Proposal of constructing new tsunami shelter buildings at Mimase in Kochi City

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SUMMARY:
The subject area of this study was Mimase area with many typical characteristics as a fishing village. As a result of our field survey, it is revealed that the housing were crowded along narrow roads, which is typically the case with most fishing villages in Japan.
Many problems to be solved were found by reviewing the efficient evacuation shelter location and escape routes in the area. It is an imminent challenge to make improvement on the existing evacuation plan, with their local characteristics taken into account.
We proposed using the calculation formula to figure out the range of practicable evacuation range while pointing out the areas where no measures are taken to enable their locals to evacuate. Further, we proposed the construction of shelter buildings and indicated different escape routes which are practicable and suitable for their local characteristics, referencing the precedence of shelter-building cases in the other disaster areas.

Keywords: Tsunami, Shelter Building, Evacuation Ranges

1. INTRODUCTION

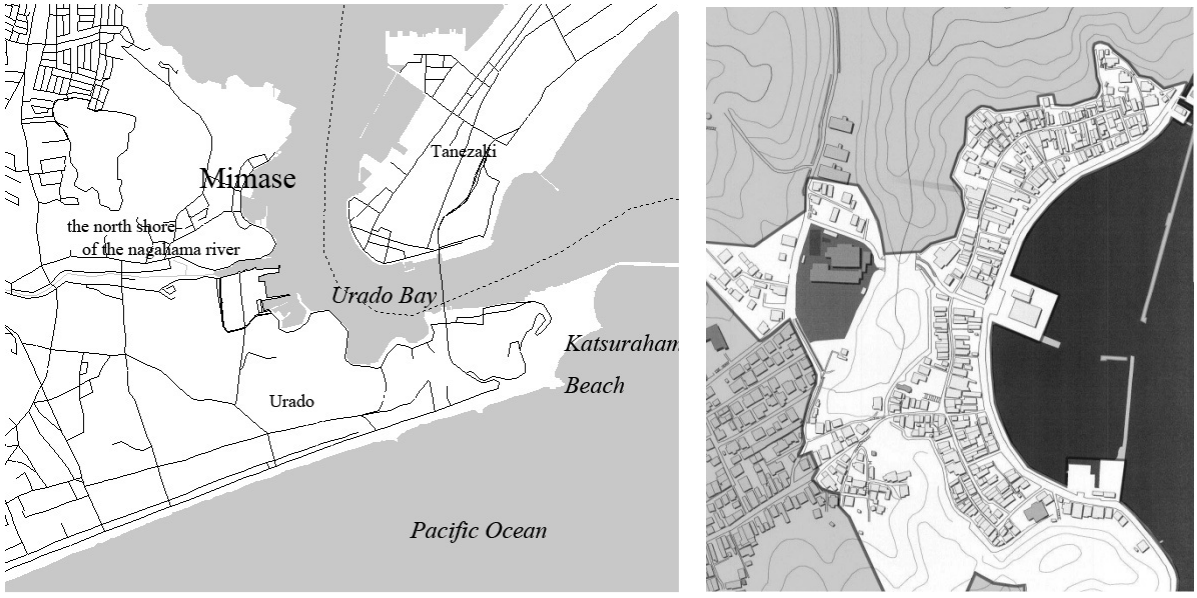
Many disaster preventive measures have been taken against Nankai Earthquake, which has been occurring in the cycle of 100- 150 years in Kouchi Prefecture. Standard policies for the disaster preventive measures, including the prediction for inundation caused by the tsunami, have been announced by the Kouchi Municipal Council and conducted ‘‘Kouchi Prefectural Tsunami Assessment Research" in 2000, based on the reports on "Kouchi Prefectural Tsunami Assessment Research" conducted in 1999 for the purpose of minimizing the damage, which was conducted by Exploratory Committee of Kouch prefectural assembly.
Master Plans for Disaster Prevention was devised by the Tsunami Disaster Preventive Assembly, designating 4 areas, Tanezaki, Urado, Mimase, the north shore of the Nagahama River, which are predicted to be damaged badly by tsunamis. The plans are based on the complementary research conducted in 2004 by Kouchi Prefectural Assembly aimed to improve the evacuation plans for respective areas and make the plans more effective and practicable.
We reviewed the points discussed in the Master Plans for Disaster Prevention for the 4 districts in Kouch City, comparing of some data [Cf.1]. We chose Mimase area as the object of our study after scrutinizing the 4 areas concerning the percentage of the elderly citizens, the hazards that evacuee may encounter in the location/ routes for evacuation and the features of the terrain. The aim of this study is to make proposals for setting the practicable locations for evacuation and for building tsunami-proof shelter buildings, examining the local characteristics of Mimase area based on our field survey.
In our field survey, the research was made on the housing in the whole Mimase area regarding the housing structure, the number of the staircases, the sort of the uses and the level of decrepitude. The width of all paved/ unpaved roads in the area was measured. In addition, the present situation of the evacuation location and routes designated in the current Master Plan in Mimase area were thoroughly examined. Based on the reports on our filed survey, we conducted detailed research putting under scrutiny the practicability of the existing measures.

