Urban Disaster Prevention Project

A feasibility study of regional disaster prevention in the Kobe Government

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ABSTRACT :

At 5:46 a.m., on January. 17, 1995, the worst disaster in postwar Japan changed Kobe, whose name in Japanese means "Heaven's door" , forever. The Great Hanshin Earthquake of magnitude 7.2 killed 5,501 people, injured 34,626, and burned out 7,456 houses and other structures. This study treats of the evaluation and planning of the examination of a burnt-out area in a characteristic district of the city. Statistics from the investigation have been used to produce an analysis of building types in the burned-out area three-dimensionally on the basis both of aerial photographic surveying and of remote sensing in Kobe city. A map of the zoning study was drawn in order to prevent the building of structures liable to spread fire both before and after an earthquake. The analysis of building types was linked to previous knowledge of building density and the narrow streets in the area. As a result, we recognize that a feasibility study of regional disaster prevention must be taken seriously in further detailed exercises.

1. INTRODUCTION

It is an established historical fact that the entire Japanese nation was frightened by the urban shock of the Hanshin Earthquake, which struck the Hanshin and Awaji region at 5:46 a.m. on January 17th,1995. It killed more than 5,500 people, injured nearly 35,000, and left 300,000 homeless. Furthermore, the collapsed buildings and houses totaled 159,544, and 531 fires broke out. As a result, 7,456 houses were destroyed by fire. The ratio of the Kobe Government's houses destroyed by fire came to 98.9% in all of the burned-out area . (Figure 1.)

At the time of the earthquake, the wind speed was calm, but a large-scale conflagration resulted. The reason for this is that it was a man-made disaster compared with the direct cause of this great earthquake. As it turned out, the houses and other buildings densely packed in the narrow streets in the city center may have been the main factor of this Kobe urban disaster.

Therefore, we feel that it would be good to improve the realizability of regional disaster prevention.

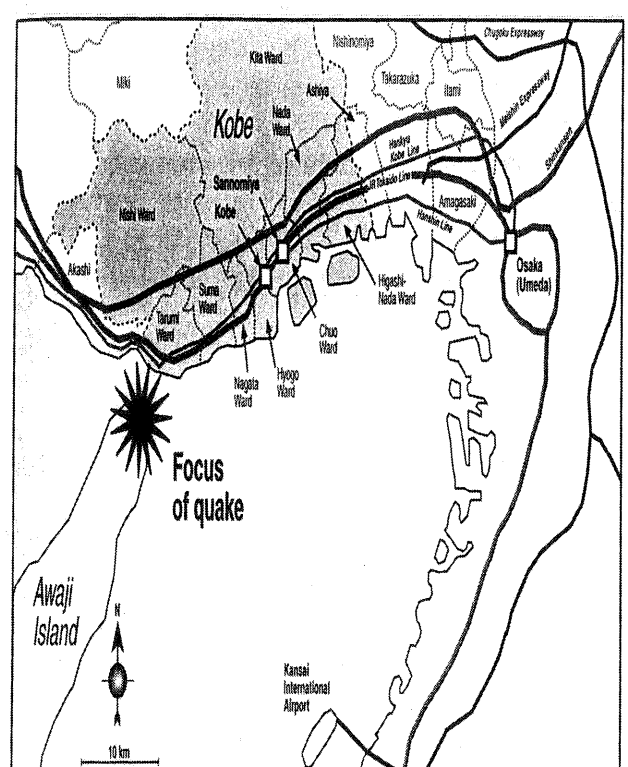


Figure 1. Map of Kobe crumble in the Great Hanshin Earthquake (Jan.17,1995 JAPAN)

Certainly it is necessary not only to revise the cooperative volunteer system, emergency medical services, and telecommunication systems, but it is also necessary for each local government to have accurate information about the present condition of urban geography. Also, city governments will have to try to review these urban problems in the light of big earthquakes through analysis of existing conditions . This paper examines a report on districts suffering damage, and various analyses of building types derived from aerial photogrammetric surveying and remote sensing in Kobe city, all of which must be taken into account in the determination of districts at risk before an earthquake occurs.

