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STUDY ON SEISMIC DAMAGED AREA WITH LINE－SHAPE IN THE 1995 HYOGO －KEN NANBU EARTHQUAKE

SUN Jian-Sheng, NAGAI Tetsuo, SHIOTSUKI Takahisa and IKEJIRI Takeshi

Technical Research Institute, AOKI Corporation,
36-1 Kaname, Tsukuba City, 300-26 Japan

ABSATRACT

In this paper, the reasons which caused the band-shape damage distribution were analyzed basing on our detailed field investigation in Hanshin area after the 1995 Hyogoken-Nanbu earthquake, and it was observed that most of the ground and buildings damages were line-shaped and nearly parallel to each other, at a site of the line-shaped damage, the ground slope was very steep and different mode of ground vibration might happened during the earthquake, and many line-shaped damages formed band-shaped zone of JAM intensity 7.

KEYWORDS

Damage, steep slope, line-shaped, band-shaped, different mode, buckle

INTRODUCTION

In 1995, a great destructive earthquake occurred in the southern region of Hyogo Prefecture, Japan. The maximum JMA (Japan Meteorological Agency) intensity value for this earthquake is 7 and it updated the historical record in Japan. The zone of JMA intensity 7 locates between Mt. Rokko and Osaka Bay, which looks like a band－shape with the length of 20km and the width of 1km. The authors investigate the relationship between characteristic of damage distribution and topography, geological structure in this region. As a result, it is cleared that the damaged area of structures and foundations shows line－shaped within limited range, and then, the line－shaped distribution is related to varieties of local topography and geological structure closely. Therefore, we consider that the band－shaped zone consists of a series of line －shaped areas. In this paper, we firstly introduce some typical examples of such damage distribution and

those relationships with topography and geological structure. Secondly, we point out that damaged area with line－shape can be observed only in the region where the damage ratio of structures is lower than 20%.

SUMARIZATION OF THE TOPOGRAPHY, GEOLOGICAL STRUCTURE AND DAMAGES DISTRIBUTION IN KOBE

In the northern part of Kobe, Mt. Rokko elongates from west to east, while its southern part faces Osaka Bay. The difference of elevation between northern and southern part is about 50～100m. Urban areas in Kobe is south－inclined and band－shaped plain with fan－shaped topography.

The granite bedrock of Mt. Rokko is exposed only 3km from the coastline. In the urban plains, more than 10 rivers flow to Osaka Bay within a distance of 22km. Thus, the Hanshin Plain consists of alluvial fans, and most soils are gravel and sand.

Fig.1 shows the areas of JMA intensity 7, which look like a band-shaped zone with the length of 20km and the width of 1km. It is along the narrow alluvial plain by the sea. In order to illustrate the relationship between band-shaped damage and geological condition, the authors carried out an on-the-spot investigation of some chosen rivers which cross the band-shaped damage zone.

