(4) Damage estimation for bridges

A. Collected data

The vehicular bridges on the main roads in the map "PLANO DE LA CIUDAD DE BOGOTÁ, D.C," IGAC, 2001, and the national roads in the eight municipalities are investigated by the Study Team.

The number of bridges investigated is shown in Table 4.2.31. Figure 4.2.27 shows the location of bridges.

Table 4.2.31 Number of Bridges Investigated by JICA Study Team

	Pedestrian bridges	Vehicular bridges		
		Flyover	River	Total
Bogotá	146	108	69	323
8 cities	19	6	11	36
Total	**165**	**114**	**80**	**359**

Source: JICA Study Team

The following characteristics are observed about the bridges in the Bogotá City Area:

- Almost all the bridges are made of concrete structures.
- Of the 194 of the total number of bridges, 80 of them, or about 40%, go across rivers. While the number of bridges across roads is 114, or 60%, and most of them are flyover bridges.
- Most of the bearings on piers and abutments are of neoprene material. Those are designed based upon the concept that the fixed or movable bearings are not distinguishable.
- 80% of the river-cross bridges are one-span simple girder type. While rigid frame, one-span simple girder, continuous girder, and simple girder of multi-span are distributed almost evenly in road-cross bridges.

The following characteristic are seen from the design viewpoint:

- It is considered that bridges were designed based on the AASHTO standard (USA design code) with modification from time to time before 1995 when Colombian bridge design code (CCP-200) was stipulated. Seismic design was performed in accordance with the AASHTO standard.
- Bridge design is performed based on the CCP-200 after 1995 and seismic coefficient of 0.2 is adopted in Bogotá City.
- Bridge design, however, is performed based on the CCP-200 after 1997 when the Microzonation Study was completed. Seismic coefficient is set in accordance with the study result. (Seismic coefficient is in accordance to the response spectrum.)
- Liquefaction is generally not considered in the design but only in a specific project when required.

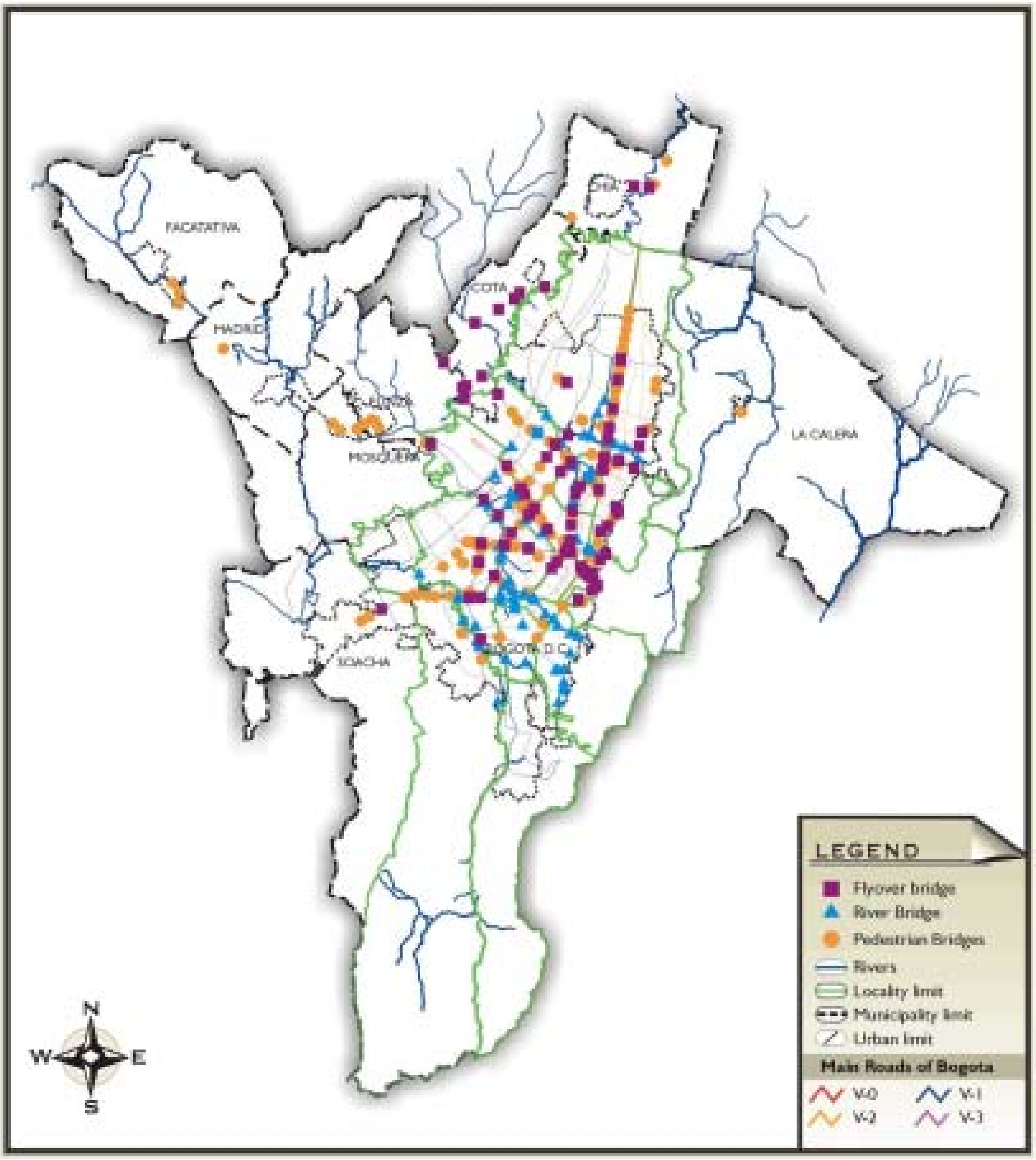


Figure 4.2.27 Locations of Bridges

Assumptions

A statistical method based on Japanese experiences is adopted, since information on collapse of bridges in Colombia is not available. The "point evaluation procedure", i.e. the multi-dimensional quantification theory, was adopted. The results obtained from the 'point evaluation procedure' describe what amount of damage may be expected to bridges at the time of an earthquake. It is crucial that once some bridges are judged to collapse then a detailed seismic analysis should be undertaken as precise as the original design.

B. Methods and procedures

Procedures

There are vehicular and pedestrian bridges in the Study Area. In this study, seismic risk of vehicular bridges is evaluated. Basic concept of seismic risk estimation for bridges is shown in Figure 4.2.28.

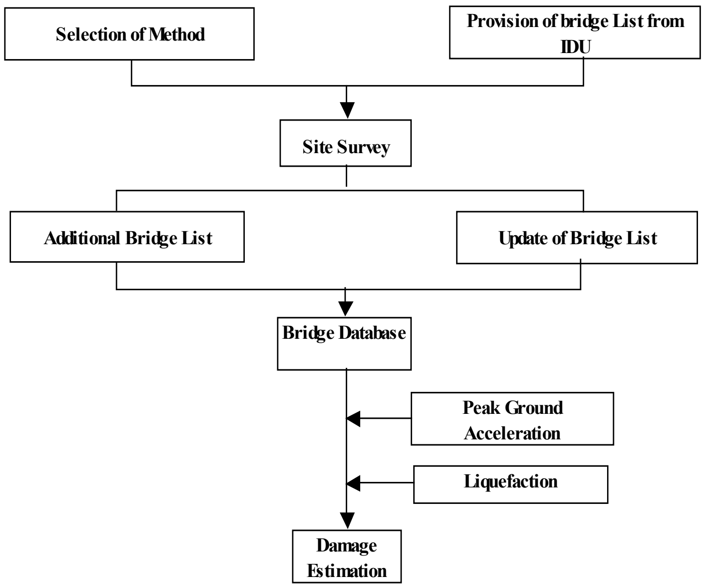


Figure 4.2.28 Basic Concept of Damage Estimation for Bridges

Methods

The criteria for seismic damage of the bridge is based on the method proposed by Tsuneo Katayama, which has been adopted in the Disaster Prevention Council of Tokyo Metropolitan Area (1978) and is widely used in Japan for practical purpose. This method only evaluates collapse of beam, and breaking of piers or foundations etc. are not evaluated. The following factors are taken into account for evaluation:

- Ground type, Liquefaction, Girder type, Number of individual girders.
- Bearing type (shoe type), Minimum bridge seat width.
- Maximum height of abutment and pier, Earthquake intensity scale.
- Foundation type, Material of abutment and pier.

