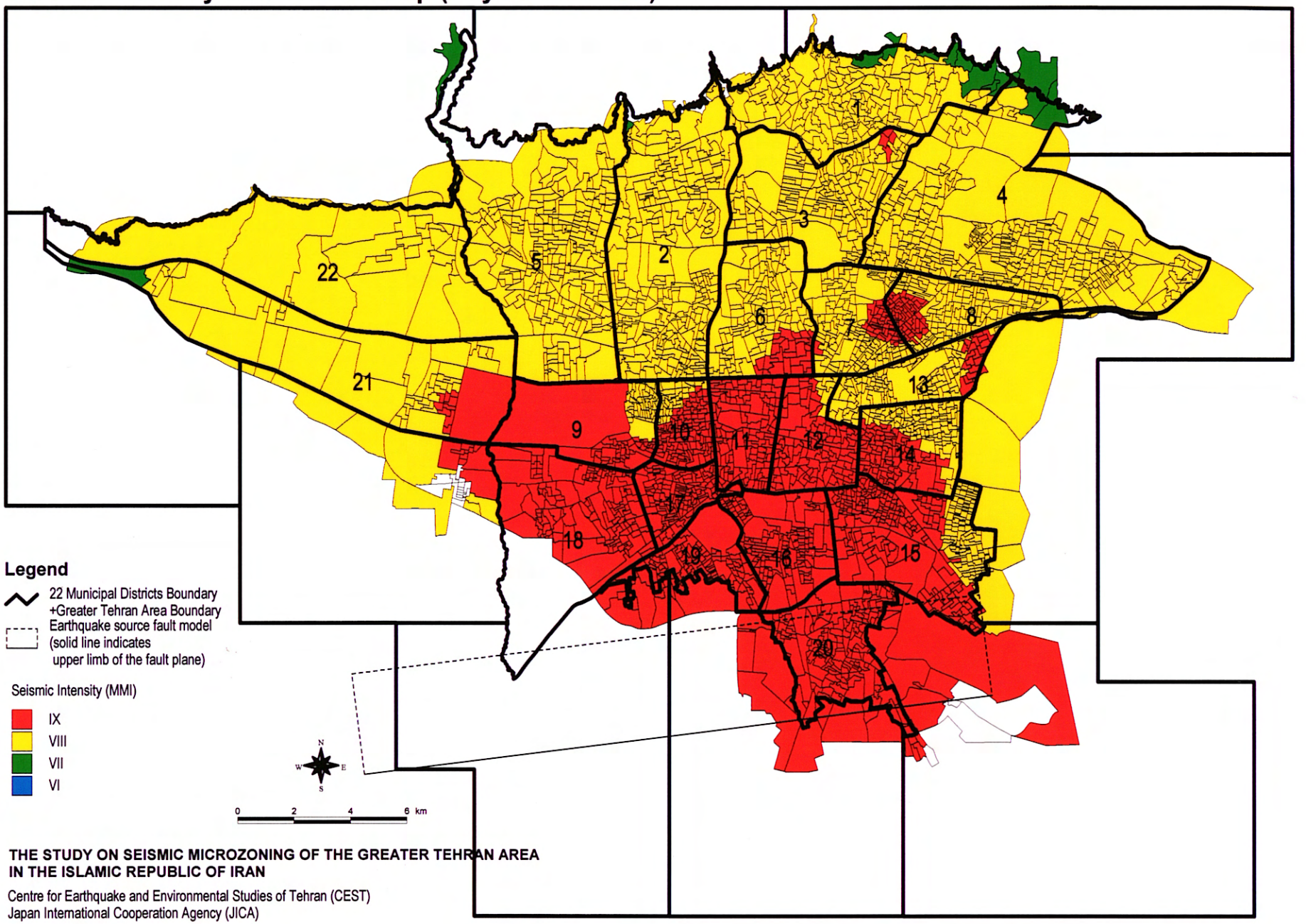
Figure 3.5.2

Seismic Intensity Distribution Map (Ray Fault Model)