2. CHARACTERISTICS OF MIMASE AREA

Residences in Mimase are widely spread out along the fishing harbor with hills right behind the residential area. Typical as most fishing villages in Japan, roads are narrow with small houses standing close together. Many houses are also strikingly decrepit, which are at high risk of collapsing in case of any sort of natural disaster. Furthermore, the area is on the mouth of the bay, where tsunamis hit 10-30 minutes earlier than any other areas in Kouchi City with the maximum depth by inundation of 5 meters as shown in the reports in the research by the Exploratory committee of Kouch Prefectural Assembly. Therefore, it is urgent to take effective measures for improving the practicability of the current shelter buildings and the escape routes.

2.1. Location

Mimase, the southern part of Kouch City, is located in the north of Katsurahama Beach facing the Pacific Ocean. It is a village stretching from north to south with fishing harbor where is the entrance to Urado Bay (Confer the map 1) .



Map 1. Mimase Area

2.2. Characteristics

Mimase area is along the mouth of Urado Bay, and thereby, it is predicted that the area will be seriously damaged by tsunamis. Almost all roads are remarkably narrow with both sides of them crowded with housing. It is presumed that houses in the area collapse by a shake and a fire spread easily, which will disrupt or block the escape routes for evacuees. Besides, demographically, the populations of the elderly citizens are very large in the area, which makes shelters the hills with steep slopes inadequate. In addition, not only can tsunamis destroy the fishing boats but damage on any housing and facilities around the area because of its locational characteristics.

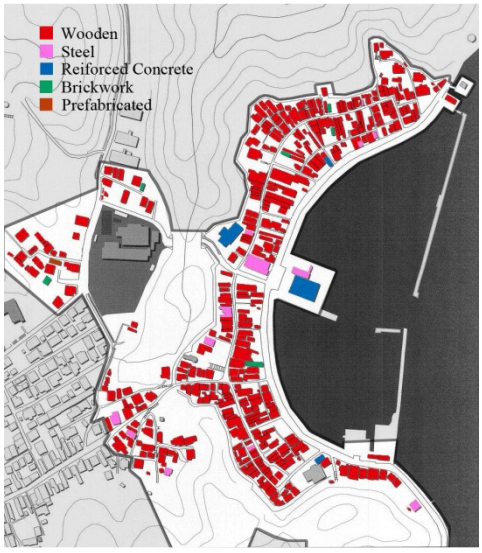
3. FIELD WORK IN MIMASE AREA

Our field survey conducted on December 17, 2009 includes the assessment of the housing structure, the number of the staircases and the level of the decrepitude. The width of all paved/ unpaved roads in the area was measured. We also grasped the present situation of the refuge and escape routes designated in the current Master Plan in Mimase.

3.1. Findings

3.1.1. Structure

The map 2 shows the distribution of the structure. The percentage and the number of housing in the area based on its structural characteristics are shown by the figure 1. As shown, the percentages of wooden houses are utterly high, which occupies 94.7%. Although wooden houses being built nowadays put weight on the durability against earthquakes and other natural disasters, almost all wooden houses in Mimase area are obviously deteriorated, which put them at high risk of collapsing and fire hazards.