Estimated seismic risk is expressed as a total score. Stability judgment of bridges is defined as follows:

- Total score is above 30: “High Seismic Risk”.
- Total score is from 26 to 30: “Medium Seismic Risk”.
- Total score is below 26: “Low Seismic Risk”.

Pedestrian Bridge

In this study, pedestrian bridges are evaluated only with respect to liquefaction potential area. This is partly because collapsed pedestrian bridges will not pose major obstacles after an earthquake, since it is relatively easy to remove the wreckage. Another reason is that there was no collapse of pedestrian bridges in earthquakes in Japan. Furthermore, no information on collapse of pedestrian bridges during earthquakes in Colombia was available.

C. Results of damage estimation

The estimated risks of bridge are shown in Table 4.2.32 and Figure 4.2.29.

Table 4.2.32 Summary of Estimated Seismic Risk

Seismic	Case 1: La Cajita		Case 2:Guayuriba		Case 3: Subduction	
Risk	Nom.	%	Nom.	%	Nom.	%
High	53	27.3	58	29.9	0	0.0
Medium	1	0.5	0	0.0	0	0.0
Low	140	72.2	136	70.1	194	100.0
Total	**194**	**100.0**	**194**	**100.0**	**194**	**100.0**

The damages of case 1 are almost the same as that of Case 2. Seismic damages for one-third of the bridges are “High". No damage is expected in Case 3. All the bridges in municipalities in Cundinamarca are expected as “low” risk for the three cases.

The estimated seismic damages of bridges by structural type are shown in Figure 4.2.30 and Tables 4.2.33 and 4.2.34.

Regarding structural type of bridges, all Rahamen type bridges are of low seismic risk for the three cases. Most bridges with more than 1 simple beam are at high risk in cases 1 and 2.

The estimated seismic risk of bridges by liquefaction effect is shown as Figure 4.2.31 and Tables 4.2.35 and 4.2.36.

Regarding liquefaction effects, more than 70% of high-risk bridges are affected by liquefaction.

Table 4.2.33 Estimated Seismic Risk of Bridges by Structural Type (Case 1)

Area	Type	Structure	Num.	%	Case 1: La Cajita fault					
					Number			(%)		
					High	Medium	Low	High	Medium	Low
Bogotá	River	Rahamen	3	1.5	0	0	3	0.0	0.0	1.5
		Simple beam	64	33.0	25	1	38	12.9	0.5	19.6
		more than 1 Simple beam	2	1.0	2	0	0	1.0	0.0	0.0
		Sub-total	**69**	**35.6**	**27**	**1**	**41**	**13.9**	**0.5**	**21.1**
	Vehicle	Rahamen	26	13.4	0	0	26	0.0	0.0	13.4
		Continuous	7	3.6	0	0	7	0.0	0.0	3.6
		Simple beam	27	13.9	1	0	26	0.5	0.0	13.4
		more than 1 Continuous	22	11.3	7	0	15	3.6	0.0	7.7
		more than 1 Simple beam	26	13.4	18	0	8	9.3	0.0	4.1
		Sub-total	**108**	**55.7**	**26**	**0**	**82**	**13.4**	**0.0**	**42.3**
	River + Vehicle		177	91.2	53	1	123	27.3	0.5	63.4
8 Municipalities	River	Simple beam	11	5.7	0	0	11	0.0	0.0	5.7
	Vehicle	Rahamen	3	1.5	0	0	3	0.0	0.0	1.5
		Simple beam	1	0.5	0	0	1	0.0	0.0	0.5
		more than 1 Continuous	2	1.0	0	0	2	0.0	0.0	1.0
		Sub-total	**6**	**3.1**	**0**	**0**	**6**	**0.0**	**0.0**	**3.1**
	River + Vehicle		17	8.8	0	0	17	0.0	0.0	8.8
Total	River	Bogotá + Cundinamarca	80	41.2	27	1	52	13.9	0.5	26.8
	Vehicle	Bogotá + Cundinamarca	114	58.8	26	0	88	13.4	0.0	45.4
	Total	**Bogotá + Cundinamarca**	**194**	**100.0**	**53**	**1**	**140**	**27.3**	**0.5**	**72.2**

Table 4.2.34 Estimated Seismic Risk of Bridges by Structural Type (Case 2)

Area	Type	Structure	Num.	%	Case 2: Guayuriba fault					
					Number			(%)		
					High	Medium	Low	High	Medium	Low
Bogotá	River	Rahamen	3	1.5	0	0	3	0.0	0.0	1.5
		Simple beam	64	33.0	25	0	39	12.9	0.0	20.1
		more than 1 Simple beam	2	1.0	2	0	0	1.0	0.0	0.0
		Sub-total	**69**	**35.6**	**27**	**0**	**42**	**13.9**	**0.0**	**21.6**
	Vehicle	Rahamen	26	13.4	0	0	26	0.0	0.0	13.4
		Continuous	7	3.6	0	0	7	0.0	0.0	3.6
		Simple beam	27	13.9	1	0	26	0.5	0.0	13.4
		more than 1 Continuous	22	11.3	7	0	15	3.6	0.0	7.7
		more than 1 Simple beam	26	13.4	23	0	3	11.9	0.0	1.5
		Sub-total	**108**	**55.7**	**31**	**0**	**77**	**16.0**	**0.0**	**39.7**
	River + Vehicle		177	91.2	58	0	119	29.9	0.0	61.3
8 Municipalities	River	Simple beam	11	5.7	0	0	11	0.0	0.0	5.7
	Vehicle	Rahamen	3	1.5	0	0	3	0.0	0.0	1.5
		Simple beam	1	0.5	0	0	1	0.0	0.0	0.5
		more than 1 Continuous	2	1.0	0	0	2	0.0	0.0	1.0
		Sub-total	**6**	**3.1**	**0**	**0**	**6**	**0.0**	**0.0**	**3.1**
	River + Vehicle		17	8.8	0	0	17	0.0	0.0	8.8
Total	River	Bogotá + Cundinamarca	80	41.2	27	0	53	13.9	0.0	27.3
	Vehicle	Bogotá + Cundinamarca	114	58.8	31	0	83	16.0	0.0	42.8
	Total	**Bogotá + Cundinamarca**	**194**	**100.0**	**58**	**0**	**136**	**29.9**	**0.0**	**70.1**