THE STUDY ON SEISMIC MICROZONING OF THE GREATER TEHRAN AREA IN THE ISLAMIC REPUBLIC OF IRAN

Centre for Earthquake and Environmental Studies of Tehran (CEST)
Japan International Cooperation Agency (JICA)

Chapter 4 :

Seismic Damage Estimation

Chapter 4. Seismic Damage Estimation

4.1. Residential Buildings

The flowchart of residential building damage estimation is shown in Figure 4.1.1. The following essential aspects are considered in the damage estimation:

- Preparing an inventory database based on the features of the residential buildings of the Study Area;
- Selecting an appropriate damage estimation method and damage function, considering the various conditions prevailing in the Study Area; and
- Calculating the damages based on the appropriate analysis condition and expressing damage in clear figures.

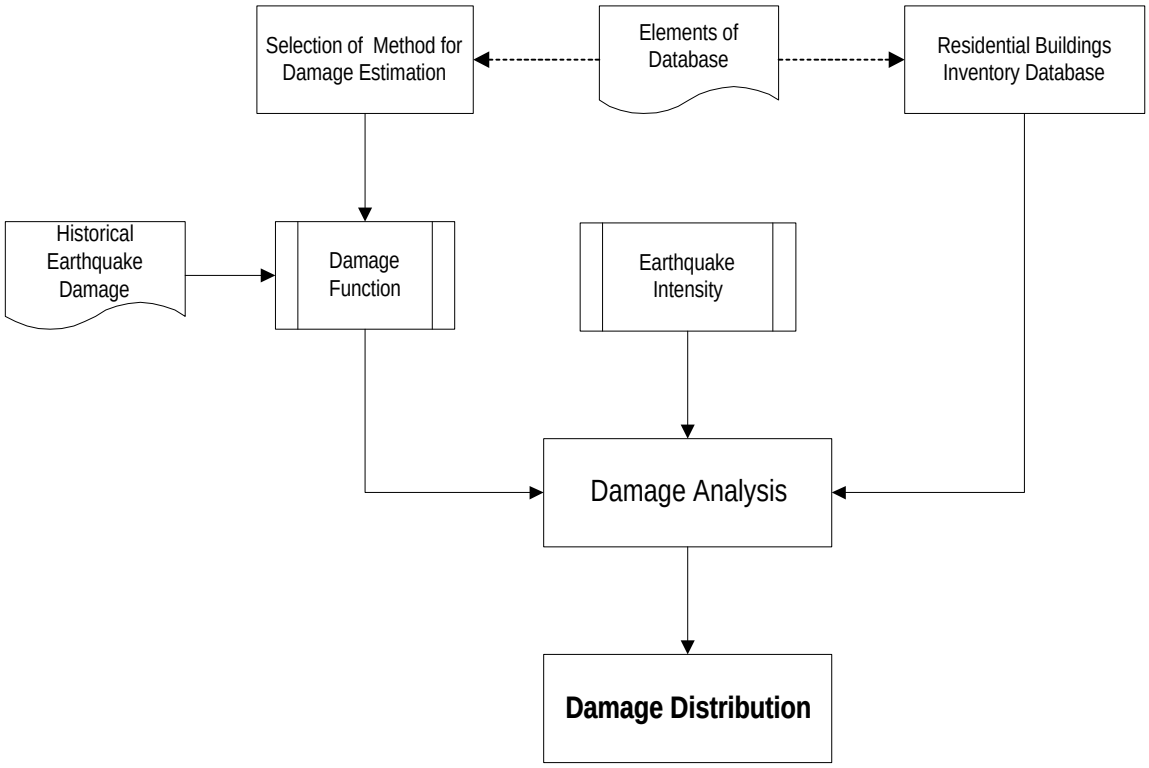


Figure 4.1.1 Flowchart of Damage Estimation for Residential Buildings

4.1.1. Method of Damage Estimation

As described in section 2.2.7, the residential building database was established based on the 1996 Housing Census data. It is complemented by building storey information supplied by the Post Office. This database has the following information items for each building:

- Census zone number and block ID number
- Construction year (interval)
- Number of stories
- Structural type
- Number of rooms
- Number of inhabitants

The construction years, number of stories and the structural type are the basic information items that describe a building's structural properties. A damage estimation method that can utilise these three items was selected.

