bureau of Kailuan, the vault peeled and cracked 25 cm in width.

455. Temporarily supported by an arch support a lane collapsed and fell down at a parking lot at the eleventh horizontal tunnel of the Tangshan Mine, Coal Mine Bureau of Kailuan.
456. The top and both sides of the arch support collapsed at the south wing train lane at the eleventh horizontal tunnel of the Tangshan Mine, Coal Mine Bureau of Kailuan.

457. The top of each arch peeled off and bulged at the parking lot for empty cars at the pit head of shaft No. 7 at the twelfth horizontal tunnel of the Tangshan Mine, Coal Mine Bureau of Kailuan.
458a. The stone arch of the engine garage peeled off at a parking lot at the bottom of the shaft at the twelfth horizontal tunnel of the Tangshan Mine, Coal Mine Bureau of Kailuan.

458b. The stone arch of the heavy truck lane cracked at the twelfth horizontal tunnel of the Tangshan Mine, Coal Mine Bureau of Kailuan.
Under the twelfth horizontal tunnel of inclined shaft of 2100 belt at the Tangshan Mine, Coal Mine Bureau of Kailuan, an arch 100 m from the feed coal engine was compressed, cracked and peeled off (above). The roof, 150 m from the feed coal engine, fell (left).
460. The machine of the inclined shaft of 2100 belt at the Tangshan Mine, Coal Mine Bureau of Kailuan was blocked and covered by coal and water. There were two holes for cleaning silt and water, one was silted up and the other had only 50 cm of height left.

461. The belt, frame, wire rope and bracket roll of conveyor broke at the lift and carry section of the twelfth and thirteenth horizontal tunnels of inclined shaft of 2100 belt at the Tangshan Mine, Coal Mine Bureau of Kailuan.
462. At the belt conveyor path from the stone gate to half way to the thirteenth horizontal tunnel at the Tangshan Mine, Coal Mine Bureau of Kailuan, the rock at the entrance of the cross pipe broke (above). The top of the cross pipe collapsed and waste rock piled up (below).
463. The mouth of the tunnel collapsed at the thirteenth tunnel of the Tangshan Coal Mine, Coal Mine Bureau of Kailuan.

464. Temporarily supported by an arch support, the vault cracked and peeled off at the entrance of the pump house at the thirteenth horizontal tunnel of the Tangshan Mine, Coal Mine Bureau of Kailuan.
465a. The underground tunnel at Lutaizhen, Ninghe County in the city of Tangshan had a reinforced concrete bottom plate, brick wall and brick arch with cement mortar. Ring cracks occurred at the tunnel crossing (left). (Photos: Liu Guanghan and Zhang Zongyan)

465b. Both sides of the wall corners also suffered cracks at the underground tunnel at Lutaizhen.
466a. Underground tunnels of reinforced concrete bottom plates, brick walls and brick arches were not covered with backfill in Hangu District in the city of Tianjin. There were cracks 9 cm wide at the t-shaped joints and vertical displacement of 14 cm. (Photos: Zhang Zongyan)

466b. There were cracks in a tunnel in Hangu District.
467. There were oblique cracks of 45° at t-shaped joints at the tunnels in Hangu District. (Photo: Zhang Zongyan)

468. An underground tunnel in the center of the city of Tianjin had longitudinal cracks at the top edge of the arches, 3 cm in width with 1.5 cm of vertical displacement, where they were not covered by backfill (Photo: Zhang Zongyan)
469. There were annular cracks, sand boils and waterspouts at the underground tunnel of the Fireproof Material Works of Tianjin. (Photo: Zhang Zongyan)

470. The Tianjin subway, a reinforced concrete structure, was intact after the earthquake. (Photo: Zhang Zongyan)
The welding seam broke at the elbow of the steel pipe joint at the water treatment pool and pump house at the waterworks of the northwest suburbs of Tangshan city.
472. The steel circulatory water pipes at the Douhe Electrical Power Plant remained intact. (Photos: Wang Gongkang)
473. The Φ900 steel pipes for delivering water to a pump house near a riverbank of the Tianjin Caustic Soda Works, Tanggu District in the city of Tianjin, had a crushed elbow which was seriously damaged due to sliding of the riverbank.

474. The elbow of the Φ300 drainage pipelines was crushed at the Tianjin Caustic Soda Works.
475. At the Tangshan East Waterworks, there was 15 cm of vertical displacement at the joint of the Φ300 cast iron pipeline and the bottom of the joint broke.

476. At the Tangshan East Waterworks, the joint of the Φ200 cast iron pipeline was pulled apart 3 cm with 22 cm of vertical displacement.
477. At the Tangshan East Waterworks, the joint of the Φ300 cast iron pipeline at well No. 14 was pulled apart 25 cm (left).

478. At the Tangshan East Waterworks the Φ300 cast iron pipeline broke at the sleeve and the joint pulled apart 15 cm.
The Φ200 joint pulled apart 10 cm, Φ75 middle-mouth dislocated 1 cm at the joint of a cast iron tee pipe at Liulin in the city of Tianjin.