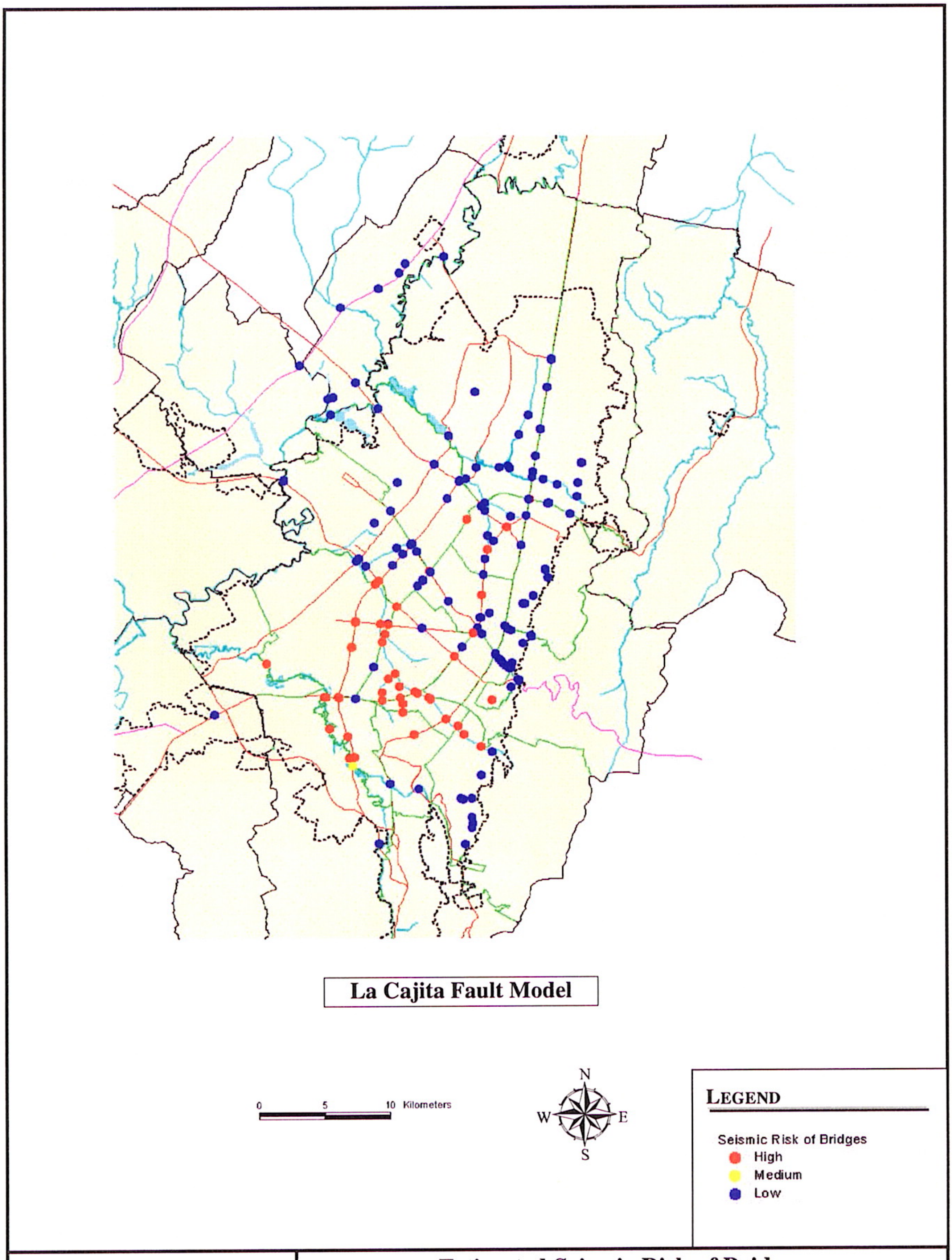
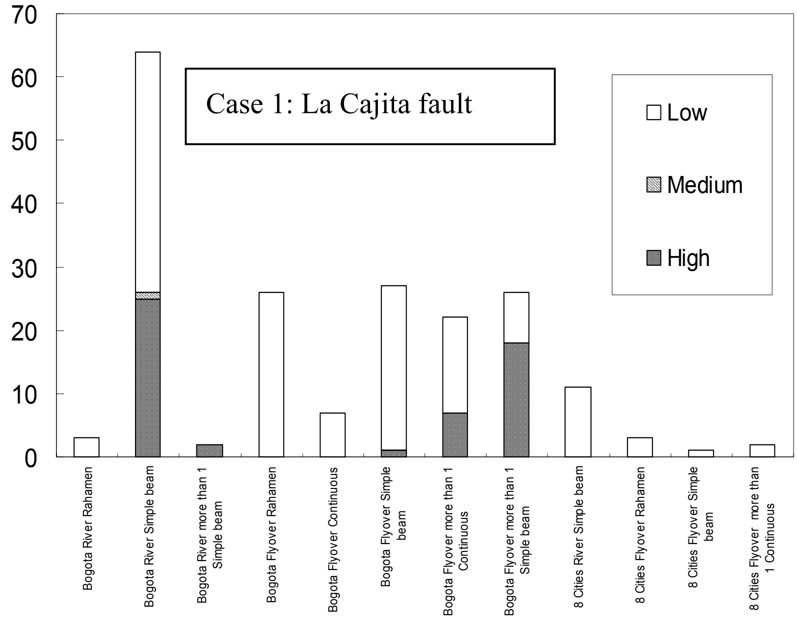


Figure 4.2.29	Estimated Seismic Risk of Bridges



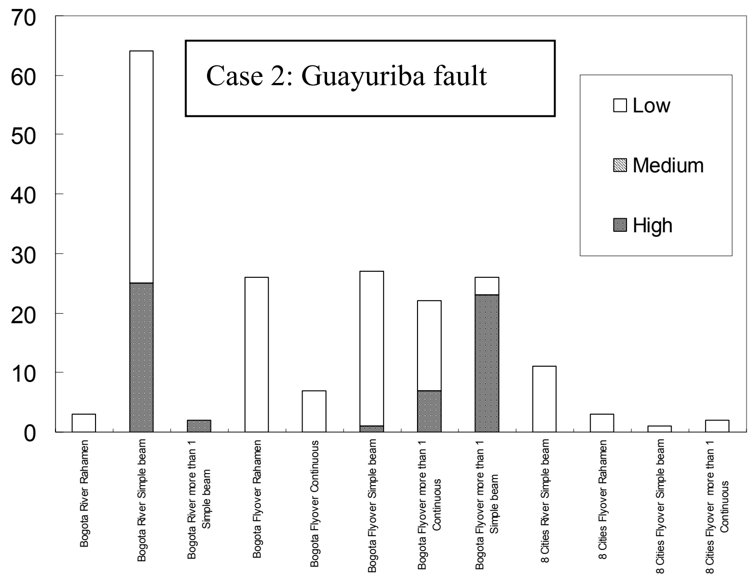


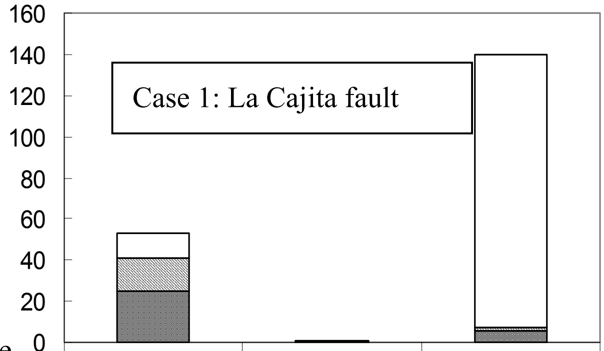
Figure 4.2.30 Estimated Seismic Risk of Bridges by Structural Type

Table 4.2.35 Estimated Seismic Risk of Bridges by Liquefaction Effect (Case 1)