2. SCOPE AND PURPOSE OF THE STUDY

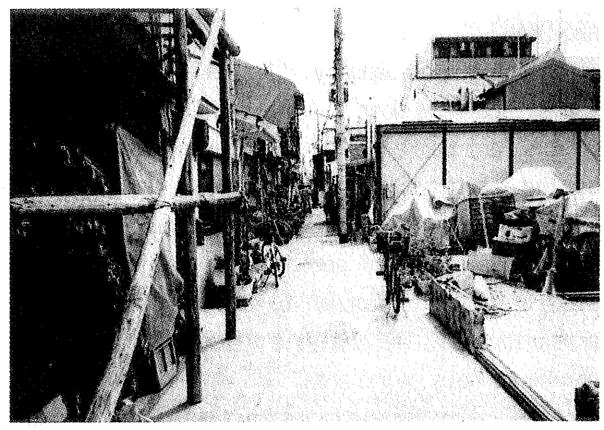
In this study, three processes were carried out in order to determine the areas at risk in urban disasters, as follows:
1. Collection of information about urban problems and geography in the the damaged district.
2. Analysis of building types in several districts in Kobe.
3. Improvement in the realizability of regional disaster prevention.
The essential aim of this paper becomes clear from the following two aspects of the above three processes of surveying by means of aerial photogrammetry and remote sensing analysis:
1. Consideration of standard decipherment for the areas at risk of the spread of fire beforehand.
2. Consideration of standard decipherment for total realizability of regional disaster prevention.

3. PROCEDURE USED IN THE STUDY

This study used the following five processes in connection with the No. 2 District of the Kobe Government:

3)-1. Collection of urban information in the disaster district.(Ref.1)~5)):
A map of dwellings on a scale of 2,000:1 was drawn up, aerial photography was carried out on a scale of 10,000:1 in monochrome, a report of the disaster in the earthquake-damaged area was compiled, and newspapers for the month after the earthquake were consulted.

Phtograoh 1. Fireproof Building (Nagata District)



Phtograph 2. Narrow Street (Nagata District)

After that, concepts and key words for the study of this urban disaster were selected from amongst this mass of information.

3)-2. Stereographical analysis of aerial photographs concerning building types in urban land use in the surveyed area (Figure 2,3 and Figure 5.):
In order to determine the building type, the situation regarding urban land use before the earthquake had to be investigated.
Therefore, this study inspected the building type and the structure one by one, using three methodologies: a geographical map on a scale of 2,500:1, a dwelling map on a scale of 2,000:1, and an aerial photograph on a scale of 10,000:1, all compiled before the earthquake, in 1992.

3)-3. Feasibility field surveying in this study area: Some low buildings and wooden-framed low houses were not included in the determination of building type after the analysis of the mapping method.

This was discovered only after a strict inspection by actual field surveying in Kobe had been undertaken.

3)-4. Analysis of remote sensing (Figure 7.):
A great deal of time and labor was spent on analysis of the stereographical method of aerial photography. The system used was that for the examination for TM data, in the case of the Kobe surveying area obtaining an image quality high enough to reduce the expense of time and labor for the conceptional observation of urban land use.

3)-5. Overlayer analysis of some mapping surveying as a present procedure of the following three methods of mapping (Figure 5,6,and 7):

1) mapping of building types before the earthquake
2) mapping of the urban disaster in the burned-out area
3) mapping of land use by remote sensing

The objective of this study is to evaluate the safety of narrow streets with a high building density by means of overlayer analysis, using the three mapping techniques mentioned above.

Table 1. Key Points of Decipherment

Building types	Key points of Decipherment
Wooden-framed houses	-Drawn by soild lines on geographical map -Shapes is simple -Decipherment 1F & More than 2F use stereography
Non-wooden-framed buildings	-Drawn by thick lines on geographical map -More than 3F buildings wrote floor # on geographical map
Openspace areas (Vacant land, Park, Car park)	-Decipherment by stereography -Decipherment by dwelling map

Table 2.Decipherment Rate of Building and House Type (Nagata District)

Building Type		Sample	Decipherment or Not		Rate %
Wooden-Frame	1 F	4	3 (3)	1 (1)	75 (75)
	2 F～	33	25 (24)	8 (9)	76 (73)
Non-Wooden-Frame	～2 F	10	7 (4)	3 (5)	70 (40)
	3 F～	32	29 (28)	3 (4)	91 (88)
Openspace Area		4	4 (4)	0 (0)	100 (100)