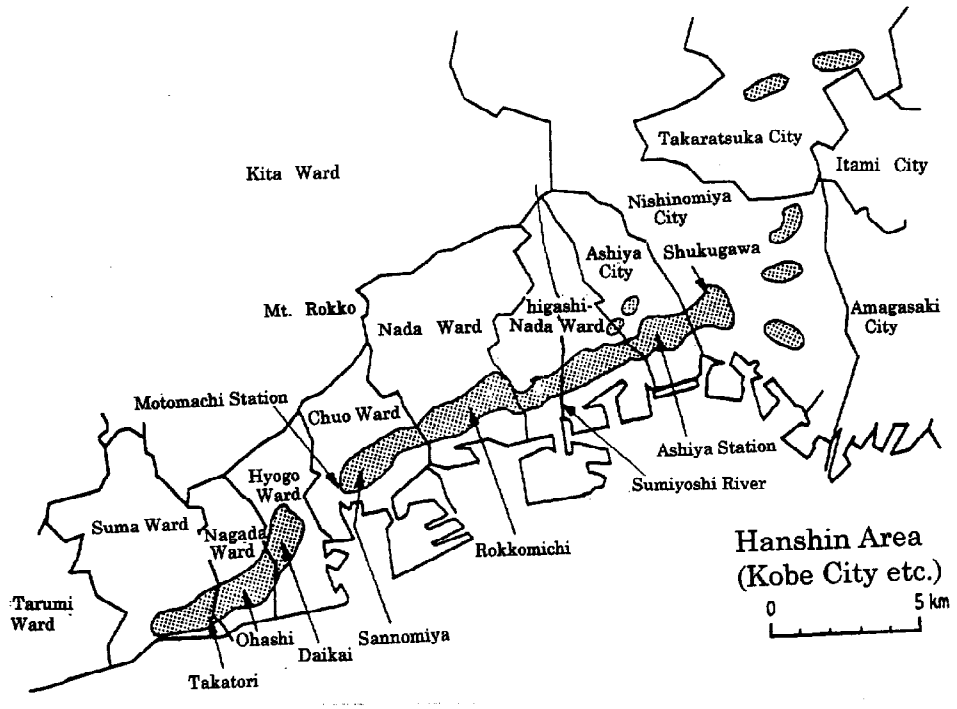

Fig.1 The distribution of JMA intensity 7 (by JWB, ADACHI, 1995)

THE OBSERVERED LINE-SHAPED DAMAGE DISTRIBUTIONS IN SURROUNDING OF THE SUMIYOSHI RIVER

The Sumiyoshi river crosses the band-shaped Hanshin area. Fig.2 is profile of the Sumiyoshi river along south to north, and it is common in the Hanshin area. In general, the damage ratio is higher with the greater gradient., except for the area near the peak which is to the north of Hankyu railway Kobe Line. The area between JR Kobe Line and the Hankyu Kobe Line is steep inclined, within this area, the damages of roads, banks and buildings formed lines which are nearly vertical to the rivers, and faced east. Fig.3 shows the situation of the observed damage lines, the distance between each other is about 50-100m. The summarization of damage lines ①~⑥ is listed in Table 1. The common points are those damages usually happened in the steep slopes, the surface of roads and the bottom concrete slabs were destroyed due to compression. Fig.4 is the outline of the damage line ③ and ④, which were observed in the north side (the upstream) of canal(on bridge). The structures on both side were safe except for those under damage lines. Such damages can be seen in photo 1 that the surface of roads and the bottom slabs are budged. The concrete facilities in right bank is damaged, and the houses in left hand is collapsed.

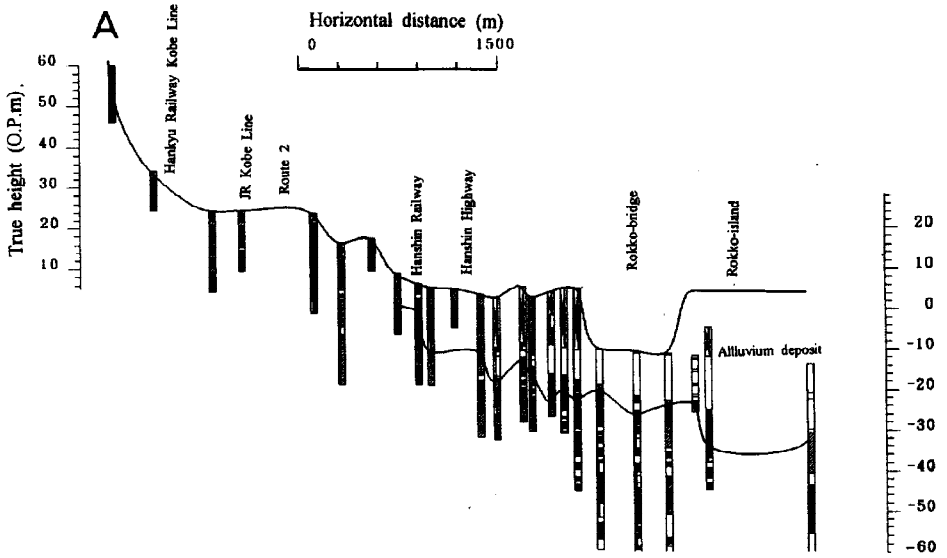

Fig.2 Profile of the Sumiyoshi River crossed Hanshin area
(Kansai Branch of the JSSMFE, 1992)

Between the JR Kobe line and Hanshin Kobe line, with rising and falling roads, most of the buildings were destroyed, and the damage lines cannot be observed. Furthermore, the geology surrounding the river is extremely complex, and the type of damage is therefore changed with the geology condiion.