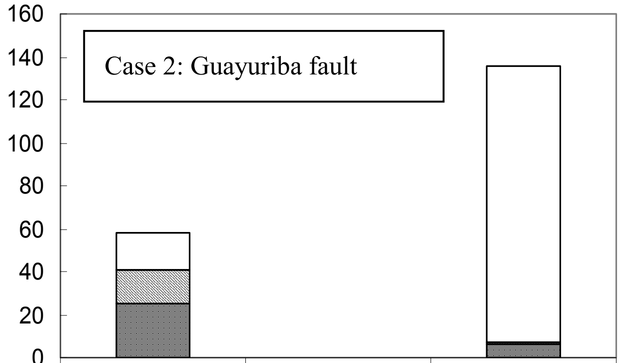
			Liquéfaction								
			Probable			Possible			None		
Area	**Type**	**Structure**	**High**	**Medium**	**Low**	**High**	**Medium**	**Low**	**High**	**Medium**	**Low**
Bogotá	River	Rahamen	0	0	0	0	0	0	0	0	3
		Simple beam	11	0	0	14	0	1	0	0	38
		more than 1 Simple beam	2	0	0	0	0	0	0	0	0
		Sub-total	**13**	**0**	**0**	**14**	**0**	**1**	**0**	**0**	**41**
	Vehicle	Rahamen	0	0	6	0	0	0	0	0	20
		Continuous		0	0	0	0	0	0	0	7
		Simple beam	0	0	0	1	0	0	0	0	26
		more than 1 Continuous	6	0	0	1	0	0	0	0	15
		more than 1 Simple beam	6	0	0	0	0	0	17	0	3
		Sub-total	**12**	**0**	**6**	**2**	**0**	**0**	**17**	**0**	**71**
	River + Vehicle		25	0	6	16	0	1	17	0	112
8 Municipalities	River	Simple beam	0	0	0	0	0	0	0	0	11
	Vehicle	Rahamen	0	0	0	0	0	0	0	0	3
		Simple beam	0	0	0	0	0	0	0	0	1
		more than 1 Continuous	0	0	0	0	0	0	0	0	2
		Sub-total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**6**
	River + Vehicle		0	0	0	0	0	0	0	0	17
Total	River	Bogotá + Cundinamarca	13	0	0	14	0	1	0	0	52
	Vehicle	Bogotá + Cundinamarca	12	0	6	2	0	0	17	0	77
	Total	**Bogotá + Cundinamarca**	**25**	**0**	**6**	**16**	**0**	**1**	**17**	**0**	**129**

Table 4.2.36 Estimated Seismic Risk of Bridges by Liquefaction Effect (Case 2)

			Liquefaction								
			Probable			Possible			None		
Area	**Type**	**Structure**	**High**	**Medium**	**Low**	**High**	**Medium**	**Low**	**High**	**Medium**	**Low**
Bogotá	River	Rahamen	0	0	0	0	0	0	0	0	3
		Simple beam	11	0	0	14	0	1	0	1	37
		more than 1 Simple beam	2	0	0	0	0	0	0	0	0
		Sub-total	**13**	**0**	**0**	**14**	**0**	**1**	**0**	**1**	**40**
	Vehicle	Rahamen	0	0	6	0	0	0	0	0	20
		Continuous	0	0	0	0	0	0	0	0	7
		Simple beam	0	0	0	1	0	0	0	0	26
		more than 1 Continuous	6	0	0	1	0	0	0	0	15
		more than 1 Simple beam	6	0	0	0	0	0	12	0	8
		Sub-total	**12**	**0**	**6**	**2**	**0**	**0**	**12**	**0**	**76**
	River + Vehicle		25	0	6	16	0	1	12	1	116
8 Municipalities	River	Simple beam	0	0	0	0	0	0	0	0	11
	Vehicle	Rahamen	0	0	0	0	0	0	0	0	3
		Simple beam	0	0	0	0	0	0	0	0	1
		more than 1 Continuous	0	0	0	0	0	0	0	0	2
		Sub-total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**6**
	River + Vehicle		0	0	0	0	0	0	0	0	17
Total	River	Bogotá + Cundinamarca	13	0	0	14	0	1	0	1	51
	Vehicle	Bogotá + Cundinamarca	12	0	6	2	0	0	12	0	82
	Total	**Bogotá + Cundinamarca**	**25**	**0**	**6**	**16**	**0**	**1**	**12**	**1**	**133**



Probable	High	Medium	Low
None	12	1	133
Possible	16	0	1
Occurrence	25	0	6



Probable	High	Medium	Low
None	17	0	129
Possible	16	0	1
Occurrence	25	0	6

Figure 4.2.31 Estimated Seismic Risk of Bridges by Liquefaction Effect

C. Pedestrian bridges in liquefaction potential area

Liquefaction during earthquakes would cause serious damage to bridges. In this Study, locations of pedestrian bridges are examined from the viewpoint of potentially liquefiable area for two scenario earthquakes. As a result, almost 20% of the pedestrian bridges are found to be located in liquefaction potential area as shown in Table 4.2.37.

Table 4.2.37 Number of Pedestrian Bridges in Potentially Liquefiable Area

	Number of bridges		Ratio (%)	
Liquefaction	**Case 1**	**Case 2**	**Case 1**	**Case 2**
None	134	133	81.2	80.6
Possible	4	4	2.4	2.4
Probable	27	28	16.4	17.0
Total	**165**	**165**	**100.0**	**100.0**

D. Recommendations

- Seismic diagnosis is recommended for all the bridges in the Study Area, except for bridges examined in second step by IDU's study in 1998.
- Among them, bridges of simple beam or more than one simple beam type is high priority for seismic diagnosis.
- Bridges in potential area of liquefaction is high priority for seismic diagnosis.
- Installation of preventive measures for beam collapse is recommended.
  Detailed investigation on liquefaction effect is recommended.

(5) Industrial facilities

A. Collected data

The investigation on the industrial facilities in Bogotá City was made by DPAE in 1999 and the industrial facilities of the eight municipalities have been investigated by the Study Team. The summary of the industrial facilities is shown in Table 4.2.38.

Table 4.2.38 Industrial Facilities Database

Area	CCS data base (Surveyed year)	DPAE GIS database As of 2001	Data used for seismic risk analysis
Bogotá	1,747 (1999)	1,206	1,582
8 Municipalities	392(2001)	-	392
Total	**2,286**	**1,206**	**1,974**

Source: JICA Study Team

The Study Team made some corrections on the locations of industrial facilities because some 319 companies were not included in DPAE's database.

These data on industrial facilities are classified and distributed as presented in Table 4.2.31.

Table 4.2.39 Number of the Industrial Facilities Classified according to Locality and Municipality

Locality	Number of Industrial Facilities								
	TYPE								Sum
	1	2	3	4	5	6	7	8	
Usaquén	2	0	3	12	24	12	11	33	97
Chapinero	1	0	0	6	13	2	6	20	48
Santa Fe	1	0	1	16	5	0	0	5	28
San Cristobal	2	0	0	0	4	0	0	5	11
Usme	0	0	0	0	0	0	0	1	1
Tunjuelito	2	0	0	19	5	0	1	32	59
Bosa	1	0	1	2	5	1	1	5	16
Kennedy	6	1	8	27	42	3	5	43	135
Fontibón	8	2	5	54	58	6	6	46	185
Engativá	1	1	9	39	27	13	4	43	137
Suba	0	0	4	17	14	8	11	39	93
Barrios Unidos	3	2	7	29	20	14	9	38	122
Teusaquillo	1	1	3	23	9	15	3	18	73
Mártires	2	1	2	21	33	7	4	34	104
Antonio Nariño	0	0	0	6	27	3	1	14	51
Puente Aranda	6	2	15	78	122	29	16	102	370
La Candelaria	1	0	2	1	3	0	0	4	11
Rafael Uribe	0	0	2	3	12	0	0	17	34
Ciudad Bolívar	0	0	0	2	1	1	0	3	7
Sub-total	**37**	**10**	**62**	**355**	**424**	**114**	**78**	**502**	**1,582**
Chía	0	0	7	0	13	1	7	21	49
Cota	0	0	2	8	7	0	2	4	23
Facatativa	0	0	5	3	14	0	4	3	29
Funza	1	4	4	7	20	2	11	34	83
La Calera	0	0	0	4	3	0	0	10	17
Madrid	0	1	4	10	7	0	9	17	48
Mosquera	2	1	0	7	5	0	3	2	20
Soacha	2	1	29	23	43	1	3	21	123
Sub-total	**5**	**7**	**51**	**62**	**112**	**4**	**39**	**112**	**392**
Total	**42**	**17**	**113**	**417**	**536**	**118**	**117**	**614**	**1,974**

Type 1: Oil & fat, Type 2: Pulp & Paper, Type 3: Soap, detergent & paint, Type 4: Inorganic chemical products, Type 5: Organic chemical products, Type 6: Medicine & drugs, Type 7: Other chemical, Type 8: Other industry

B. Method of analysis

In Japan, seismic risk analysis for industrial facilities is made by statistical approach, so the same kind of method is used. Flowchart is shown in Figure 4.2.32.