The Φ200 cast iron valve of natural gas line broke at Liulin in the city of Tianjin.
481. The Φ200 cast iron pipeline valve of natural gas broke, pulled apart 54 cm, had 4 cm of vertical displacement and 10 cm of horizontal displacement at Liulin in the city of Tianjin.

482. At the Tianjin General Paper Mill the flange of the Φ500 cast iron pipeline broke.
483. At the Tianjin General Paper Mill the straight pipeline flange linking the $\Phi 500$ cast iron pipeline and elbow broke.

484. At the North Suburb Waterworks in the city of Tangshan, a rubber ring broke away from the joint of the $\Phi 400$ pressure cement pipeline but the cement filling was still in the joint.
485. At the North Suburb Waterworks in the city of Tangshan, water spouted from the joint of the Φ500 pressure water pipeline (rubber ring joint).

486. The joint of a reinforced concrete circulatory water pipeline dislocated and was vertically displaced at the Douhe Power Plant.
487. The joint of a reinforced concrete circulatory water pipeline dislocated at the Douhe Power Plant.

488. A joint of the dust removing pipeline pulled apart at the Douhe Power Plant.
(Photo: Shi Guobin)
489. At the Douhe Power Plant, the Φ600 pre-stressed concrete dust removing pipeline was snakelike in shape. (Photo: Shi Guobin)

490. A joint of reinforced concrete water pipeline from the Douhe Reservoir to the power plant pulled apart. (Photo: Chen Dasheng)
491. The circulatory water supply pipeline pulled apart at the Tianjin Chemical Works, Hangu District in the city of Tianjin. (Photo: The Sixth Design Institute, Ministry of Chemical Industry)

492. At the Tianjin Chemical Works, the Φ1500 water supply pipeline broke near the joint. (Photo: The Sixth Design Institute, Ministry of Chemical Industry)
493. The joint of a concrete sewage pipe pulled apart at the Yueya riverbank, Zhangdazhuang, in the city of Tianjin.

494. The joint of a drain pipe pulled apart and the plaster broke near the No. 1 bridge of Jingtang Highway in the city of Tianjin. (Photo: Tong Xingzhen, et al)

(Photos without credits in this section have all been supplied by the Group of Earthquake Resistance Code, Beijing Design Institute of Municipal Administration)
495. A pipe on top of its support was displaced at the Tangshan Iron and Steel Company. (Photo: Du Zhaomin)
496. A pipe slipped off of its support at the Second Steel Works of the Tangshan Iron and Steel Company. (Photo: Han Jiagu)

497. A pipe slid and its bracket was displaced at the Tangshan Coking Plant. (Photo: He Guangfu and Qu Zhaojia)
498. The brick support of a recovery pipe collapsed and the pipe fell to the ground at the Tangshan Coking Plant. (Photo: Han Jiagu)

499. At the Douhe Power Plant an I-shaped steel support on the top of an elevator shaft pulled apart and bent. (Photo: Wang Gongkang)
500. At the Douhe Power Plant the end of a steel truss footpath between an elevator shaft and oxygen remover at a coal bunker bent and pulled apart. (Photo: Wang Gongkang)

501. The roof of a vaporization room at the Douhe Power Plant collapsed and smashed the pipes and facilities. (Photo: Wang Gongkang)
502. A pumping station at a village in Luanxian County collapsed but the pipeline was basically intact. (Photo: Qi Yongquan)

503. At the Tianjin Chemical Works a reinforced concrete support for a pipe was damaged. (Photo: Mao Shihong)
504. At the Tianjin Caustic Soda Works a support for an overhead pipe was damaged.
(Photo: Earthquake Resistance Office, Ministry of Machinery Industry)
505. At the Dagu Chemical Works in the city of Tianjin, the pipeline at the section of polyvinyl chloride polymerization was basically intact. (Photo: Han Guangzhu)
506. Two phases of 110 KV circuit breakers with less oil were pulled out from the base at the Tangshan Power Plant.

507. One phase of 110 KV circuit breakers with less oil was pulled out from the base at the Tangshan Power Plant.
508. At the Tangshan Power Plant the support frame for leading wire from the 110 KV iron core sector filled with oil and was pulled out of the anti-shock wall.

509. All three phases of the 110 KV bus bar lighting arrester were broken at the base at the setup station of the Tangshan Power Plant.
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510. Insulator string and lead wire broke and the sleeve broke at the base at the set-up transformer substation at the Tangshan Power Plant.

511. The transformer substation of the Tangshan Power Plant was basically intact.
512. The 115 KV switch with less oil, current mutual inductance, voltage mutual inductance and circuit breaker were intact at the Tangshan Power Plant.

513. Two phases of 115 KV switch with less oil were intact at the Tangshan Power Plant.
514. A transformer at the Douhe Power Plant displaced and tilted.

515. At the Douhe Power Plant, fixed bolts connecting a wheel at the bottom of a transformer were sheared, the transformer tilted, the wheel stand separated and the wheel positioner bent.
516. At the Douhe Power Plant a porcelain insulator for a lightning arrester at the middle portion of a transformer broke.