Map 2. The distribution of the structure

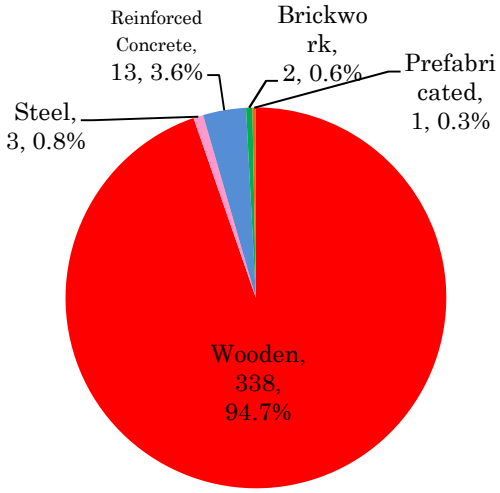
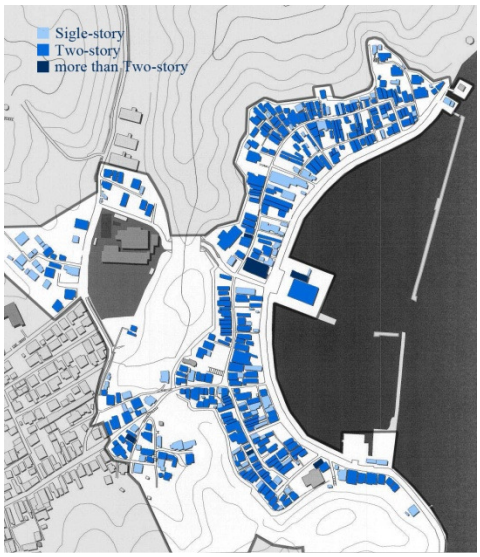


Figure 1. The percentage and number of Structural characteristics

3.1.2. The Number of Staircases

The map 3 shows the distribution of the number of the staircase. The percentage and the number of housing in the area based on its number of staircases are shown by the figure 2. Two-story houses are prominently many, which indicates 78.4%. It is predicted that these houses are much likely to collapse, and thereby disrupt or block the evacuation route. The figure 3 is the result of cross-totaling of the housing structure and its number of the staircases, which shows that the percentages of two-story wooden houses are remarkably high.