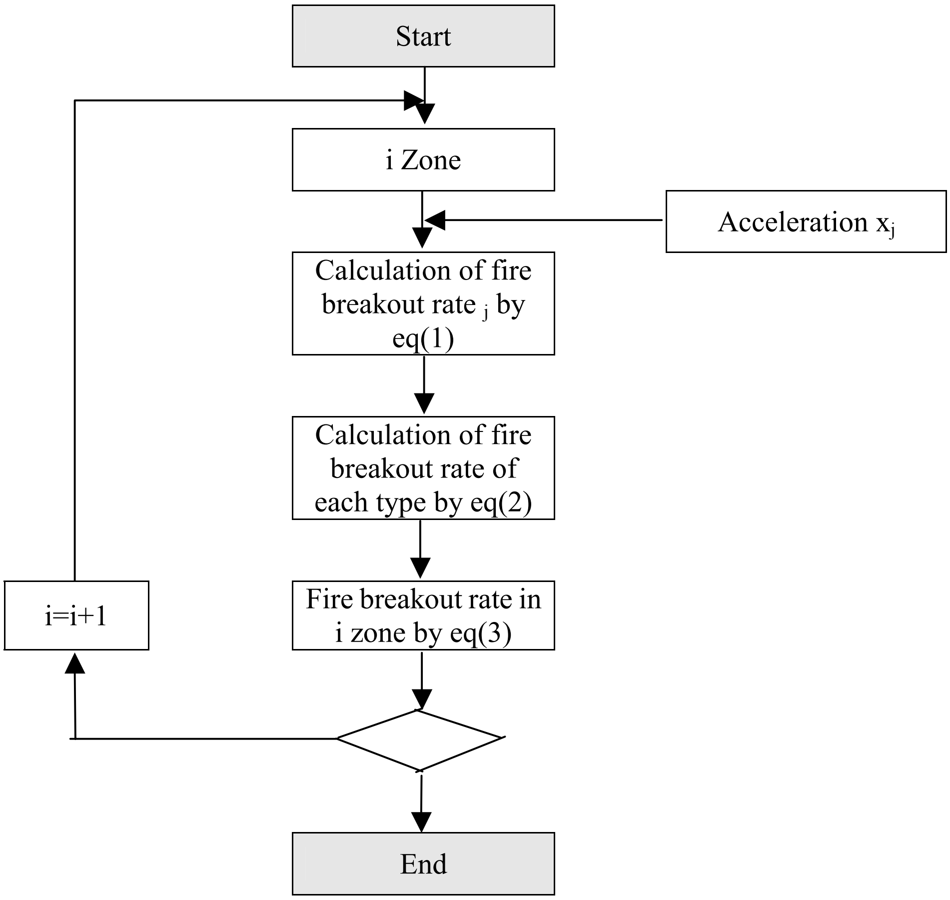


Figure 4.2.32 Flowchart of Fire Break Out Calculation

<u>Assumptions</u>

Tokyo Fire Department investigated the fire break out rate after an earthquake based on the past damage results and various experiments and research. These figures show the fire break out rate at the peak ground acceleration of 350 gal. Also, Tokyo Fire Department classified the industrial facilities into 8 types according to the dangerousness, that is, the degree of risk they presented (see Table 4.2.40).

Table 4.2.40 Fire Break Out Rate After an Earthquake

Type	Type of industrial facility	350gal
1	Oil and fat manufacturing from animals and plants	0.0168
2	Pulp, paper manufacturing	0.0056
3	Soap and detergent, paint manufacturing	0.0098
4	Inorganic chemical products manufacturing	0.0172
5	Organic chemical products manufacturing	0.0255
6	Medicine & drugs manufacturing	0.0467
7	Other chemical company	0.0111
8	Other industry (No use of hazardous materials)	0.0

Source: Tokyo Fire Department (1987)

On the other hand, Kanagawa Prefecture came up with an equation to estimate other acceleration as follows:

- Change rate in fire break out rate = $4.0\times10^{-4}\times$(Acceleration) +0.16.
- Combining this equation and fire break out rate at 350 gal, the fire break out rate at the other acceleration is calculated by the equation as shown in (1).

Since this estimation method uses a statistical approach, absolute values of calculation results are not so meaningful; however, relative value is important. High value indicates high risk of fire break out rate, which corresponds to the relative damage of the industrial facilities.

Calculation method

$$A_{ij} = A_j \times (1.333\times10^{-3}\,\alpha_i + 0.533) \quad (1)$$

$$D_{ij} = A_{ij} \times N_{ij} \quad (2)$$

$$D_i = \Sigma D_{ij} \quad (3)$$

i : Zone number i

j : Type of industrial facilities

α_i : Peak ground acceleration in i-the zone

Nij : Total number of j type industrial facilities in i zone

Aij : Fire break out rate of j-the type industrial facilities in i-the zone

Aj : j-the type of fire out break rate at 350 gal

Dij : Damage or fire break out number of j-the type industry in i-the zone

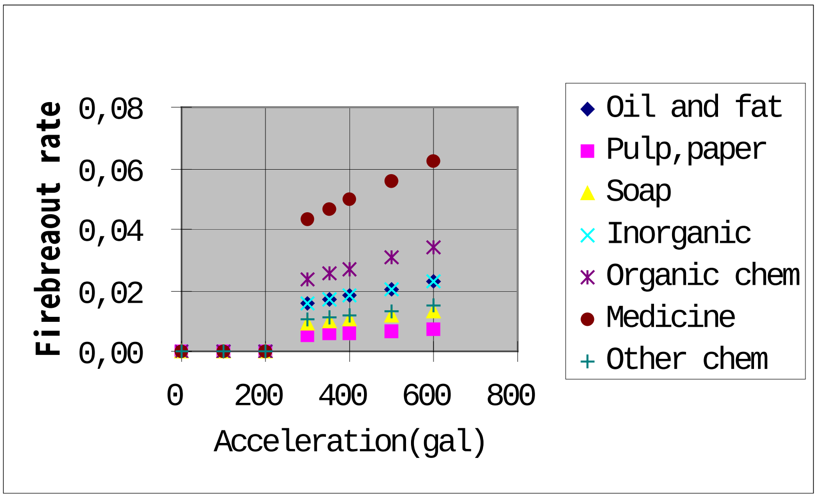


Figure 4.2.33 Fire Break Out Rate by Facility Type

Note 1) 350 gal data is shown on the basis of Tokyo Fire Department data. Other outbreak rate can be estimated by Kawasaki City's estimation method depending on acceleration experiment results.

$A_{ij} = A_j \times (1.333 \times 10^{-3}\ \alpha_i + 0.533)$ where A_j is at 350gal value above

2) There is no fire break out in case acceleration is less than 300 gal.

3) Gas station is classified into type 8 despite handling gasoline. Japanese experience showed no fire break out, because gasoline is stored in the underground tank.

C. Calculation results and evaluation

Risk by earthquake ground motions

Estimated seismic risks and number of the industrial facilities classified by locality and municipality is shown in Table 4.2.41. Estimated seismic damages for industrial facilities for Case 1 scenario earthquake (La Cajita Fault Model) is shown in Appendix 4.2.10. Estimated seismic risks for industrial facilities for Case 2 scenario earthquake (Guayuriba Fault model) is shown in Table 4.2.41 and Appendix 4.2.10.