517. The bus bar of a side phase was shaken down at a transformer substation at the Douhe Power Plant.
One phase broke, one phase parted from the casing pipe of a pillar and damage occurred at the insulator of the 220 KV lightning arrester at a transformer substation at the Douhe Power Plant.

(Photos 506-518 were supplied by Qi Yongquan)
519. Electric porcelains were seriously damaged but the structure basically remained intact at the 220 KV step-up station of the Douhe Power Plant. (Photo: Shi Guobin)

520. Electric porcelain insulators broke at the 220 KV step-up station at the Douhe Power Plant. (Photo: Wang Gongkang)
521. At the 220 KV step-up station at the Douhe Power Plant, the structure was basically intact and the SF6 switch was intact. (Photo: Wang Gongkang)

522. The bus bar of a side phase pulled apart and the lightning arrester broke at a 110 KV transformer substation at the Douhe Power Plant. (Photo: Qi Yongquan)
523. The main transformer derailed at the Jiaanzi transformer substation in the city of Tangshan. (Photo: Wang Gongkang)

524. A 35 KV lightning arrester broke and fell down at the Jiaanzi transformer substation in the city of Tangshan. (Photo: Wang Gongkang)
525. A structural beam collapsed at the Lujiatuo transformer substation in the city of Tangshan. (Photo: Qi Yongquan)

526. Soil liquefaction occurred, a transformer collapsed and a support frame tilted at the main transformer substation of Fangezhuang Mine, Coal Mine Bureau of Kailuan. (Photo: Coal Mine Bureau of Kailuan)
527. An oil switch and an electric porcelain broke and fell down at the Hangu transformer substation in the city of Tianjin. (Photo: Shi Guobin)

528. A support tilted, a cross beam broke and a voltage mutual inductance fell down at the Hangu transformer substation in the city of Tianjin. (Photo: Shi Guobin)
529. Voltage mutual inductances which had been strengthened remained intact at the Junliangcheng Power Plant in the city of Tianjin. (Photo: Wang Gongkang)

530. Porcelains of electric facilities linked with flexible cord remained intact at the Junliangcheng Power Plant in the city of Tianjin. (Photo: Wang Gongkang)
531a. Main transformers, which were fixed or had a spacing device before the earthquake, showed no signs of derailment or displacement after the earthquake (above and below).

(Photos: Wang Gongkang)
531b. Photos of main transformers continued (above and below).
532. Column caps were sheared and the pool dropped down at a sewage treatment pool at the Guye Chemical Fertilizer Plant. (Photo: The Sixth Design Institute, Ministry of Chemical Industry)
533. At the precipitating tank of the Tanggu Waterworks in the city of Tianjin, the body of the tank cracked, the multi-hole wall at the water entrance collapsed, cracks 50 cm of visible depth were found on the foundation, expansion joints at the base plate pulled apart 15 cm, and there was 5 cm of vertical displacement (left). (Photo: The Group of Earthquake Resistance Code, Beijing Design Institute of Municipal Administration)

534. The enclosing wall of the Cement Design Institute of Tangshan toppled over from the bottom to a side with no buttress. (Photo: Zhou Bingzhang)
535. An enclosing wall of an oxygen preparation station toppled over to the outer side at the Douhe Power Plant. (Photo: Shi Guobin)

536. An enclosing wall toppled over in both directions in Tanggu District in the city of Tianjin. (Photo: Earthquake Resistance Office, Ministry of Machine-Building Industry)
537. Reinforced concrete round electric poles partially broke (above) and toppled over (below) in the city of Tangshan. (Photos: Wang Gongkang)
538. A reinforced concrete electric pole broke at the Xinfeng shaft of the Tangshan Mine, Coal Mine Bureau of Kailuan. (Photo: Chen Dasheng)

539. Electric poles along the dam of the Douhe Reservoir were broken. (Photo: Chen Dasheng)
540. Reinforced concrete electric poles broke at Dagu Chemical Works in the city of Tianjin. (Photo: Han Guangzhu)

541. A breakwater wall cracked and a cast iron electric pole broke at the main dam of the Yanghe Reservoir. (Photo: Zhang Bochong)
542. The lightning arrester on top of a triangular reinforced frame structure was bent, at a transformer substation at the Xinfeng shaft of the Tangshan Mine, Coal Mine Bureau of Kailuan. (Photo: Earthquake Resistance Group of Design Administrative Bureau, Ministry of Coal Industry)
543. Three passenger trains on line for special use toppled over at the Tangshan Rolling Stock Plant. (Photo: Lu Yaoyong)
Jingshan line K248+150 (intensity rating IX), passenger train No. 40 derailed, the diesel locomotive caught fire, and rails were locally bent. (Photos: Chen Dasheng)
545. A goods train derailed and an oil tank toppled over on Jingshan line in the vicinity of K244+100 (intensity rating IX). (Photos: Chen Dasheng)
546. The photos to the left and below show four sections of the traveling oil tank train No. 041 that toppled over on Jingshan line in the vicinity of K221+100 (intensity rating IX).
547. The running train No. 1020 at the Lutai Railway Station on Jingshan line K219+700 (intensity rating IX) derailed and the rail broke off.