Map 3. The distribution of the number of staircases

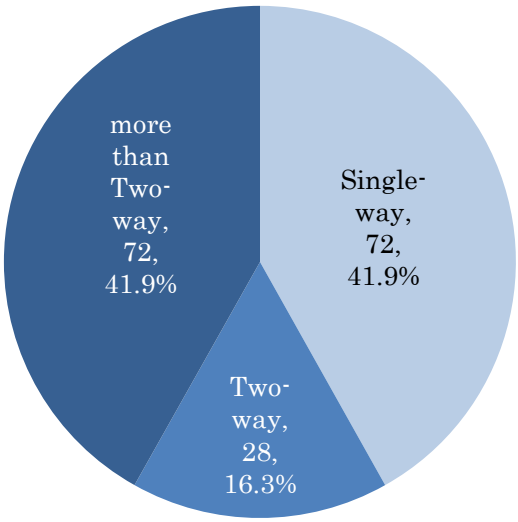


Figure 2. The percentage and number of staircases

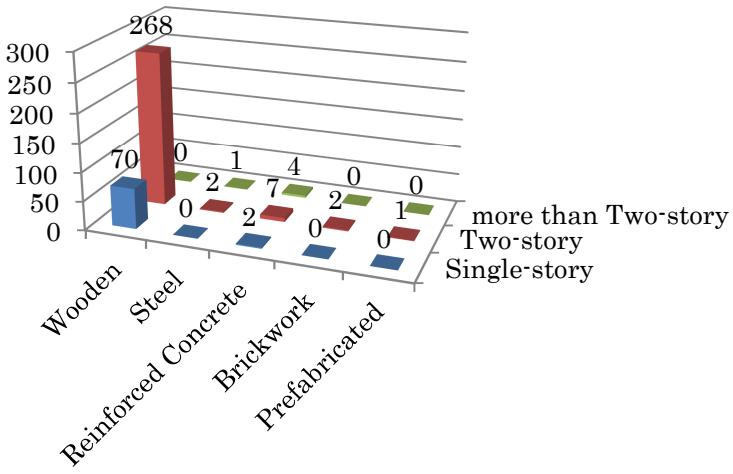
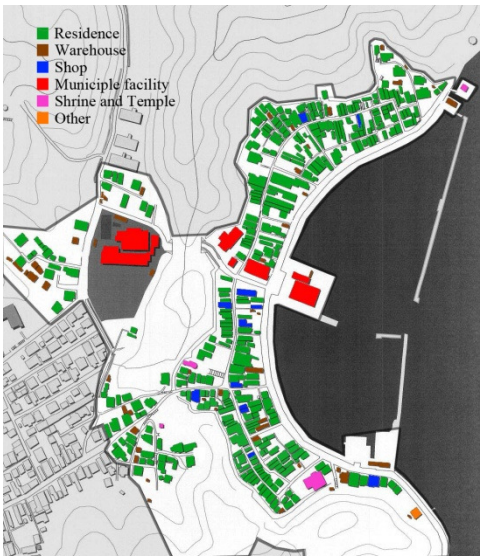


Figure 3. The housing structure and its number of the staircases

3.1.3. The sort of the Uses

The map 4 is the distribution map of housing classified by its purpose of its use and the figure 4 shows the number and percentage of the houses based on the data. In Mimase, residences occupy nearly 85% of all buildings in the area with small number of shops and municipal facilities. The whole community sits right behind the fishing harbor where most of its residents depend on fishery.



Map 4. The distribution map of housing classified

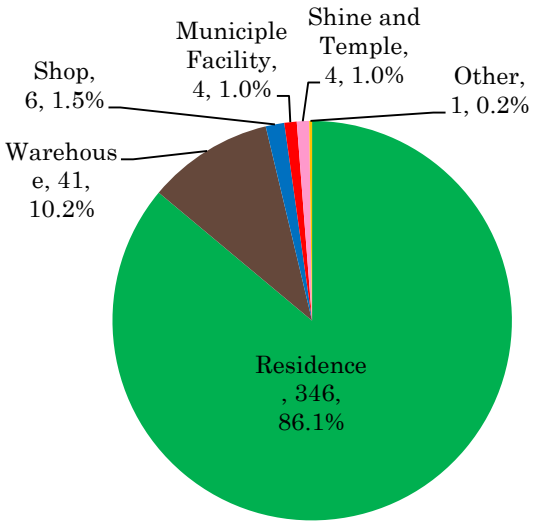


Figure 4. The number and percentage of the houses

3.1.4. Levels of Decrepitude

We categorized the houses in the area by the following criteria to estimate their decrepitude.

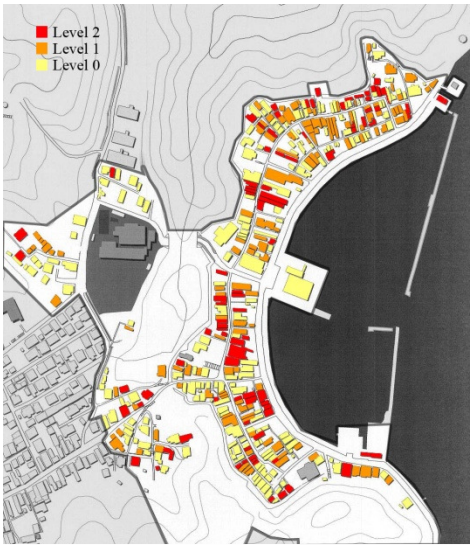
[Decrepitude Level Criteria]

Decrepitude Level 0: Housing in new and immaculate state where damage on the entire building can be hardly found.

Decrepitude Level 1: Housing in the state with some decrepitude in fittings and subject to further deterioration

Decrepitude Level 2: Housing in the state of obvious deterioration with eminent damages.

The map 5 shows the distribution of the levels of decrepitude. The percentage and the number of housing in the area based on its levels of decrepitude are shown by the figure 5. According to this criteria, the result showing that 60% of housing in the area is estimated on the Level 1 or 2, which is presumed to collapse in disaster. The rest of housing which are assessed under Degree 0, however, has the possibility of collapse as well.