These results indicate the following:

- High risk area are Puente Aranda and Los Mártires in both cases, because the number of industrial facilities that handles hazardous materials is high and peak ground acceleration is rather high.
- Soacha is medium risk area in both cases, because the number of industrial facilities is rather high and peak ground acceleration is rather high.

Table 4.2.41 Estimated Seismic Risk by Locality and Municipality

Locality	Seismic Risk Evaluation		
	Case 1	Case 2	Case 3
Usaquén	Low	Medium	Low
Chapinero	Low	Low	Low
Santa Fe	Low	Low	Low
San Cristóbal	Low	Low	Low
Usme	Low	Low	Low
Tunjuelito	Low	Low	Low
Bosa	Low	Low	Low
Kennedy	High	Medium	Low
Fontibón	Low	Medium	Low
Engativá	Low	Medium	Low
Suba	Low	Low	Low
Barrios Unidos	Low	High	Low
Teusaquillo	Low	Medium	Low
Mártires	High	High	Low
Antonio Nariño	Low	Low	Low
Puente Aranda	High	High	Low
La Candelaria	Low	Low	Low
Rafael Uribe	Low	Low	Low
Ciudad Bolívar	Low	Low	Low
Chía	Low	Low	Low
Cota	Low	Low	Low
Facatativá	Low	Low	Low
Funza	Low	Low	Low
La Calera	Low	Low	Low
Madrid	Low	Low	Low
Mosquera	Low	Low	Low
Soacha	Medium	Medium	Low

D. Risk by liquefaction

La Cajita case covers an area a bit smaller than the Guayuriba case. The total number of industrial facilities located in the liquefaction area is 474.

E. Risk analysis for gasoline tanks

The Study Team carried out a case study on the seismic influence to the gasoline tanks based on the data from TEXACO. The detailed analysis is shown in tank calculation.

F. Recommendation

- The gasoline tanks are located at Puente Aranda. The Seismic influence to the gasoline tanks must be assessed, because their holding amounts are so huge that catastrophic disaster may occur if the tanks are destroyed. And also the toxic substances such as Cl_2 and NH_3 must be assessed, because these are very dangerous substances: TLV (Threshold Limit Value) is 1 vol. ppm for chlorine and 25 vol. ppm for ammonia.

- The big companies, which handle hazardous materials, are listed in Table 4.2.42. These companies should make the risk assessment of liquefaction influence.

Table 4.2.42 Big Companies Handling Hazardous Materials in Liquefaction Area

Name	Locality	Activity Description	Hazard Resource	Hazard
Cyquim De Colombia S.A	Puente Aranda	Production of basic industrial chemical substances except fertilizer	Dangerous substances management and dangerous process	D, F, I, E
Novartis De Colombia S.A.	Puente Aranda	Manufacturing and mixture of insecticides, pesticides, fungicides and herbicides	Dangerous substances management and dangerous process	D, F, I, E
Emp De Licores De Cundinamarrca	Puente Aranda	Distillation of ethyl alcohol, for any use	Alcohol management, combustible storage and caldron use	D, I, E
Merck Colombia S.A.	Puente Aranda	Fabrication of pharmaceutical products and medicine	Dangerous substances management	D,I
Boehringer Ingelheim S.A.	Puente Aranda	Fabrication of pharmaceutical products and medicines	Dangerous substances management and dangerous process	D, I
Fabrica Nacional De Muñecos S.A.	Puente Aranda	Fabrication of basic shape plastics, lamina, film, sticks, pipes and similar products	Management of combustible materials	I
Aga Fano Fabrica Nacional De Oxigeno S.A.	Kennedy	Manufacturing of industrial gases except chlorine and other halogens, natural gas and raw hydrocarbons	Dangerous substances management and dangerous process	D, F, I, E
Quimica Comercial Andina S.A.	Kennedy	Chemical products fabrication	Dangerous materials management, dangerous operations	D, F, I, E
Ico Pinturas S.A	Kennedy	Paint and varnish production for industrial and general use	Inflammable and volatile substances management. Dangerous reactions	D, I, E
Bayer S.A.	Kennedy	Fabrication of pharmaceutical products and medicines	Dangerous substances management and dangerous process	D, I
Gaseosas Lux S.A.	Kennedy	Manufacturing of nonalcoholic drinks or noncarbonated fruit drinks	Use of ammonia as refrigerant gas	F
Filmtex S.A.	Ciudad Bolivar	Plastic production fabrication	Dangerous substances management	I

Legend: D: Spillage F: Leakage I: Fire E: Explosion

(6) Slope

In order to evaluate the landslide possibility in an earthquake, slope stability is calculated based on the maximum horizontal acceleration in each zone by three scenario earthquakes. Thus the distribution of the possible landslide disaster area is presented.

A. Data

The slope data used in this analysis is based on maps obtained from IGAC, which was digitized and converted to grid data by the Study Team. The size of grid is 50m by 50m within basin area, or 25m by 25m within mountainous area. Slope angles (θ') were calculated for each mesh.

B. Method

The method assumes that the area of the landslide disasters should be estimated by the distribution of the area with a critical slope angle, decided by the average of the critical slope angles in the following three slope failure modes.

$$F_S = \frac{\tan\varphi(\cos\theta - k_H \sin\theta) + c\ell}{\sin\theta + k_H \cos\theta} < 1$$

Where:

F_s: safety factor.

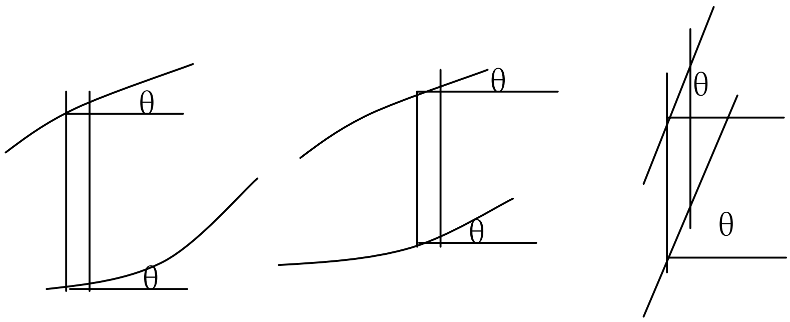
ϕ: internal friction angle of slip surface (degree).

θ: angle of slip surface (degree).

k_H: horizontal acceleration (gal).

c: cohesion (tf/m^2).

ℓ: length of slip surface per unit width (m) $\ell = 1/\cos\theta$.



Landslide Flow Fall

Table 4.2.43 Adopted Values for Slope Stability Analysis During Earthquake

Mode	c tf/m²	ϕ °	θ
Flow	0.5	20	$\theta=\theta'$ Slope angle θ' is equal to the angle of the slip surface
Landslide	0.2	25	$\theta=2/3 \cdot \theta'$ Slip surface just under the slice is equal to 2/3 of θ'
Fall	0.0	35	Slope angle is assumed parallel to the slip surface.

The equation used here to calculate slope stability is a simplified Bishop method, added with horizontal seismic intensity. Weight of sliced volume is assumed as unit weight of 1tf. Pore pressure changes during earthquake is not included here.

The area in which Fs in each failure mode is less than 1.0 is regarded unstable. Strength of the slip surface is assumed from the results of laboratory test as follows:

- Though cohesion of the soil varies from 0 to 1, mean value is adopted in case of Flow, 0.2 (roughly half of the mean value) is adopted in case of Landslide, and 0 is adopted while in case of Fall, because the slip surface is separated.
- Internal friction angle shows 20° to 30°, and 25° is adopted in case of Landslide. The lower limit, 20° is adopted for the case of Flow. In case of Fall, 35° is adopted because 40° is the upper limit. The slope begins to move under the condition of the Fs below 1.0. If the Fs is less than 0.95, it is certain that the slope slides.