548. The running trains No. 117 derailed on the Jingshan line in the vicinity of K201+000 (intensity rating VII).
549. A section of continuous rail was seriously bent on Jingshan line.  
(Photo: Scientific Research Institute of Railways)

550. The continuous rail was horizontally bent on Jingshan line K312+250 (intensity rating IX).  (Photo: Zhang Naiheng)
551. The road bed cracked and subsided and the rail was horizontally bent on the Jingshan line K308+450 (intensity rating VIII). (Photo: Zhang Naiheng)

552. The rail was bent horizontally at K246+350 in the intensity IX region along the Beijing-Shanhaiguan (Jingshan line) Railroad. (Photo: Chen Dasheng)
553. The rail track was bent horizontally near a culvert in the vicinity of K244 (intensity rating IX) on the Jingshan line. (Photo: Chen Dasheng)

554. There were sand boils and waterspouts in many locations and the rail bent horizontally at the Lutai Railway Station on Jingshan line K219+700 (intensity rating IX).
555. The rail track bent horizontally at K192+000 (intensity rating VII) on the Jingshan line.

556. The rail track bent horizontally on the Nanbao line for special use K11+020 (intensity rating VIII).
557. The ground loosened and the rail bent horizontally on the Nanbao line for special use K10+730 (intensity rating VIII).

558. The embankment subsided and the rail bent on the Tongtuo up line in the vicinity of K0+400 (intensity rating IX).
559. The road bed and rail was deformed on the Tongtuo up line (intensity rating IX). (Photo: Institute of Geology, State Seismological Bureau)

560. The road bed subsided and the rail was seriously deformed on the Tongtuo up line K1+900 (intensity rating IX).
An embankment subsided and the rail was deformed on the Tongtuo up line (intensity rating IX).

At an excavated area of a man-made lake at the Tangshan Mine, Coal Mine Bureau of Kailuan, rails slipped and were deformed. (Photo: Chen Dasheng)
563. The road bed subsided and the rail bent on the Gu-Lu Fan Railway on the line for special use at the Coal Mine Bureau of Kailuan. (Photo: Coal Mine Bureau of Kailuan)

564. The ground was dense and stable and the rails were basically intact in the meizoseismal area (intensity XI) in the city of Tangshan.
565. The road bed was firm and the rail was basically intact at the Xugezhuang Station on the Jingshan line K254+800 (intensity rating X).

566. Limestone roadbed and the rail were intact on the Tongtuo up line K0+930-K1-360 (intensity rating IX).
567. The roadbed was saturated silt and a fine sand and the embankment subsided up to 3 m on the Jingshan line in the vicinity of K282+000 (intensity rating X).

568. Longitudinal fissures occurred along the road bed on Jingshan line in the vicinity of K250+500 (intensity rating IX).
569. The photo shows longitudinal fissures which were found along the road bed on Jingshan line in the vicinity of K191-K192 (intensity rating VIII).

570. At an 8 m span of reinforced concrete beam bridge on the Tongtuo up line K2+945 (intensity rating IX), the right embankment at the end of the bridge subsided and the rail hung in the air.
571. On the Tongtuo up line K2+600 (intensity rating IX), an embankment at the end of a 23.8 m span pre-stressed concrete beam bridge subsided 3 m.

572. On the Tongtuo up line (intensity rating IX), an embankment at the end of a bridge subsided and the facing of the slope was damaged.
573. The end of a railway bridge subsided and the rails hung in the air north of Shezhuang Village, Luanxian County. (Photo: Seismo-geological Brigade, State Seismological Bureau)

574. The up line bridge of the Ji Canal on Jinshan line K210+827 (intensity rating IX), had two 20 m spans of top supported plate girders shown at the right side of the photo, two 62.8 m spans of bottom supported trusses, an open caisson base and the ground was silty-sandy clay. The open caissons of the bridge pier No. 1 and No. 3 were shallower than No. 2. Bridge pier No. 1 and No. 3 relative to No. 2 subsided 0.68 m and 0.57 m. The bridge was impassable to traffic.
575a. Ground deformation at Ji Canal on Jingshan line shortened 2.31 m and the rail on the embankment on the end of the bridge on the Beijing side bent.

575b. The rail on the bridge floor became a broken line.
576. Bridge pier No. 1 (above) and bridge pier No. 3 (right) of Ji Canal on the Jingshan line each moved 2.0 m towards the center of the river.
577. On the Jingshan line the gravity abutment on the Shanhaiguan side slipped towards the center of the river. The plate girder bearing was damaged and the end of the girder stood up to the back wall of the abutment.

578. The down line bridge of the Ji Canal on Jingshan line K210+827 (intensity rating IX) was built with one 8.0 m span of an I-shaped beam, two 9.7 m spans of top supported plate girders, two 62.8 m spans of bottom supported trusses, one 15.7 m span of a top supported plate girder, a wood pile base and the ground was of a silty-sandy clay. The length of the ground deformation shortened 2.37 m and the rail track on the bridge floor was pressed and bent.
579. The concrete bridge piers of the down line bridge of the Ji Canal were broken off. The photo below is a close-up view of broken bridge pier No. 2.
(Photo: Chen Dasheng and Liao Shuqiao)
580. The rails were seriously bent at the end of the down line bridge of the Ji Canal on the Beijing side.