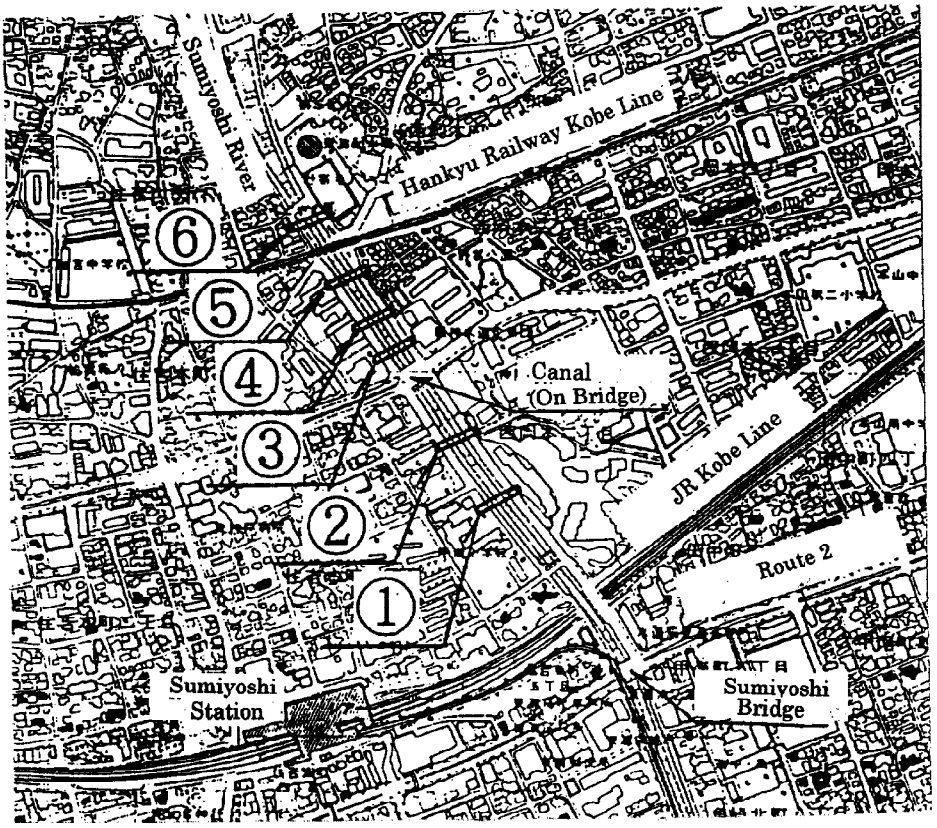

Fig.3 Situation of the observed damage lines along Sumiyoshi River

Table 1. Summarization of damage line ①~⑥

No. of Line-Shape	Situ	Outline of Damage		
		River	Bank Road	Structure
①	Side of the Konan Primary School	Stone Pavement of Banks Cracked, Slab(Compression) damaged	Cracks Faced East on Right Bank	
②		Stone Pavement of Banks is Cracked		
③	From Canal (on Bridge) to Upstream about 50m	Slabs in two Sides are Buckled and Pushed Up	Road pavement of Right Bank is Buckled and Cracks Faced East	
④	From Canal (on Bridge) to Upstream about 100m	Stone Pavement of Road Side is Buckled (Pushed Up and Compressed to Upstream	Road pavement of Right Bank is Pushed Up and Cracks Faced East	Right Bank: Two Buildings are Damaged by Shock, Retaining Wall Joint is Opened. Left Bank: Two Houses are Collapsed
⑤	From Canal to Upstream about 160m		Road pavement of Right Bank is Pushed Up and Cracks Faced East	Left Bank: Houses are Collapsed
⑥	From Hankyu Line to Upstream about 30m			Houses on Two Banks are damaged