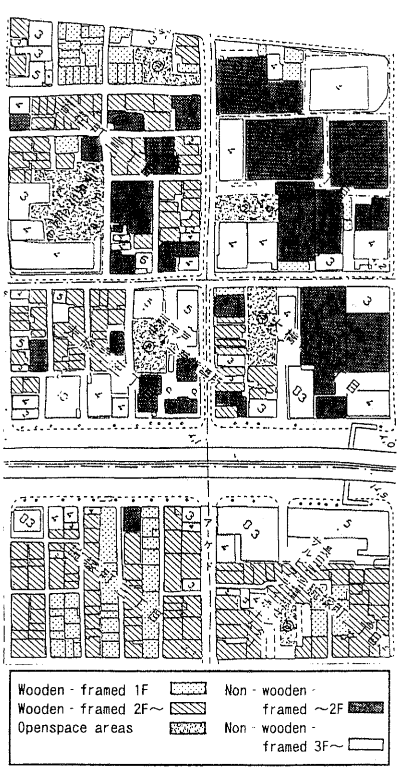


Figure 2-1 Map of Decipherment in Nagata (Before)

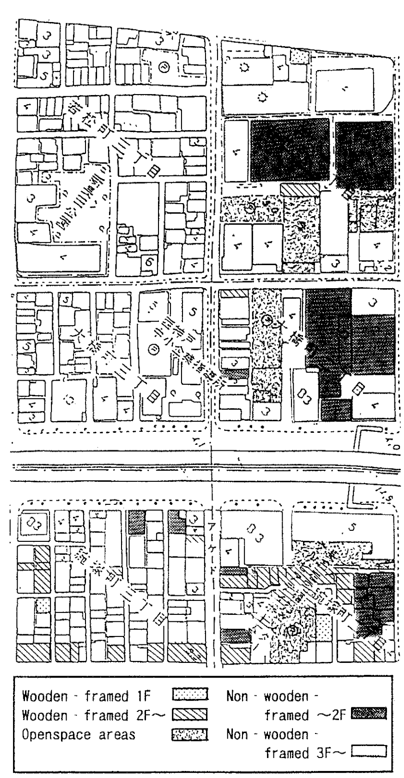


Figure 2-2 Map of Decipherment in Nagata (After)

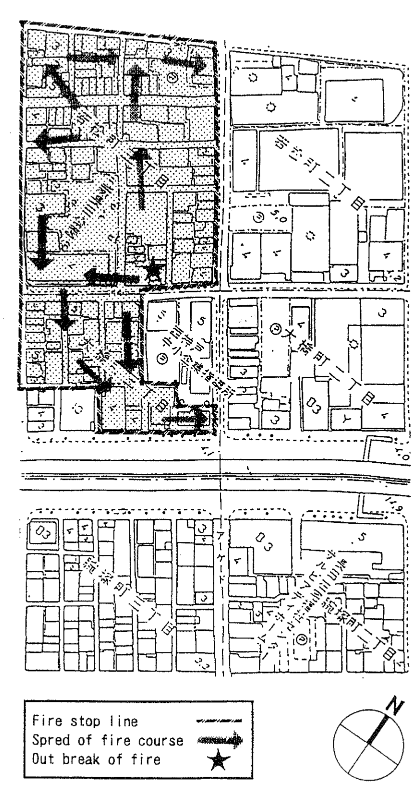


Figure 2-3 Map of Urban Disaster of fire in Nagata

4. SURVEYING IN NO. 2 DISTRICT IN KOBE

After the necessary further examination of the following points: the high building density, the narrow streets, and the excessive concentration of population, two districts were selected for further study. The first was Nagata District and the second was Nada District, and the decipherment of analysis of building types in Kobe Government was here carried out as below (Figure 2,3):

4)-1. Decipherment map of building type and height
This decipherment map was drawn up for the relative evaluation of the surrounding area by means of stereography based upon aerial photographs.(Table 1)

4)-2. Further detailed mapping of the types of buidings surviving after the earthquake in an actual field survey of this No. 2 District.(Fig.2-1,3-1)

4)-3. Mapping of inspected damaged structures, classifying each as "burned out" or "not burned out", in the urban disaster area.(Fig.2-2,3-2)

4)-4. More detailed mapping compared with stereographical analysis, field surveying and the dwelling map in addition .

4)-5. Consideration, for each district, of the risk of fire, through the building type mapping and urban disaster mapping. The points examined were elements of geographical natural information, the architecture of the houses and other buildings, and urban facilities.(Fig.2-3,3-3)

5. DECIPHERMENT OF BUILDING TYPE

5)-1. Rate of building and house type (Table 2,3) : Table 2 represents the result of the decipherment rate of building type through stereography based on aerial photography, the topographical map, and the dwelling map.The lower side of the table shows the result of stereography and topography mapping, and the upper side shows the rate of results to be added to the dwelling map from this stereography and topography mapping. Rate decipherment of open spaces and of buildings of more than three stories was determined correctly, but that of wooden-framed housesand one-storied houses was somewhat underestimated in decipherment of building types.