C. Result

The resulted figures are as Appendices 4.2.11 to 4.2.13.

The unstable slope areas are recognized in the region where no preservation object exists. The possibility of slope failure that induces landslide disaster is very low except for Case 1 scenario earthquake. With respect to the landslide disaster type for Case 1 scenario earthquake, possible disaster area tends to decrease in order of Flow, Landslide and Fall. For all types, unstable areas are mainly distributed in the southern part of the Study Area close to the epicenter.

4) Estimated Damage from Damage Estimation

(1) Implication of the results

Summary of status in the Study Area is shown in Tables 4.2.44 and 4.2.45. Summary of estimated damage for cases 1, 2 and 3 is shown in Tables 4.2.46, 4.2.47 and 4.2.48.

Table 4.2.44 Summary of Estimated Damage by Earthquake Scenario

Items		Earthquake Scenario: Case 1 (La Cajita)	Case 2 (Guayuriba)	Case 3 (Subduction)
Seismic Intensity		Maximum peak ground acceleration reaches to 0.908g. All the area will suffer seismic intensity higher than VII (strong), and southern part of study area has seismic intensity of XI (very violent) to X (violent).	Maximum peak ground acceleration is 0.361g, lower than that of case 1 due to the long distance to the fault. Major area will suffer seismic intensity of VIII (very strong) or VII (strong).	Due to the long distance to the fault, maximum peak ground acceleration is 0.125g. Central part of study area will suffer seismic intensity of VII (strong) to VI (moderate).
Direct Effects	Building	Heavily damaged: 399,384 Building damage:$ 17,316,160 Million Peso More than 50 % of the building damage is expected in the following localities. Usme, Ciudad Bolivar San Cristobal ,Tunjuelito La Candelaria, Rafael Uribe Santa Fe, Antonio Narino, Bosa	Heavily damaged:421,989 Building damage:$ 22,198,638 Million Peso 50 % of building damage is expected in the following localities. Usme, Tunjuelito, La Candelaria, Bosa San Cristobal , Rafael Uribe Kennedy , Santa Fe Antonio Narino	Heavily damaged: 61,829 Building damage:$ 4,056,774 Million Peso Building damage is expected in the study area, yet the number of affected building is mostly less than 10 % in Bogotá. Among the eight municipalities, Cota, Chia, Funza and Madrid are more than 10% of damage ratio.
	Human Casualty	It is expected more than 250 thousands injured person whole study area. The following localities have more than 10,000 injury. Ciudad Bolivar Kennedy San Cristobal Rafael Uribe Usme Bosa Tunjuuelito Puente Aranda	Following localities would have more than 10,000 injured person. Kennedy Egativa Suba Ciudad Bolivar San Cristobal Bosa Rafael Uribe Usme Usaquen Puente Aranda	Injured person also small comparing to other two cases. The highest locality is Kennedy of more than 4,000 persons.
	Infrastructure	Damage: $ 378,683 Million Peso. Bridge damage: 53 bridges Water and Gas pipeline Ciudad Bolivar, San Cristobal Usme, Kennedy, Bosa Puente Aranda Electricity and telephone cable Usme,Ciudad Bolivar, San Cristobal, Rafael Uribe	Damage: $ 408,921 Million Peso. Bridge damage: 58 bridges Water and Gas pipeline Kennedy, Puente Aranda Rafael Uribe, Usme Electricity and telephone cable damage is expected in the study area, especially most of liquefaction area.	No infrastructure damage is expected.
Secondly Effects	Industrial Facility	Seismic risk to industrial facilities is high in Puenta Aranda and Martires localities in Bogotá, medium in Kennedy locality, and in Soach municipality in Cundinamarca.	Seismic risk to industrial facilities is high in Puente Aranda and Martires in Bogotá, and medium in Usaquen, Kennedy, Fontibon, Barrios Unidos and Teusaquillo localities and Soacha municipality in Cundinamarca.	All localities and municipalities are classified into low seismic risk.
	Landslide	The possibility of slope failure that induces landslide disaster is high only for this case. Insatiable areas are mainly distributed in southern part of study area.	No landslide is expected.	No landslide is expected.

(2) Disaster Scenario

The disaster scenario shows an outline of the direct damage in the Case 1 scenario earthquake (Cajita fault) and also suggests necessary disaster prevention and emergency response to protect the Bogotá Metropolitan Area from disasters by severe earthquakes.

A. Earthquake

An earthquake with epicenter in the Cajita fault will occur early in the morning. The MMI will range from Ⅶ to Ⅹ, i.e., the area near the epicenter: Ⅷ-Ⅹ, the southern part of Bogotá: Ⅷ-Ⅸ, the central part and northwestern part of Bogotá: Ⅶ, but the terrace and cone in Facatativa and the piedmont soil at the eastern part of Bogotá and La Calera: Ⅷ.

Buildings at the southern part of Bogotá will be heavily damaged, and from the central to the northwestern part, half of the buildings will be damaged but slightly. There will be numerous deaths and injuries in areas of heavily damaged buildings. In the southern part of Bogotá, due to the liquefaction effects, collapsed bridges will block the emergency road network at many places. The lifeline facilities, such as water supply, gas, electric power supply and telephone service facilities, will also be damaged, and public services will be stopped. The seismic damage of the Bogotá Metropolitan Area will affect the regional economy. Furthermore, the effect of the seismic damages will be spread and increased due to the delay of the arrangement related to government and non-government entities for emergency response and also the delay of the arrangement of inter-municipal, interregional and international cooperation. It will become a tragic disaster.

Consequently, the functions of the Bogotá Metropolitan Area will be paralyzed and resumption of operations will take a long time, and that will give serious impact not only to the regional economy but also to the national economy.

B. Expansion of the damage due to the delay of arrangement of disaster prevention and emergency response organizations

On the same day the, President will declare a curfew, and the next day, a state of national disaster. The Metropolitan Police and the Military will start their functions and responsibilities. The Bogotá Metropolitan Area will be militarized. Also, the President will establish a Fund for the reconstruction and social development of the Bogotá Metropolitan Area and set up a national emergency response headquarters.

The responsible entities for disaster prevention and emergency response of Bogotá City, Cundinamarca and the national government, will be affected due to blockage of the emergency road network. The emergency response activities will be delayed due to the lack of preparation for emergency response activities and there will be many difficulties for the administrative entities in conducting their emergency response activities, except the military, police, civil defense, the Red

Cross and firefighting bodies. The delay of overall emergency response and recovery activities by the administrative entities will cause and expand new problems and damages.

C. Building Damage

There are 956 thousand buildings either without any seismic resistance capacities or with low resistance capacities. However, a full-scale reinforcement of buildings have not been conducted yet, thus, about 400 thousand buildings in the Bogotá Metropolitan Area will be damaged, especially in the localities of the southern part of Bogotá City, i.e. Ciudad Bolivar, San Cristobal, Tunjuelito, La Candelaria, Rafael Uribe, Santa Fe, Antonio Nariño, Bosa and Kennedy. These localities are lack of basic infrastructure and are therefore vulnerable. The government or public buildings, except the buildings currently constructed, will be damaged in a seismic disaster. The destruction of many of the government buildings will paralyze emergency response activities and cause diminished administrative functions. The demolition of heavily damaged buildings and the clearance of a large volume of debris will be required.

The delay of arrangement of shelters and evacuation places and of reconstruction support activities, due to the lack of preparation, will lead social unrest.

D. Casualties and injuries due to building collapse

The collapse of about 400 thousand buildings will cause 39,000 deaths and 270,000 injuries. The scale of deaths and injuries will overwhelm the medical response capacity of the Bogotá Metropolitan Area. Due to the destruction of many medical facilities and hospitals, the emergency medical response capacities will be diminished and make difficult the conduct of relief activities and transportation of the injured. Also, due to lack of arrangement, support activities from the other cities and other countries will be delayed. Conditions will turn even more miserable.