581a. On the down line bridge of the Ji Canal, the gravitational style abutment on the Shanhaiguan side slipped toward the center of the river roughly 1.6 m.
581b. The steel girder separated from the abutment on the Beijing side.

582. The up line bridge of the Yongding New River on Jingshan line K194+048 (intensity rating IV) had a series of 20-23.8 m spans of prestressed concrete beams. The ground was soft plastic sandy clay. The foundation had drill hole piles. After the earthquake there was no apparent change in the elevation of the supports.
583. On the up line bridge of the Yongding New River in the vicinity of bridge pier No. 13, the flood land displaced and cracked.

584. The bridge pier No. 13 displaced and the rocker shaft of movable bearings dislocated.
585. The abutment was displaced and an anchor bolt on bridge pier No. 15 was sheared on the up line bridge.

586. The abutment on the Shanhaiguan side of the up line bridge was broken.
587. At the Luanhe Bridge on the Jingshan line (intensity rating IX), the movable bearing on the Shanhaiguan side of the top supported plate girder on the 20th span was tilted. (Photo: Zhang Naiheng)

588. On the Beijing side of the Luanhe Bridge, one anchor bolt bent and the other sheared at the 20th span of the up line. (Photo: Zhang Naiheng)
589. At the Tongtuo up line K3+157 (intensity rating IX), one 8.0 m span of reinforced concrete beam sideways 0.5-1.2 m.

590. On the Tongtuo up line K2+704 (intensity rating IX), a 23.8 m span of a prestressed concrete beam bridge was displaced to the curved side 0.5 m.
591. On the Tongtuo up line K2+271 (intensity rating IX), one beam of a 12.0 m span of a reinforced concrete beam bridge was transversely displaced 75 cm.
592. On the Tongtuo up line K2+600 (intensity rating IX), a 23.8 m span of a prestressed concrete beam bridge located on a circular arc of R=600 m, the curved external side beam fell into the river (above). The photo to the right is a profile view. The foundation material was saturated silt and fine sand. (Photos: Liao Shuqiao and Chen Dasheng)
593a. The Douhe River Bridge on Tangzun line K2+955 (intensity rating X), had three 16.0 m spans of reinforced concrete beams. The ground was saturated silt and fine sand. The distance between abutments was shortened 3.70 m and the plain concrete abutment and bridge piers were sheared. (Photos: Liao Shuqiao and Xu Changjiang)
593b. The photos on this page are close-up views of the sheared abutment and bridge piers.
594. On Jingshan line K266+926 (intensity rating IX) there were three 19.0 m spans of a top supported plate girder bridge. Before the earthquake the neighboring ends of the spans were connected by steel plates.

595. Before the earthquake on Jingshan line K255+926, a $\Phi 26$ round reinforcing bar was connected to the two adjacent rings to prevent separation. After the earthquake the reinforcing bar was pulled off and broken. See Photo 596 for an example. (Photo: Liu Chun)
Before the earthquake, at the up line bridge of Yongding New River on Jingshan line K194+048 (intensity rating VII), rings at the adjoining beam ends were connected by double Φ26 reinforcing bars to prevent separation (above). The concrete at the ends of the beam was cracked and broken (below).
597. Two 6.0 m spans of reinforced concrete slabs over trunk culverts were intact after the earthquake at the Yonghong tunnel bridge in the city of Tangshan (intensity rating XI).

598. Two 4.0 m spans over reinforced concrete trunk culverts were intact after the earthquake on Jingshan line K255+000 (intensity rating X).
599a. A close-up view of a wood canopy at the Tangshan Railway Station which remained intact.

599b. Another view of the wood canopy at the Tangshan Railway Station.
600. A platform bridge constructed of steel at the Tangshan Railway Station was intact.

601. In the city of Tangshan, the retaining wall of the Yonghong tunnel bridge was intact.
602. A retaining wall on Jingshan line K267+334 (intensity rating X), which was constructed of schist blocks tilted outward. The maximum displacement was up to 20 cm.

(Photos without credits in this section have been supplied by Liao Shuqiao)
An aerial photograph showing the Shengli Bridge in the city of Tangshan. The riverbank and the abutment moved toward the center of the river. A span on the western end collapsed. See photo 610. (Photo: Zhou Xuegong)
604. The photo above shows fractured and displaced pavement 200 m long with a maximum width of up to 3 m on the western end of Shengli Bridge in the city of Tangshan. (Photo: Earthquake Research Institute, SSB)

605. The photo shows a fractured pavement band along the highway from the city of Tangshan to Daodizhen. (Photo: Chen Dasheng)
606. A network of ground fissures on the highway at Mengzhuang, Xigezhuang Commune, Fengnan County. (Photo: Chen Dasheng)

607. A ground fissure band along the highway in the vicinity of Laoyuying in the southern portion of Luanxian County was roughly 30 m long and 8 m wide. The width of a single fissure was up to 1 meter and 1.5 m in visible depth. The general strike was in an east-west direction. (Photo: Institute of Geology, State Seismological Bureau)
608. There were longitudinal fissures on the highway road surface in the vicinity of Bachigang, Luanan County. (Photo: Institute of Geology, State Seismological Bureau)