Map 5. The distribution of the levels of decrepitude

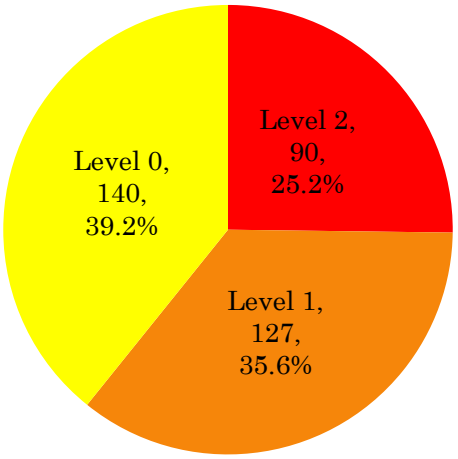


Figure 5. The number and percentage of the level

3.1.5. The Width of the Roads

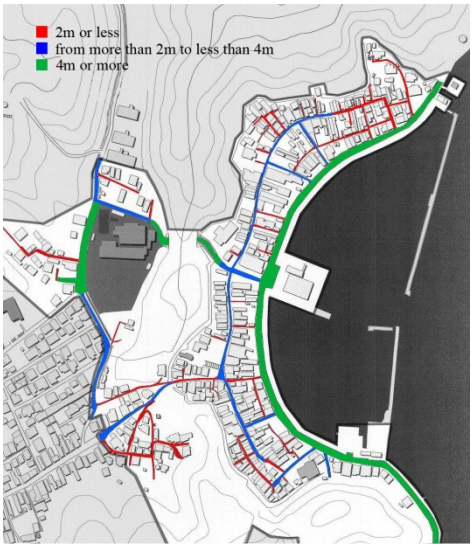
As to the width of roads, we categorized the road by colors as follows:

Red: Extremely narrow roads of 2 meters or less

Blue: Roads of from more than 2 to less than 4 meters

Green: Roads of 4 meters or more where emergency vehicles can pass

Map 6 is the distribution map of the roads and the figure 6 shows the percentage of the each sort of these roads. As shown in the figure 6, approximately 50% of the roads in Mimase area are as narrow as 2 meters or less. Furthermore, only 23.0% of the roads are more than 4 meters and as high as almost 80% of the road cannot allow emergency vehicles such as ambulances or fire engines to enter and function, which consequently makes the rescue operation impossible or extremely difficult. Also, many of the roads are not only narrow but complicatedly winding and inadequate as escape routes.



Map 6. The distribution map of the roads

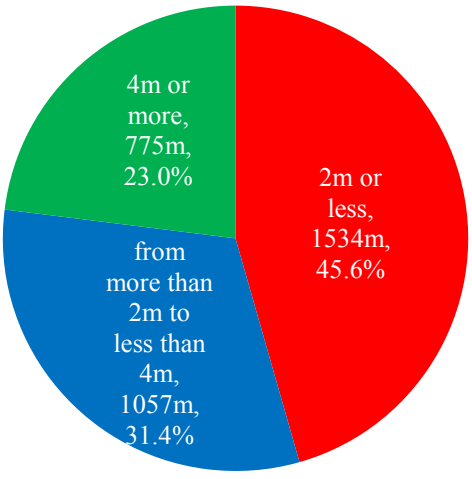


Figure 6. The number and percentage of the each sort of these roads

4. IMPROVEMENT PROPOSALS FOR A SHELTER LOCATION AND ESCAPE ROUTES

According our detailed field survey, many problems to be solved were found on the currently designated evacuation shelter and escape routes in the local Master Plan in Mimase. Reviewing the present situation, we propose other emergency shelter buildings and escape routes.