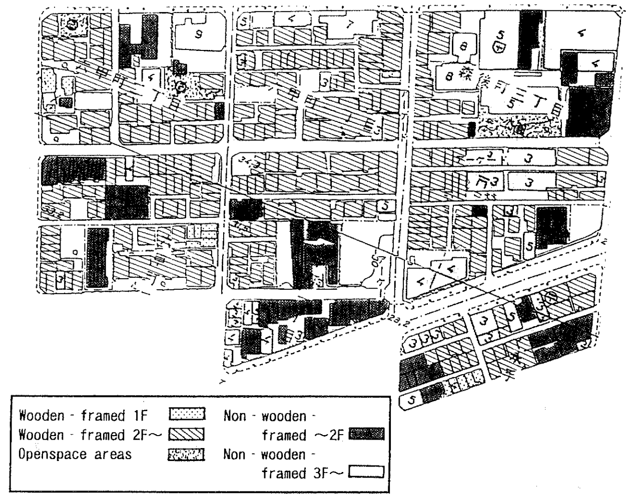


Figure 3-1 Map of Decipherment in Nada (Before)

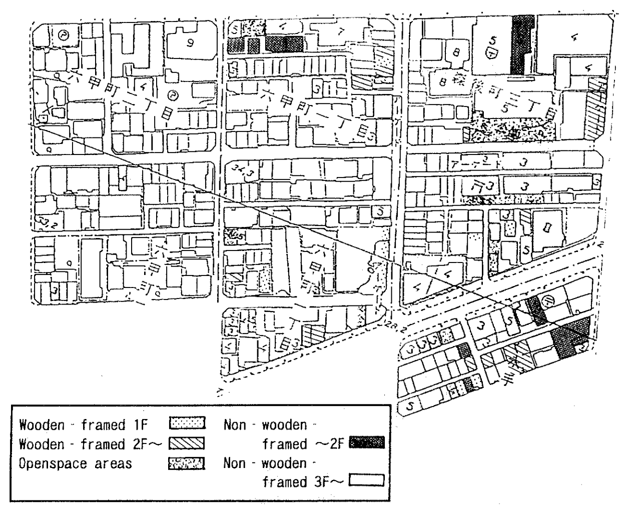


Figure 3-2 Map of Decipherment in Nada (After)

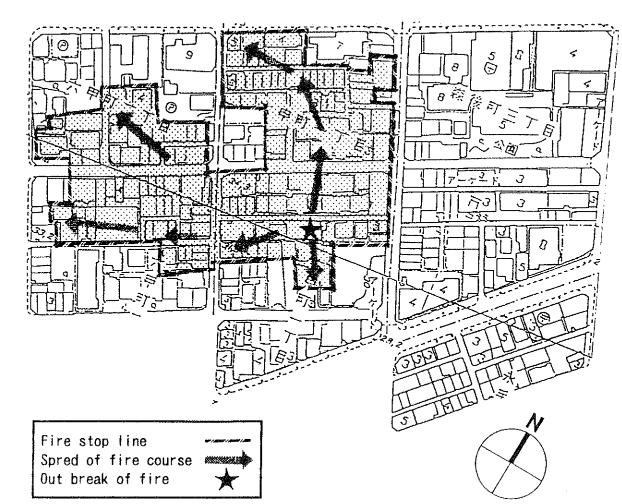


Figure 3-3 Map of Urban Disaster of fire in Nada

5)-2. Consideration of each district :

Wooden-framed houses of one story existed in great numbers and in high density in Nagata District. However, only a few such one-storied houses were seen in Nada District. In Nagata district, wooden-framed houses were built on narrow sites, and the houses were crowded on adjacent lots along the network of narrow streets. These key factors of high density, wooden frames susceptible to fire, and narrow steets unsuitable for fire-fighting were causes of the large-scale urban fire . Concerning the situation of fires extinguished by fire-fighting, fireproof buildings had to fulfill their role as firebreaks when the fire started to spread. In consequence, high densely crowded houses were at high risk in the event of a fire or earthquake .