609. The wheels of a truck got stuck in a ground fissure on the edge of the highway at Fuzhuang, Hangu District in the city of Tianjin. (Photo: Yu Zeliang)
610. Shengli Bridge in the city of Tangshan had five spans. The piers were poured concrete piles of dual-column style. The bridge was skewed 15° from west to east. Pier No. 4 collapsed. (Photo: Earthquake Research Institute, State Seismological Bureau)

611. In the city of Tangshan, relative displacement occurred at Quzhuang Bridge between the bridge floor and abutment. (Photo: Xu Changjiang)
612. Bridge piers tilted at the July the First Bridge at the Tangshan Power Plant. (Photo: Qi Yongquan)

613. The bottom of Pier No. 1 cracked approximately 15 cm at Dazhong Bridge in the city of Tangshan. (Photo: Xu Changjiang)
614. Piers tilted and column caps dislocated at the Nuzhizhai Bridge in the city of Tangshan.  
(Photo: Xu Fengyun)

615. The Yuehe Bridge in the city of Tangshan had poured piles and simple beams. The bank slopes slipped toward the center of the river and the bridge piers tilted.  
(Photo: Xu Fengyun)
616. The left abutment slipped toward the center of the river on a small wooden bridge at the Tangshan Tap Water Company. (Photo: Xu Changjiang)

617. The five spans 10.6 m each of the power plant bridge of the Tangshan Iron and Steel Company had a wooden pile base. Above the piles there were reinforced concrete piers which remained intact after the earthquake. (Photo: Xu Changjiang)
618. At Chengzizhuang in the city of Tangshan, a bridge with 17 spans constructed of rectangular stone blocks was intact after the earthquake. (Photo: Xu Changjiang)

619. Xiyao Bridge in the city of Tangshan was slightly damaged. It had a wooden pile base, a plain concrete abutment and pier, and two spans of a continuous beam. (Photo: Xu Changjiang)
620. Daodicon Bridge in Fengnan County had two spans collapse. (Photo: Seismo-geological Brigade, State Seismological Bureau)

621. One span collapsed at the Shahe River Highway Bridge in Leizhuang County. (Photo: Earthquake Research Institute, State Seismological Bureau)
622. The village bridge in Luanxian County collapsed. (Photo: Qi Yongquan)

623a. The Luanhe River Highway Bridge in Luanxian County, which was 600 meters in length and approximately 8 meters in width, collapsed during the earthquake. (Photos: Institute of Geology, State Seismological Bureau)
623b. An aerial photo of the Luanhe River Highway Bridge after the earthquake.  
(Photo: Zhou Xuegong)

624. An aerial view of the Luanhe River Highway Bridge after the earthquake.  
(Photo: Zhou Xuegong)

625. A close-up view of the fourth damaged opening of the Luanhe River Highway Bridge.  
(Photo: Li Fusheng)
626. A close-up view of the fifth damaged span of the Luanhe River Highway Bridge. (Photo: Li Fusheng)

627. A close-up view of the sixth damaged span of the Luanhe River Highway Bridge. (Photo: Li Fusheng)
628. A close-up view of the tenth damaged opening of the Luanhe River Highway Bridge.  
(Photo: Li Fusheng)

629. A close-up view of the eleventh damaged span of the Luanhe River Highway Bridge.  
(Photo: Li Fusheng)
630. A full view of the eleven openings of the Luanhe River Highway Bridge taken from the eastern bank. (Photo: Xu Fengyun)

631a. Pier No. 10 broke off at the Luanhe River Highway Bridge at Zhuacun, Qianan County in the photo above. (Photos: Chen Dasheng)
631b. In the photo to the left the beams of the No. 10 and 11 spans collapsed and the cap of the No. 10 pier fell to the bridge floor of the eleventh opening.

632. A beam fell at the Wangtucun flood way bridge in Luannan County.
(Photo: Chen Dasheng)
633. The pier tilted and a side of the contact of the pier cap and bridge surface separated at the Ji Canal Highway Bridge in Hangu District in the city of Tianjin. (Photo: Yu Zeliang)

634. The Lutai Bridge at Hangu in the city of Tianjin was 176 m total in length and 54 m of the tied arch in the middle portion collapsed. (Photo: Institute of Geology, State Seismological Bureau)
635. The floor of the Lutai Bridge dislocated in a transverse direction.

(Photo: Chen Dasheng)
636. The expansion joint pulled apart (left) and compressed (below) at the Lutai Bridge.  
(Photo: Chen Dasheng)
637. The Red Banner Bridge at Yeli in the city of Tangshan which collapsed after the earthquake was a single opening reinforced concrete double-curved arch bridge with 36 m of span. (Photo: Xu Changjiang)

638. The single span 40 m Liuguantun double-curved arch bridge collapsed. (Photo: Xu Changjiang)
639. There was no damage at the Zhaogezhuang Bridge in the east coal mine area in the city of Tangshan. The 36 m single opening double-curved arch bridge with a rock base remained basically intact. (Photo: Cui Fuwen)

640. In the suburbs of Tangshan, the Houtun stone arch bridge was slightly damaged. (Photo: Xu Changjiang)
641. At the Shimen stone arch bridge in Lulong County, a stone of the main arch was displaced at the left and joint between the small arch and the supporting column was displaced. (Photo: Gao Jinying)
642a. At the Douhe Reservoir in the city of Tangshan, the slope protection of the up stream at the right section of the main dam was displaced indicating an outward movement of the slope. (Photos: Chen Dasheng)
642b. Another photo showing the displacement at the Douhe Reservoir.