(1) General Features of the Building Structures in Tehran

Based on the residential building database and site reconnaissance, the features of the residential buildings of the Study area are shown in Figure 4.1.2 and summarised as follows:

1) 45 % of the buildings are steel and brick structures, 40 % are steel structures, 10% are RC structures and only a small percent have adobe structures.

2) There has been a recent increase in the number of steel structure buildings. 60 % of the steel structure residential buildings have been built during the last 10 years.

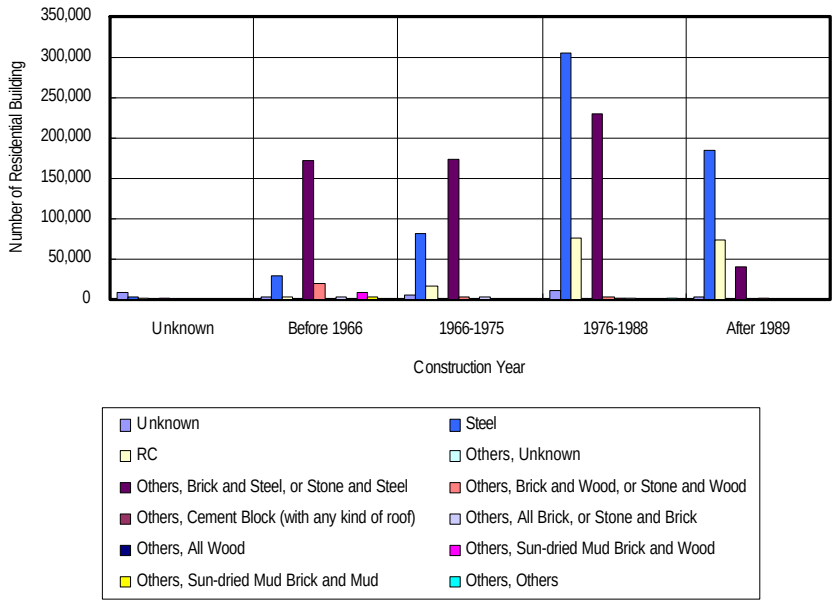


Figure 4.1.2 Number of Residential Building by Structure and Year Band

Source: 1996 Housing Census

(2) Basic Idea of the Damage Estimation Method for Tehran Residential Buildings

Available building information in this Study is structural type, construction year and the number of stories. Based on this information, the buildings in the Study Area were categorised into the following 9 types, especially from the viewpoint of resistance of buildings:

1) Brick and steel or stone and steel
2) Steel-1: Steel structure, built after 1992, with 1 to 3 stories
3) Steel-2: Steel structure, built before 1991 or with more than 4 stories
4) RC-0: Reinforced concrete structure, with more than 6 stories
5) RC-1: Reinforced concrete structure, built after 1991 and with 1 or 2 stories
6) RC-2: Reinforced concrete structure, built before 1991 or with more than 3 stories
7) All wood
8) Cement block (with any type of roof), brick and wood or stone and wood, all brick or stone and brick
9) Sun-dried mud brick and wood, sun-dried mud brick and mud

The earthquake resistant property of buildings differs from area to area and from country to country. The relationship between the seismic force and the damage ratio is not always the same, even if buildings are similar to each other by outlook. It is considered that different methods of construction are a reason for the differences. Therefore, the collection of the seismic disaster record and the establishment of a damage function based on local experience are the most important aspects of the damage estimation.