4.1. The Analysis of the Present Situation of Our Subject Area

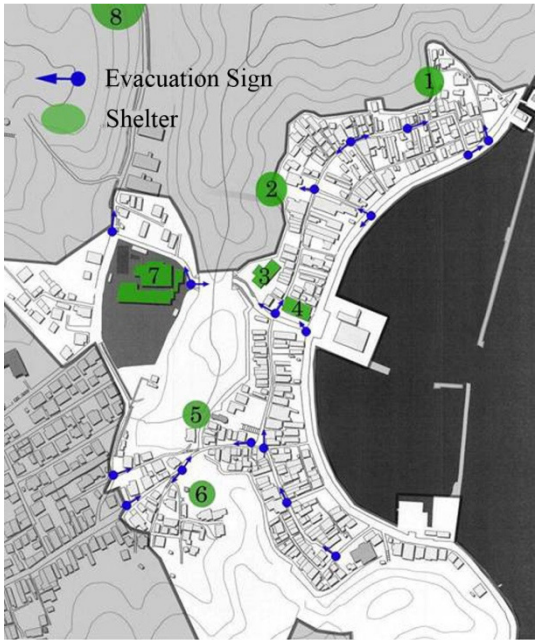
8 shelter locations are designated in the Master Plan in Mimase, which are shown in the map 7 with the instructions given in their evacuation signs in the area.
We examined the shelter locations and escape routes in our field survey. As a result, we came to the conclusion that the following locations are not suitable as shelter location because of the characteristics with many hills with steep stairs and slopes on which these shelters are located:

Ekawayama (1)
Hayasidatei Urayama (2)
Tenmamiya Urayama (5)
Seihachimangu Shrine (6)

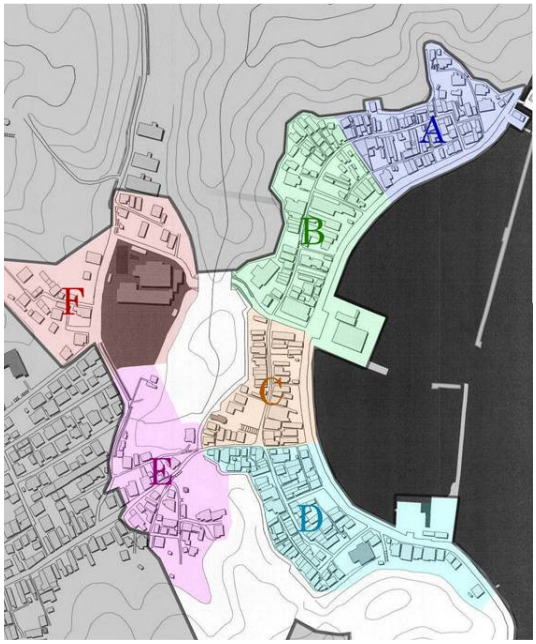
It is not feasible to enable the elderly citizens to escape to such locations. We also have to point out that disorganized shelters and escape routes are not efficient as are in the current situation. Seikaen Garden (8) is extremely remote from residential areas, which makes it impossible to use it as an evacuation shelter as well. Therefore, we determined the following locations as other effective emergency shelters.

Kouch Municipal Mimase Community Center (3)
Shiokaze Group Home (4)
Mimase Elementary School (7)

While considering the three shelters mentioned above as effective shelters, we propose more other emergency shelter locations. This is done by dividing the Mimase area into 6 ranges from A to F, reviewing the efficiency of the shelters. The map 8 shows the ranges divided and the table 1 describes the details about the capacity of these shelters.



Map 7. 8 shelter locations and evacuation signs



Map 8. The range divided in Mimase area

Table 1. The details about the capacity of these shelters in the divided area

Area	The number of houses	The number of residents	Effective emergency shelters	Capacity of shelter
A	84	114	None	0
B	71	97	Kouch Municipal Mimase Community Center	150~180
C	39	54	Shiokaze Group Home	
D	92	125	None	0
E	36	49	Mimase Elementary School	80~100
F	24	33	None	

4.2. Proposals for Shelter Buildings and Evacuation Routes

By using the calculation formula in the "The Guideline for Tsunami Shelter Buildings" devised by Cabinet Office, we have determined efficient evacuation ranges.