5)-3. Decipherment of the building type :

< Before the earthquake >

There were many open spaces left by the urban planning of the city government. It would easily have been possible to predict the destroyed or damaged houses and the spread of fire from a decipherment of the building type before the earthquake. It would have been guessed that the causes of the spread of fire on a large scale would be the densely built-up areas, the network of narrow streets, and the lack of fireproof structures.

< After the earthquake > (Phtograph 1,2,and 3)

Buildings and houses with high fire resistance were left intact unless burned-out by fire. Although these fireproof buildings splendidly fulfilled their roles in the prevention of the spread of fire, the narrow streets turned out to be an obstacle to fire-fighting, and in addition the high residential density influenced the size of the urban fire disaster.

In thinking about the commercial zoning in both parts of No. 2 District, the wooden-framed buildings will have to be improved in the renewal planning, in view of the fact that large numbers of the public were gathering in these places at any time of day.

5)-4. Analytical dynamics of urban information (Tables 4,5):

According to information produced by the fire department of Kobe, it was clear that Nagata and Nada districts had a low level of fire safety.

Photograph 3. Fireproof Building (Nada District)

Table 3. Decipherment Rate of Building anf House Type (Nada District)

Building Type		Sample	Decipherment or Not		Rate %
Wooden-Frame	1 F	8	4 (2)	4 (6)	50 (25)
	2F~	15	11 (11)	4 (4)	73 (73)
Non-Wooden-Frame	~2F	9	7 (6)	2 (3)	78 (67)
	3F~	47	41 (35)	6 (12)	87 (74)
Openspace Area		7	7 (3)	0 (4)	100 (42)

The points considered were the population density, the business areas, residential areas, and areas where fires had previously occurred, according to the data of1985 (Table 4.)

When thinking about some data concerning the characteristic district, for example the ratios of building type in each district, it was realized that the amount of open space was low and the number of wooden-framed houses was high in the No. 2 district of Nagata and Nada(Table 5.)

In the event of an urban disaster, the lives of citizens would be dependent upon how much open space was available.

Table 4. Urban Dynamics information in Study Area

Ward name	summary #	population density (/100m²)	corpolation density (/100m²)	Mean of burned-out areas (m²/fire)	rate of resi-denntial areas (%)
NAGATA	158	5 2.154655	5 0.228408	2 26.2231	4 59.1185
	143	5 2.154655	4 0.228408	1 8.5672	5 37.6844
	159	4 2.546550	4 0.185555	2 8.5672	1 59.1185
	144	4 2.546550	5 0.228408	5 45.8776	2 27.2440
	139	2 1.043830	5 0.228408	5 45.8776	1 18.6780
	131	2 1.043830	5 0.228408	4 45.8776	1 18.6780
	149	4 2.546550	5 0.228408	2 8.5672	2 27.2440
	145	2 1.043830	5 0.228408	5 45.8772	1 18.6780
HYOGO	109	5 2.546550	5 0.229408	2 8.5672	2 27.2435
NADA	44	4 2.154655	5 0.186055	4 28.2177	4 33.8422
HIGASI-NADA	30	2 1.043830	2 0.034470	2 0.8567	4 59.1185
	22	2 1.043830	2 0.034470	2 0.8567	4 59.1419

Table 5. Rate of Urban Land Use in Study Area

Ward name / Building types		NAGATA %	HYOGO %	NADA %	HIGASI NADA %
Wooden-framed houses	1F	5	4	9	5
	2F~	32	39	25	19
Non-wooden-framed buildings	1, 2F	25	8	20	10
	3, 4F	12	11	15	11
	5F~	7	2	6	5
Openspace areas		19	36	25	50

6. ANALYSIS OF REMOTE SENSING

Much time and labor was spent on the methodology of stereographical analysis and the mapping system for urban information. Therefore, in order to reduce this time and labor, this study used an additional method, that of remote sensing analysis, for the next stage. Remote sensing was done to identify those zones that would be in danger of the spread of fire after an earthquake. This was done according to data provided by TM Landsat in September1984, when this remote sensing analysis was carried out.