643. The down stream slope of the main dam 0+900 of the Douhe Reservoir was cracked, indicating an outward displacement. (Photo: Kuang Zhong)
644. The top of the main dam cracked at the Douhe Reservoir. (Photo: Zhang Bochong)

645. 2+000 down stream slope of the dam was damaged and the top of the dam subsided 35 cm at the Douhe Reservoir. (Photo: Kuang Zhong)
646. At the Miyun Reservoir in the city of Beijing, the side of the dam facing the water collapsed. The photo shows the slope protection that was placed immediately following the earthquake. (Photo: Institute of Geology, State Seismological Bureau)

647a. At the Peizhuang ship lock on Jintang Canal in Fengnan County, the T-shaped beam and switching device on the Π-shaped rack of the up ship lock fell into the water. (Photos: Mao Wohua and Qin Jiafeng)
647b. The concrete at the bottom of the Π-shaped rack by the side of the staircase broke and the reinforcing bar was exposed.

647c. The Π-shaped rack appeared to be v-shaped.
648. The bifurcation wall of the lock gate dislocated at the Peizhuang ship lock.
(Photo: Qin Jiafeng)
649. The Village Bridge gate in Leting County was damaged. (Photo: Qi Yongquan)

650a. The base wall cracked and the body of the gate structure tilted. At the tidal protection structure in Haitian, Leting County. (Photos: Qi Yongquan)
650b. This is a photo of the damaged gate pier in Haitan.

651 At the water gate of the irrigation and drainage pumping station at Wangzhuang, Chadian Commune, Hangu District in the city of Tianjin, the gate wall cracked 0.8 m in width and subsided 1.4 m. (Photo: Yu Zeliang)
652a. The first and second sections of the lock wall from the down gate together with the adjoining breast wall were dislocated at the Jai Canal Beitang ship lock, Tanggu District in the city of Tianjin. (Photos: Qi Jiafeng)

652b. The maximum displacement of the left wall at the Ji Canal Beitang ship lock was 106 cm.
653. The upstream slope protection of the pilotage course, which was constructed of stones and mortar, cracked at the Ji Canal Beitang ship lock. (Photo: Qin Jiafeng)

654a. The main structure of the Ninggu gate in Tanggu District in the city of Tianjin basically remained intact. (Photos: Tianjin Scientific Research Institute of Water Conservancy)
654b. At the Ninggu gate the downstream wing wall cracked.

655. The new Beitang gate built for protection against the tide at the Ji Canal in Tanggu District in the city of Tianjin had relative displacements between the bank pier and gate pier which were 6-13 cm and the bridge heads at both banks subsided. (Photo: Qin Jiafeng)
656a. The eastern bridge heads at the Beitang gate separated. (Photos: Qin Jiafeng)

656b. The western bridge heads also separated.
657. T-shaped beams on I-shaped columns at the openings of Nos. 1-6 and the switching device fell onto the working bridge at the Beitang gate. (Photo: Zhou Bing)

658. The gate pier towards the center of the river subsided as a result of liquefaction and the slabs of the bridge floor fell at Luding Bridge in Changping County in the city of Beijing. (Photo: Zhu Chendong)
659a. The Yujiabao Foreign Trade Wharf of Tanggu in the city of Tianjin was 102 m in total length. The upstream section of the wharf tilted towards the center of the river and subsided; only a portion of the back boundary of the wharf floor was visible above the water.

659b. The pile head of the front row cracked at the Yujiabao Foreign Trade Wharf.
660. The paved strip at the Yujiabao Foreign Trade Wharf subsided and cracked.

661. The shore wall of steel sheet-pile tilted up 10:1; the head beam and trough rotated; and concrete blocks which covered the wharf loosened at the Shipyard Wharf of the First Navigation Engineering Bureau, Ministry of Communications at Tanggu in the city of Tianjin.
662. The Xinhe Foreign Transport Wharf at Tanggu in the city of Tianjin was 132 m in total length. The bank slope slipped towards the river; base piles of the back row tilted towards the bank; base piles of the front row tilted towards the river; and the middle fork pile uplifted.

663. Base piles tilted and pile caps separated from the floor slab at the Xinhe Foreign Transport Wharf.
664. The floor slabs of the Xinhe Foreign Transport Wharf of the upstream section were partially uplifted and broken.

665. The upstream section of the Xinhe Foreign Transport Wharf (far end of photo) tilted forward. The displacement was greater than at the downstream section.
666. The retaining wall of the Xinhe Foreign Transport Wharf subsided lower than the floor slab of the wharf.