The calculation formula is given by

L1=P1 (T−t1−t2)

where the details are explained as follows:

L1: Practicable walking distance for evacuation
P1: Walking velocity
(We assume the average walking speed of an average ordinary person in the crowd as 0.88m/ sec, while that of the elderly, those who have walking disabilities, babies and little children and those who have serious illnesses is supposed to be 0.5m/ sec.)
T: Estimated time left before tsunamis hit the area
(This time is defined in the current Master Plan.)
t1: Time necessary to enable evacuees to start evacuating after the first earthquake
(We set the average time represented is 5.3 minutes, referencing the report based on the questionnaire replies by Hokkaido Nanseioki Earthquake evacuees. The figure, however, should be subject to change, depending both on geographic differences in regions/areas and the extent of community awareness against earthquakes.)
t2: Time necessary to go up the slopes, stairs and hills
(This figure is given by **H／P2** where **H** is the maximum depth of inundation referencing the report on the Tsunami Assessment Research and **P2** stands for the ascending velocity when going up the stairs and steep slopes: 0.21m/sec.)

<Calculation Sample 1: The Case of an Ordinary Adult>

The practicable walking distance **L1** is given by the above-mentioned calculating formula:

L1=P1 (T-t1-t2) as follows:
L1=0.88 × { (10 × 60) – (5 × 60) – (5 ÷ 0.21) } = 243.1m

This distance helps us determine that the shelter location, including a hill or a building, is practicable as long as it is within the range of 243.1 meters before tsunamis hit the area.

<Calculation Sample 2: The Case of the Elderly Citizens or Others with Disabilities>

The practicable walking distance **L1** is given

L1=0.5 × { (10 × 60) – (5 × 60) – (5 ÷ 0.21) } = 138m

This figure help us determine that the shelter location, including a hill or a building, is practicable as long as it is within the range of 138 meters before tsunamis hit the area.

The calculation examples mentioned above allow us to determine the practicable evacuation range, which are shown in the map 9. In the range map, the area circled in black indicates the practicable range revealed by the calculation sample 1 and the one circled in red shows the range calculation sample 2 for the elderly or others with disabilities to evacuate. It is revealed that the shelter buildings or location is inevitably required in the Range A and D. As we have mentioned, almost half the population is occupied by senior citizens in Mimase and the practicable evacuation range in the map exclude the Range A, D and F. The area in the Range F, however, is located on top of the hill, which we assume that it is not necessary to implement any further improvement proposals.

Map 9. The practicable evacuation range

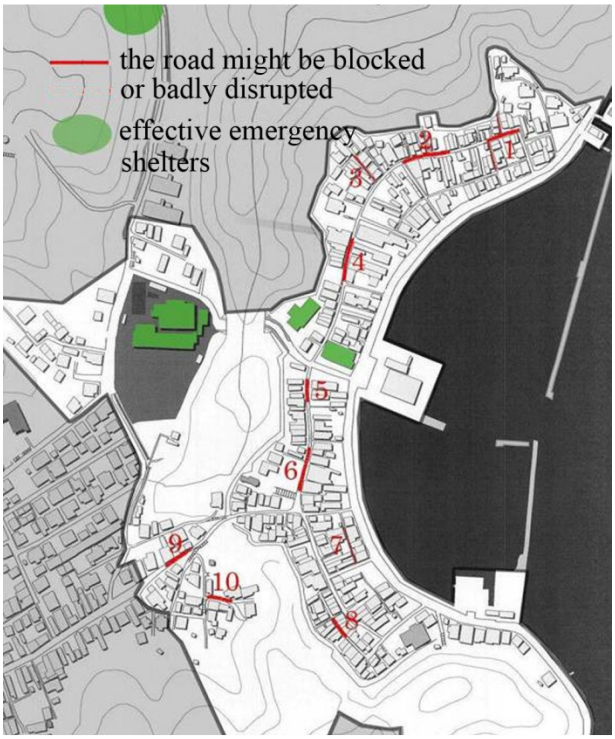
The map 10 illustrates the roads that might be blocked or badly disrupted, which are colored in red, while the practicable shelter locations are colored in green on the basis of our field survey.

- Areas with crowded housing/ buildings on Decrepitude Level 1-2
- Areas where housing/ buildings on Decrepitude Level 1-2 are located on narrow roads
- Areas where housing/ buildings are two-storied and serious damage is predicted

Table 2 shows the surroundings of the roads shown in the map 10. It enables us to propose the different safe shelter locations and escape roads using the existing roads, which are shown in the map 11. It is important to note that some escape roads can be blocked and hinder immediate evacuation.