6)-1. Determination of the spectrum of classification for ground truth data (Figure 4.):
This study extended the use of the decipherment map of building types, already drawn up for ground truth data, into the process of analysis of land use classification.
According to the examination for classification of land use, there were five classes characteristic of the spectrum:

1. Wooden-framed houses in densely built-up areas
2. Non-wooden-framed buildings in densely built-up areas
3. Open space areas (green land)
4. Open space areas (agricultural land and grassland)
5. Not classified

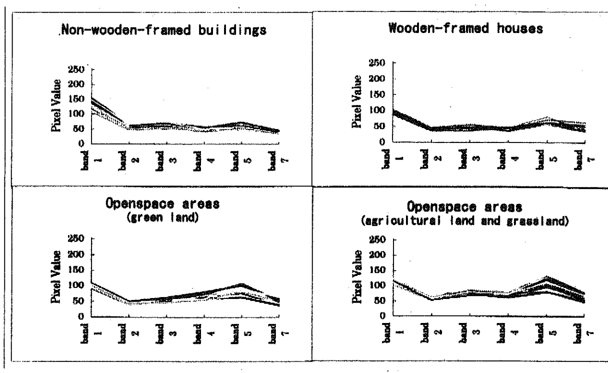


Figure 4. Spectrum Data of Classification in each band

By the simulation of visual image quality improvement using ground truth data, it was confirmed that the useful bands were # 2, 4, and 7.
Although in this study, the land use type was determined with an analytic efficiency of the target ground surface of 30m square in Nagata district, it is still useful to receive conceptional recognition of urban features where replacement of reflectors is very difficult.
The red zone on next page shows the outline of the danger area as estimated by remote sensing.(Fig.7)
It was absolutely essential to determine the danger area before an earthquake or other urban disaster, so as not to have a repetition of the same burned-out disaster.

7. RESULT OF KOBE'S DISASTER

The result of this study in Kobe are as follows :
1) Research overlaps for the danger zone from over-layer analysis compared with mapping of building types (Fig. 5.) and mapping of remote sensing (Fig.7.) can be seen.
2) Also, there can be seen the need for further research in view of the nearly doubled area of fire damage derived from overlayer analysis compared with building type mapping and fire spread mapping.(Fig.6)
3) Simulation and estimation of danger areas in the residential zone will be desirable for the citizens in the future renewal planning by the urban department of the government.

4) The stepping up of the decipherment ability was connected to the raising of the estimated size of danger areas, but this method of improvement is not connected with the urban disaster prevention project.The facts revealed by this study must be communicated to community organizations in order to protect the lives of citizens.

8. CONCLUSION AND EXERCISE

The required next stages in this study are as follows :

1) Stereographical analysis (Table 2.3,Figure 5.) : Through the methodology of stereography based on a aerial photograph, it was easy to distinguish buildings of more than three stories, large buildings, and open spaces.
However, it was found to be very difficult, in the case of one- or two-storied buildings in high-density residential areas, to determine the number of stories. Therefore it was necessary to check, using dwelling maps and an actual field survey, to clarify the number of stories.

2) About the geographical information system (G.I.S.) :(Table 4,5)
In order to resolve in further detail overlayer analysis, each layer of data had to be collected exhaustively from various information collected by the city planning department, the fire department,and the civic department of the municipal government. New elements in the prevention of urban disasters were, for example, density of space (green space and open space), the quality of fire resistance, and the ratio of population in high-density residencial areas.

3) Direction of the study process:
This study used the following process: firstly, steregraphical analysis; secondly, remote sensing analysis; and thirdly, overlaying analysis of the mapping of the burned-out area.
In the next study carried out by any other city government, the first procedure will be remote sensing analysis, and the second stereographical analysis. After that, the area at risk for the spread of fire should be estimated. The increasing efficiency of remote sensing should obviate the need for large amounts of time and labor.

4) Selection of band number in spectrum classication:
In Japan there are many wooden-framed houses. To realize the area of high density of wooden- framed houses, the band of the spectrum of the roofing materials where there are no wooden-framed houses must be correctly determined by means of the remote sensing method . Detatched house will always have a little garden, which may appear like roofing material, which is the spectrum value selected in each band.There are many cases of reaction caused by the humidity of such green gardens.(Figure 7.)
Therefore, we have to try to distinguish whether buildings have wooden frames or not in any continued project . Also, the TM data must be used in conjunction with the SPOT data because it is very difficult to distinguish these points.

5) Further development of applicational analysis in other cities:
It is absolutely esssential to accelerate research into urban disaster areas in those areas previously affected by earthquakes before any further earthquakes occur.(Figure 6.)

6) Japan as an earthquake country :
It is impossible to predict an earthquake, but it is quite possible that science and technology will be able to determine areas in danger of the spread of fire, and dictate environmental improvement in urban disaster prevention projects in any other city.
It would not be good if the present situation, in which there is no renewal planning in Japan's cities, were to be allowed to continue.

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