(3) Damage Ratio for the Steel & Brick Structures in Iran

Tavakoli and Tavakoli (1993) studied damage of villages located near the epicentre of the 1990 Manjil earthquake in Iran. They compiled the relationship between peak ground acceleration (PGA) and building damage. This is the only one numerical relationship between damage ratio and seismic motion for buildings in Iran, which the Study Team obtained. Therefore, this relationship was used as the basic function to establish damage functions for other types of structures.

(4) Damage Function for Other Types of Buildings applied in the Study

Based on the damage function for steel and brick structures, damage functions for the other types of structures were determined. These were obtained by sliding the steel and brick curve along the seismic intensity axis.

The damage functions are summarised on Figure 4.1.3.

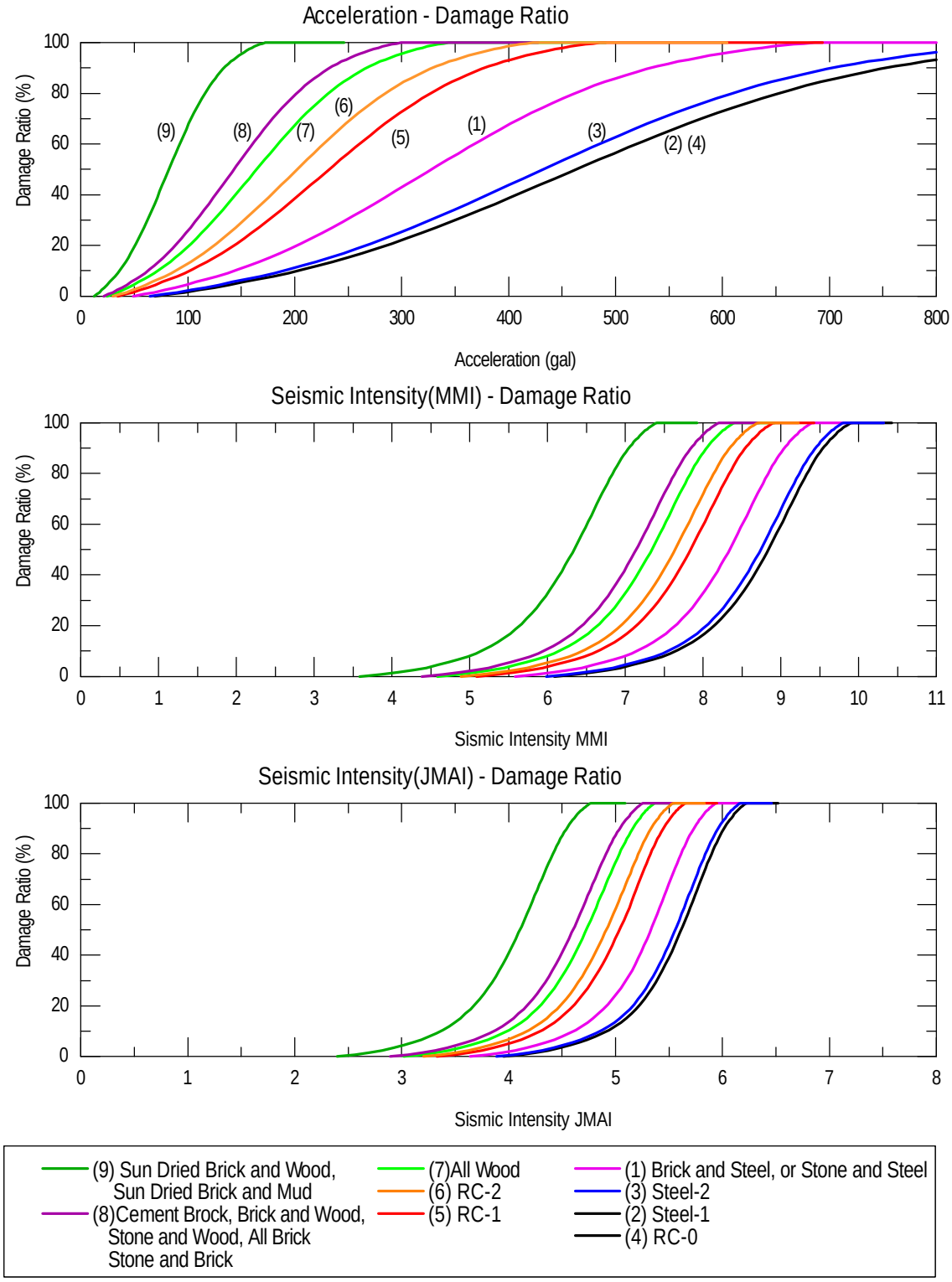


Figure 4.1.3 Vulnerability Function of Residential Buildings applied in the Study

4.1.2. Inventory Database Set-up

In this Study, the dwelling unit inventory database was prepared based on the 1996 Housing Census data. The flowchart of database preparation is shown in Figure 4.1.4.

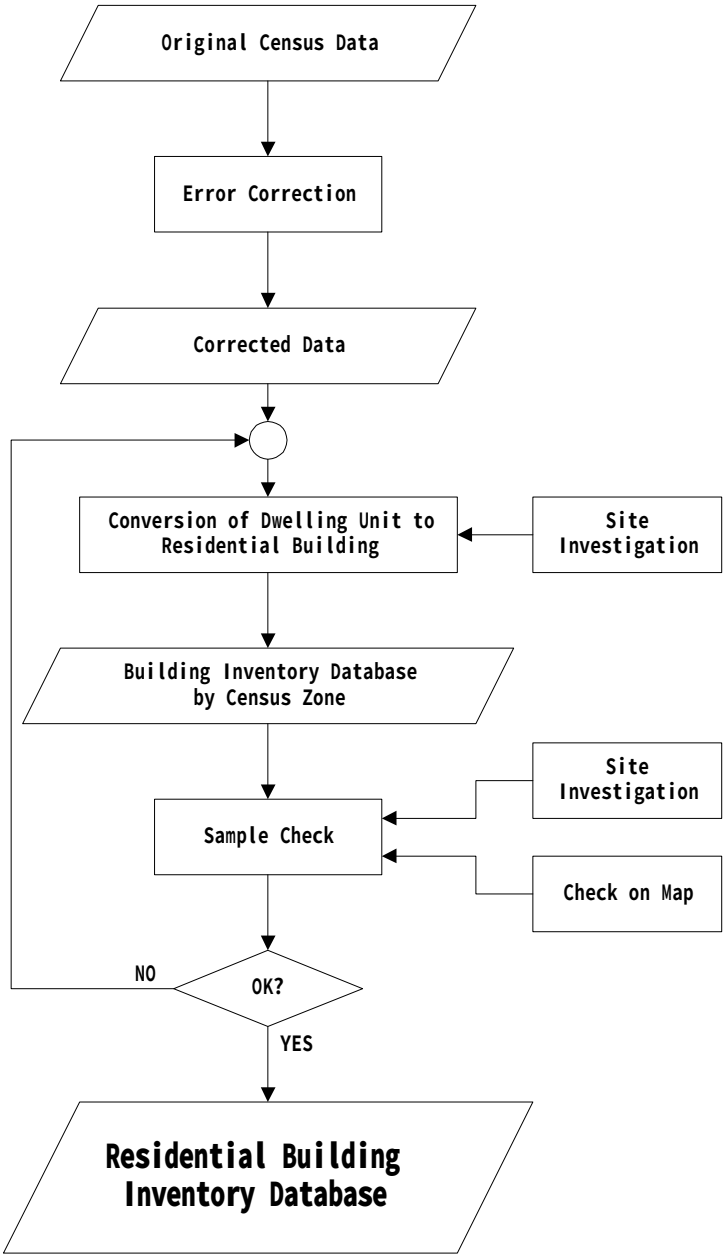


Figure 4.1.4 Flowchart of Dwelling Unit Inventory Database Set-up

Original 1996 Housing Census data is vast in quantity and valuable. It includes such information as building structure, number of resident, construction year, etc. for each dwelling unit. Some data, however, were considered inapplicable to the seismic disaster estimation because of some problems and limitations. Therefore, this census data was arranged for the new database as follows:

1) Error Correction

2) Conversion of dwelling unit to building

Basically, the census data provides information by dwelling unit. For example, if there are 30 dwelling units in one building, the census data gives 30 individual data entries. Necessary data for the disaster estimation is not the number of dwelling unit but the number of buildings. Therefore, the conversion of dwelling unit to buildings is required. Without such conversion, damage in the densely constructed tall buildings area will be over evaluated.

The results of conversion were verified for some sample zones by site inspection and by counting the actual number of building on the topographic map of 1:5000 scale.

The database tabulated for each district is shown in Table 4.1.1 and Figure 4.1.5. As indicated, there are about 900,000 of buildings in the Study area. The structure of 400,000 buildings is ‘ steel and brick’ and 350,00 buildings are of ‘ steel’ . The maximum number of buildings per district is 75,000 in District 15.

Distribution of the ratio of low seismic resistance buildings to the total number of buildings in each census zone is shown in the Figure 4.1.7. Here, low seismic resistance buildings are defined as all buildings, excluding buildings of Steel-1, Steel-2 and RC-0 structural types. From this figure, it is obvious that seismic resistance is different from place to place, even in the adjacent census zones. As a whole, the seismic resistance of buildings at the northern edge and in the southern area is relatively low.

Table 4.1.1 Number of Buildings in Each District by Structure

District	Type of Main Structure											Sum
	?	1	2	3	4	5	6	7	8	9	10	
1	1,398	17,610	7,202	10,950	1,074	213	689	23	216	196	63	39,634
2	2,115	32,960	17,101	11,253	166	202	612	12	21	27	172	64,641
3	1,112	20,548	5,576	8,712	251	76	295	8	97	91	35	36,801
4	3,215	40,498	6,515	30,936	369	276	655	41	45	37	55	82,642
5	1,645	29,250	11,763	9,875	269	260	152	8	76	11	43	53,352
6	756	14,278	2,577	10,233	286	34	180	54	14	33	8	28,453
7	1,576	18,710	1,907	20,914	1,070	124	376	12	122	48	33	44,892
8	1,700	18,985	1,352	28,309	188	28	721	13	8	25	10	51,339
9	503	4,747	557	14,500	171	12	121	1	2	60	6	20,680
10	1,186	8,117	218	28,682	986	18	708	6	296	70	42	40,329
11	1,051	9,975	492	15,338	3,137	31	472	53	1,249	330	136	32,264
12	958	8,493	436	9,648	4,698	59	493	205	2,710	850	141	28,691
13	1,133	11,781	580	20,459	1,148	23	196	12	104	84	8	35,528
14	1,716	19,946	839	29,726	1,822	82	158	111	639	284	25	55,348
15	2,714	27,203	1,945	38,546	2,286	114	292	99	508	308	1,240	75,255
16	1,408	8,852	424	23,399	1,495	144	462	70	967	208	9	37,438
17	1,229	7,490	148	23,401	385	14	336	4	95	98	12	33,212
18	1,306	11,496	269	22,247	132	12	164	1	20	26	3	35,676
19	759	9,273	292	16,086	107	16	134	5	20	30	8	26,730
20	1,381	16,480	2,082	21,139	713	307	440	24	377	273	62	43,278
21	741	8,798	1,831	10,366	55	479	29	1	18	28	21	22,367
22	132	4,312	1,500	740	11	7	32	2	0	1	1	6,738
City	29,734	349,802	65,606	405,459	20,819	2,531	7,717	765	7,604	3,118	2,133	895,288