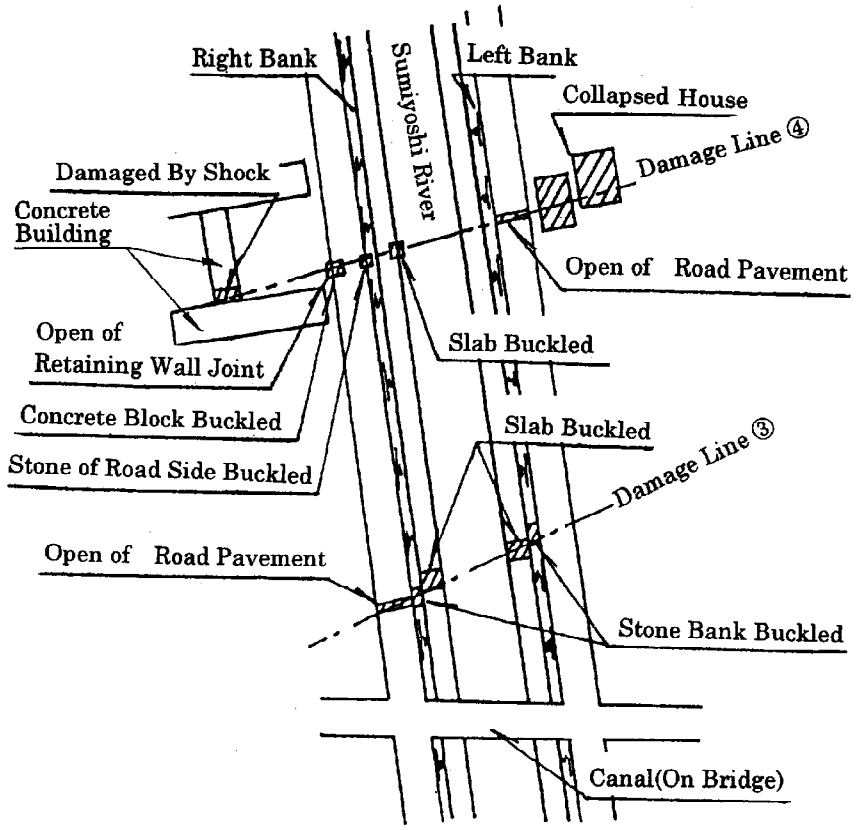

Fig.4 Description of the damage line ③ and ④

THE OBSERVED DISTRIBUTION OF DAMAGE LINES NEAR KOIKAWA SUJI STREET

Koikawa suji is an ancient river bed, it crosses the east part of JR Motomachi station, the zone is band-shaped and discontinuous. To the north of JR Kobe Line, there is also several damage lines at abrupt inclined sites(Fig. 5 Ⓐ-Ⓓ), and the damage conditions are listed in Table 2. An detailed investigation was made around point Ⓐ, and its sketch of the damage is shown in Fig. 6, From which one can see that the cracks, sink of lands and the destruction of buildings and poles, composed the damage lines. One can also see that the severely destroyed buildings is compared with the slightly destroyed one.

CONCLUSIONS

There are lots of researches on the seismic reaction of uneven foundation. Based on the measurements and observations on-the-earthquake-spot, Nishio(1989) proposed that in the interface between soft and stiff soil, the gas pipe was tensive and compressive destroyed due to the discontinuous vibration of ground. During this surveying, the authors found that the line-shaped destruction occurred on the steep slope or the abrupt

change sites. Due to the inclination and the sharp change in Hanshin area, the different mode and phase happened, which caused the destruction of foundations and upper structures. In the meanwhile, those destruction spots were connected to chains, furthermore, those chains conjoined into band-shaped zone.