The aim of our proposal is uniquely to improve and complement the existing disaster prevention plan for the purpose of minimizing tsunami damages. The map 12 shows the effects of the improved shelter locations and escape roads plans in our proposals. Our proposals are based on the detailed field survey, which revealed that setting the escape routes on sufficiently wide roads obviously enable the most efficient evacuation. The improvement plan also include the proposal for constructing the Tsunami Shelter Buildings in the range A and D, by which the evacuation range can consequently cover the whole Mimase area. If our improvement plan was taken into account to complement the

existing disaster prevention plan, it enables the solid evacuation by all citizens, including the senior in the area.



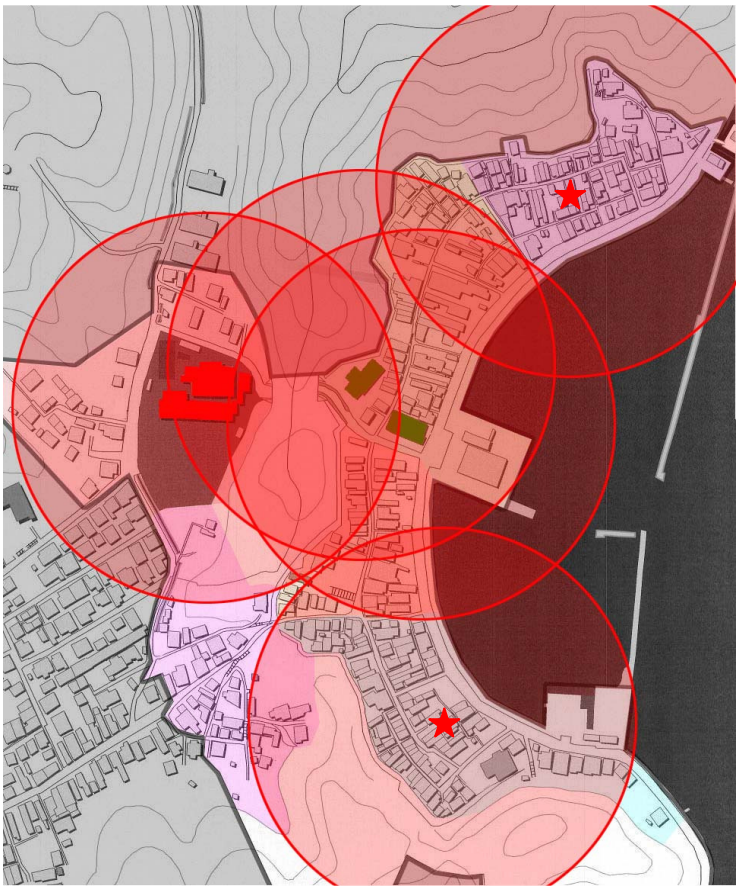
Map 10. The distribution of the roads that might be blocked or badly disrupted

Table 2. Surroundings of the roads that might be blocked or badly disrupted

	The houses in Surroundings	The number of staircases	The level of decrepitude	The width of the roads
1	Residence	only two-story	1 and 2	~2m
2	Residence	only two-story	1	2~4m
3	Residence	only two-story	1 and 2	~2m
4	Residence	Single and two-story	2	2~4m
5	Residence and Shop	only two-story	1 and 2	2~4m
6	Residence	only two-story	2	2~4m
7	Residence and Warehouse	Single and two-story	2	~2m
8	Residence	Single and two-story	1 and 2	~2m
9	Residence	Single and two-story	1 and 2	2~4m
10	Residence	Single and two-story	1 and 2	~2m

<area A> <area D>

Map 11. The different safe shelter locations and escape roads in area A and D



Map 12. The evacuation range in our proposal

Although the subject area in this study was Mimase, a variety of measures are being implemented in the other 3 areas mentioned in the introduction. It is inevitable to thoroughly examine the local characteristics of respective areas to create suitable measures from now on, constantly improving any existing ones. In addition, challenges hereby is to provide the social/ political support with local communities, such as organized communication system, construction of durable breakwaters, restoration plans for devastated areas.

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