667. The concrete paving of the Xinhe Foreign Transport Wharf cracked.
668. At the Tanggu Wharf No. 4 in the city of Tianjin the stone retaining wall behind the first approach at berth No. 1 slipped toward the river; subsided; tilted backward and face upward; cracked (the wall of the approach distended); pressed the back row of piles under the approach and broke them.

669. The piles of retaining wall under the fourth approach of berth No. 2 were broken and the slotting plate subsided at the Tanggu Wharf.
670. At the Tanggu Wharf the retaining wall behind the seventh approach at berth No. 3 slipped toward the river and subsided. Two rows of piles in front of the wall tilted towards the bank and the floor slabs of the approach became uneven in height.

671. At the Tanggu Wharf the retaining wall behind the approach at berth No. 4 toppled and two rows of piles in front of the wall were tilted.
672a. A diagonal pile which was located near the bank cracked at the Tanggu Wharf.

672b. The photo shows a diagonal pile which was pulled out from the pile cap.
The photo above shows a broken pile cap and the photo below shows a diagonal pile towards the bank which was pulled out from the pile cap at the Tanggu Wharf.
674. A diagonal pile towards the bank was pulled out and broken. A diagonal pile towards the river was pressed and broken at the Tanggu Wharf.

675. The top of a vertical pile was broken at the Tanggu Wharf.
676. The cap of a vertical pile separated from the floor slab at the Tanggu Wharf.

677. A vertical pile on the river surface was cracked; towards the bank the surface was pressed and broken; and the corner of the floor slab was torn and cracked at the Tanggu Wharf.
678. The Overhaul Works Wharf of the Tanggu Course Bureau in the city of Tianjin was 27.5 m in length. The floor of the wharf was deformed after the earthquake, both sides of the back edge had warped and the floor slab cracked.

679. The first front row of fork piles on the upstream side of the Overhaul Works Wharf was damaged.
680. The back row of fork piles on the upstream side of the Overhaul Works Wharf was damaged.

681. The first front row of fork piles on the downstream side of the Overhaul Works Wharf was damaged; the pile also sank into liquefied soil.
682. The fork piles of the back row on the downstream side of the Overhaul Works Wharf were pulled out; the top of the pile subsided 0.5 m; the pile cap displaced towards the river 80 cm; five ring cracks were on the top of the pile; and a diagonal pile towards the river became steeper and was broken.

683. The vertical piles of the front row of the approach were broken and the corners of the floor slab were torn at the Overhaul Works Wharf.
684. This is a general view of the upstream side of the Tanggu Freezer Wharf after the earthquake in the city of Tianjin.

685. Diagonal piles towards the river faced upward; diagonal piles toward the bank tilted; a pile head broke; the pile cap was cut; vertical piles tilted; and pile caps and the floor slab separated at the Tanggu Freezer Wharf.
686. The middle portion of the floor slab at the upstream section bulged and broke at the Tanggu Freezer Wharf.

687. The deformation joint between the upstream section and the downstream section was pulled away at the Tanggu Freezer Wharf.
688. The diagonal fork pile No. 16 near the bank was damaged at the wharf of the Xinhe Shipyard at Tanggu in the city of Tianjin.

689. The back retaining wall subsided at the Xingang Seaport Wharf in the city of Tianjin.
690. The back retaining wall of the third wharf at the Xingang Seaport subsided; displaced toward the sea; the top of the wall tilted toward the bank; the back fill subsided; and the sleeper together with the rail was hanging.

(Photos 659-690: Design Institute of Water Transport, Ministry of Communications)
691. The bank wall of the Ji Canal at Lutai, Ninghe County, in the city of Tianjin collapsed. (Photo: Water Engineering Section of Ninghe County)

692. The slope protection of the Ji Canal at Hangu District, in the city of Tianjin cracked and the breakwater wall which was roughly 50 m long collapsed. (Photo: Yu Zeliang)
693. A brick drainage ditch at the Douhe Power Plant became deformed and dislocated and some of the reinforced concrete cover slabs fell into the ditch. (Photo: Wang Gongkang)

694. The brick wall of a drainage ditch at the Douhe Power Plant collapsed. (Photo: Geographical Institute of Hebei Province)
695. The aqueduct at the Luanhe riverbank in Luanxian County was damaged. (Photo: Qi Yongquan)

696. An aqueduct near the Luanhe River Highway Bridge in Luanxian County was damaged. (Photo: Qi Yongquan)
697. An aqueduct was damaged in Luanxian County. (Photo: Seismological Brigade, State Seismological Bureau)

698. The embankment on the Douhe River subsided, the pumping station tilted and the brick wall cracked. (Photo: Qi Yongquan)
699. At the Transformer Substation of Leting County, the ground subsided but the pump well basically remained intact. (Photo: Chen Dasheng)

700. There was liquefaction and subsidence around the cement well-tube. (Photo: Qi Yongquan)
701. The pumping station subsided at the Tianjin Chemical Plant. (Photo: Yu Zeliang)

702. The lighthouse basically remained intact at Dagu in the city of Tianjin. (Photo: Zhang Xueyan)