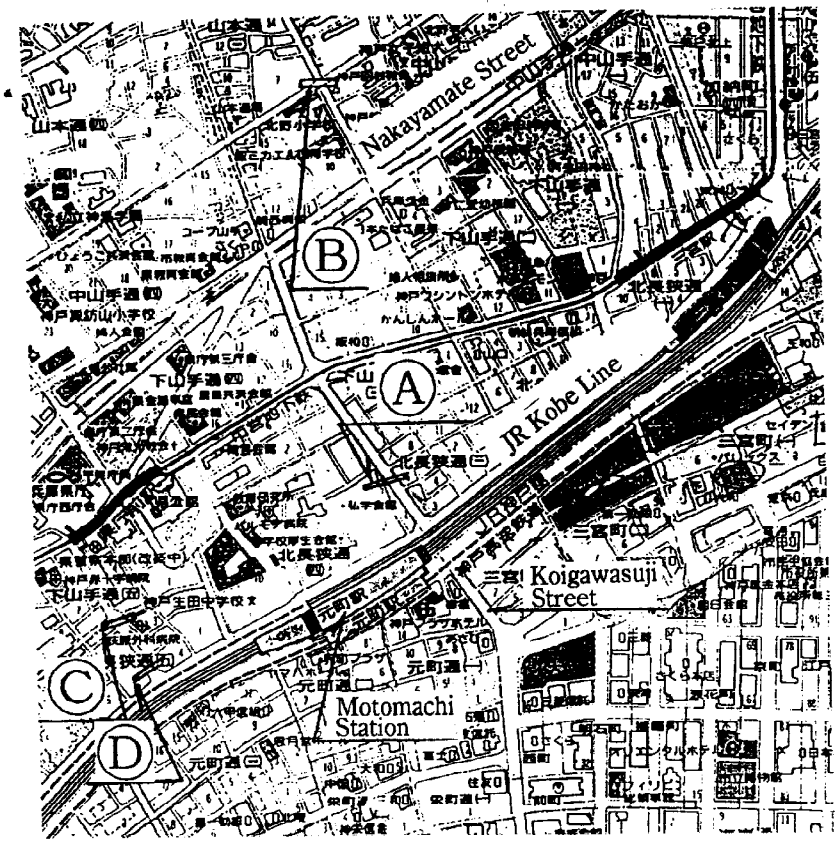

Fig. 5 Situation of the observed damage lines

Table 2. Summarization of damage line Ⓐ ~ Ⓓ

No. of Line-Shape	Situ	Outline Of Damage	
		Road	Structure
Ⓐ	Kitanagahaza-Dori 3-Chome	Marks of Repair on Pavement Faced East	Collapsed Houses Made East-Faced Lines
Ⓑ	Yamamoto-Dori 3-Chome	Cracks Faced Southeast	At Two Sides of Steep Slope, Collapsed Houses Made Southeast-Faced Line
Ⓒ	Shimoyamate-Dori 5-Chome	Cracks Faced East	At Two Sides of Steep Slope, Collapsed Houses Made East-Faced Line
Ⓓ	Kitanagahaza-Dori 5-Chome	Cracks Faced East	At Two Sides of Steep Slope, Damage of Stone and Concrete Retaining Wall Made East-Faced Line

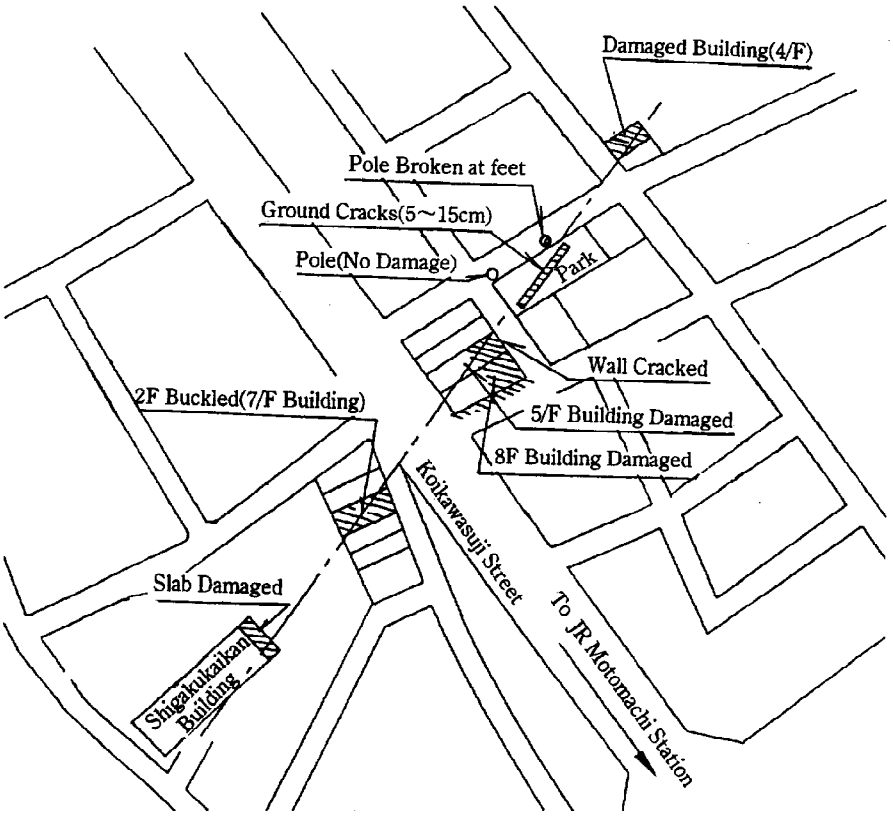

Fig. 6 Description of the damage line A

REMARKS

Because of the confusion in the earthquake district, it is much difficult to make a thorough investigation, only outlines cab be described, the detailed surveying and study will be performed in the future.

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