Legend for Structure

?:Unknown 1:Steel 2:RC 3: Others, Steel & Brick or Steel & Stone
4: Others, Wood & Brick or Wood & Stone 5: Others, Cement Block 6: Others, All Brick or Brick & Stone
7: Others, All Wood 8:Sun-dried Mud Brick & Wood 9:Sun-dried Mud Brick & Mud
10:Others

Note: After Conversion from Dwelling Unit to Residential Building

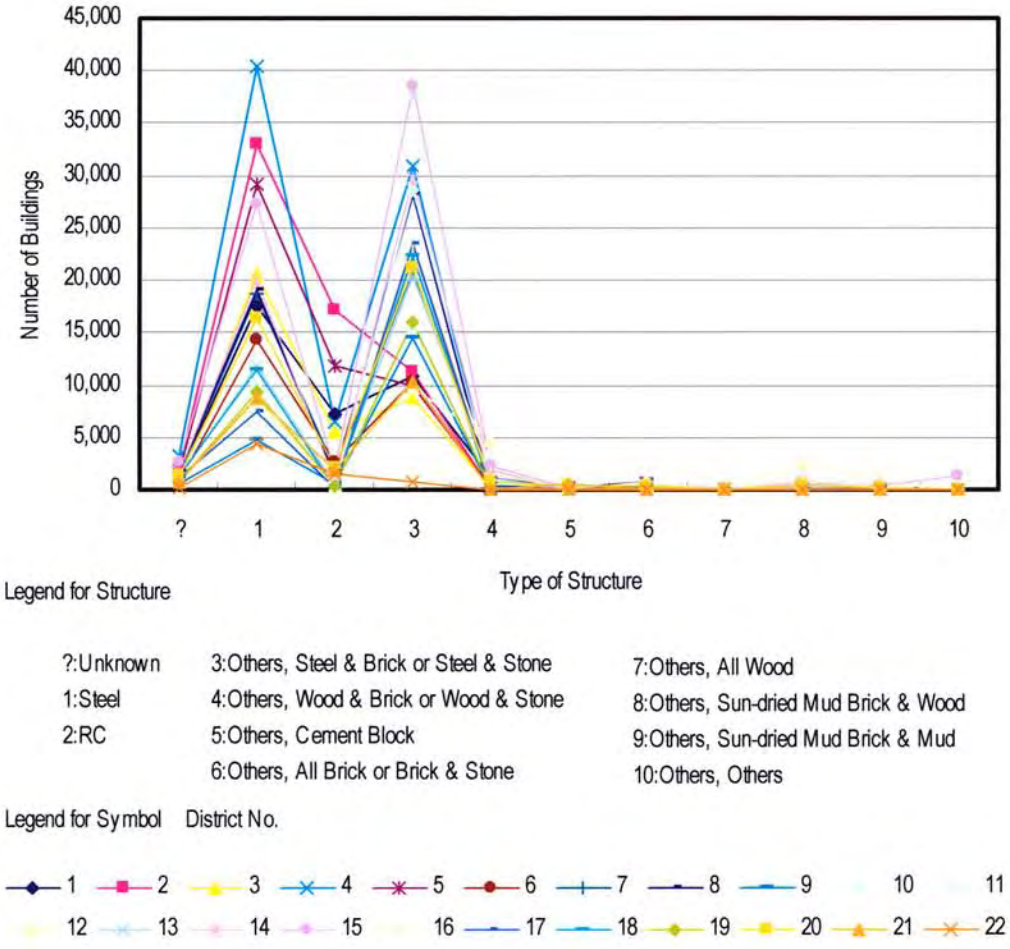
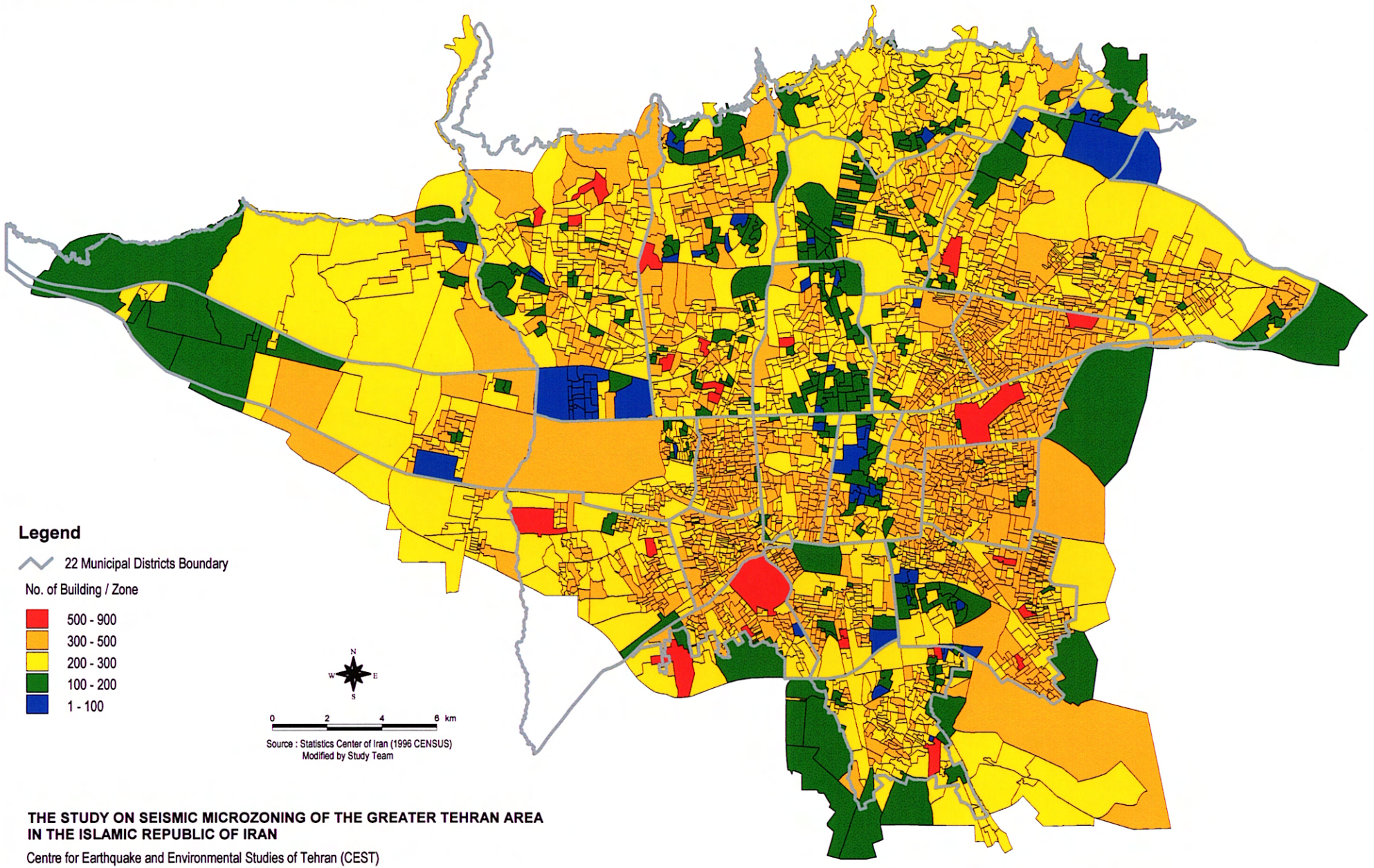


Figure 4.1.5 Number of Buildings in Each District by Structure, After Conversion from Dwelling Unit to Residential Building

Figure 4.1.6

Building Distribution by Structure (Total)



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