E. Diminishing transportation capacity due to the damage to infrastructure

In the disaster 53 bridges will be collapsed. The trunk roads in the Bogotá Metropolitan Area will be blocked at many points and lose their function for emergency transportation. Removing the debris is the easy part; it is the recovery of function, which will take a long time because of the lack of preparation and the delay of clearing the roads. Emergency response activities and emergency transportation will be conducted through the bypasses. Traffic will totally be controlled and vehicles for emergency activities only will be allowed entry into the Metropolitan Area.

F. Victims, evacuation space and place of refuge

In the Bogotá Metropolitan Area, about 400 thousand houses/buildings would be damaged, leaving over 3 million people homeless. However, both evacuation spaces and places of refuge will not be sufficient. Numerous victims will have to stay in the collapsed houses because of lack of evacuation spaces and evacuation facilities, water supply, food and other necessities of life.

G. Damaged lifeline facilities and lack of emergency response facilities

In the disaster, lifeline facilities will be damaged in a number of places, i.e., water supply pipeline at 3,753 places, gas pipeline at 428 places, electric cable at 2,077 places, and telephone cable at 2,771 places. The service companies will give their best efforts; however, the fundamental public services like water supply service will be stopped for a long time. In the Bogotá Metropolitan Area, there is almost no emergency water supply for victims.

H. Heavy damage in the vulnerable areas

Vulnerable areas in the southern part and some in the northern part of Bogotá, will show a high damage rate. The indirect damage will increase because of lack of basic infrastructure like evacuation sites and evacuation roads.

I. Communication

Telephone service will be cut locally in the southern part of Bogotá. Wireless telephones and portable telephones will be used. However, it will be difficult to communicate smoothly the necessary disaster and emergency information, including personal safety information.

J. Secondary damage

The earthquake will trigger fires at some of the industries, and will continue to burn, in the localities of Puente Aranda and Los Martires because of blockage of emergency road network and also because of diminished capacities of firefighting bodies owing to their own collapsed facilities. Landslides will occur in the southern part of Bogotá, in areas near to the epicenter, and some inhabitants will have to be evacuated. Landslide areas are shown in Appendices 4.2.11, 4.2.12 and 4.2.13.

(3) Issues for Disaster Management

For prevention and mitigation of the Seismic damages it requires to conduct countermeasures as follows:

A. Arrangement of disaster prevention organizations

In order to alleviate or mitigate the damages to casualties and assets it will be a basic measure for the Bogotá Metropolitan Area to establish organizations for disaster prevention and emergecy responses.

B. Strengthening of buildings, infrastructure and lifeline facilities

In order to decrease the number of casualties it is indispensable for the Bogotá metropolitan Area to alleviate or mitigate the building damages. Also for smooth conduction of emergency response activities it is indispensable for infrastrcture like bridges and lifeline facilities to be strengthened against earthquake.

C. Arrangement of emergency responses to minimize the damage in a disaster

In order to conduct the necessary emergency responses it is necessary for the government organization to prepare for emergency responses and also to prepare initial emergency response activities. For smooth recovering and rebuilding, it is necessary to study on the necessary responses before disaster.

D. Enhancement of public awareness for disaster to alleviate casualties and damages in a disaster

It is important for the government to promote the participation of local people and communities in disaster prevention and emergency responses. In a disaster people's self support activities will be necessary in an initial stage. For the purposes it is necessary for the government continuously to enhance the people's awareness for disaster.

Table 4.2.45 Summary of Status

		Area		Population		Building		Water Pipeline		Gas Pipeline (60psi)		Electricity Cable (11kv)		Telephone Line		Industrial Facilities	
	Locarity or Municipality	(km2)	Ratio (%)	(persons)	Ratio (%)	Number (nos)	Ratio (%)	Length (m)	Ratio (%)	Length (m)	Ratio (%)	Length (m)	Ratio (%)	Length (m)	Ratio (%)	Number (nos)	Ratio (%)
Bogota	Usaquen	66.13	3.4	421,320	6.0	40,051	4.6	488,253	7.2	432,656	4.9	489,993	8.5	909,409	7.8	92	5.1
	Chapinero	27.39	1.4	122,991	1.8	16,108	1.8	253,606	3.7	171,736	2.0	153,649	2.7	624,075	5.3	42	2.3
	Santa Fe	56.22	2.9	107,044	1.5	15,850	1.8	183,903	2.7	168,985	1.9	122,543	2.1	273,938	2.3	28	1.5
	San Cristobal	55.23	2.8	455,028	6.5	54,156	6.2	394,344	5.8	577,386	6.6	108,693	1.9	455,996	3.9	10	0.6
	Usme	110.24	5.7	244,270	3.5	35,442	4.0	164,430	2.4	377,866	4.3	219,758	3.8	319,246	2.7	1	0.1
	Tuenjuelito	9.81	0.5	204,367	2.9	18,409	2.1	168,040	2.5	196,268	2.2	102,755	1.8	219,470	1.9	52	2.9
	Bosa	24.21	1.2	410,099	5.9	49,854	5.7	260,657	3.8	531,520	6.0	119,129	2.1	460,995	3.9	3	0.2
	Kennedy	38.39	2.0	912,781	13.1	92,050	10.5	668,722	9.8	981,395	11.2	481,478	8.4	912,358	7.8	113	6.2
	Fontibón	32.23	1.7	278,746	4.0	26,743	3.0	280,423	4.1	285,122	3.2	386,083	6.7	461,707	3.9	161	8.9
	Engativá	36.06	1.8	749,068	10.7	83,203	9.5	615,661	9.1	887,072	10.1	531,266	9.2	1,124,449	9.6	124	6.8
	Suba	100.81	5.2	706,528	10.1	85,586	9.7	717,165	10.6	912,479	10.4	883,720	15.3	1,199,997	10.3	85	4.7
	Barrios Unidos	12.02	0.6	176,552	2.5	29,077	3.3	272,517	4.0	310,006	3.5	254,921	4.4	625,227	5.3	117	6.4
	Teusaquillo	13.69	0.7	126,125	1.8	17,095	1.9	269,816	4.0	182,259	2.1	304,835	5.3	381,311	3.3	70	3.9
	Mártires	6.60	0.3	95,541	1.4	15,632	1.8	189,365	2.8	166,661	1.9	103,143	1.8	387,133	3.3	103	5.7
	Antonio Nariño	4.99	0.3	98,355	1.4	13,677	1.6	135,302	2.0	145,818	1.7	67,120	1.2	223,236	1.9	48	2.6
	Puente Aranda	17.68	0.9	282,491	4.0	38,082	4.3	418,009	6.2	406,013	4.6	242,553	4.2	756,847	6.5	334	18.4
	La Candelaria	2.08	0.1	27,450	0.4	2,864	0.3	55,631	0.8	30,535	0.3	13,951	0.2	96,182	0.8	10	0.6
	Rafael Uribe	13.68	0.7	384,623	5.5	51,679	5.9	333,689	4.9	550,978	6.3	178,746	3.1	533,466	4.6	32	1.8
	Ciudad Bolívar	232.56	11.9	575,549	8.2	66,505	7.6	384,162	5.7	709,046	8.1	156,880	2.7	538,203	4.6	4	0.2
	Sub Total	860.03	44.1	***6,378,928***	91.3	***752,063***	85.5	6,253,693	92.1	8,023,800	91.3	4,921,217	85.4	10,503,245	89.8	1,429	78.6
Cundinamarca	Chía	80.14	4.1	61,783	0.9	18,111	2.1	142,361	2.1	182,544	2.1	54,482	0.9	64,909	0.6	49	2.7
	Cota	53.68	2.8	14,784	0.2	4,631	0.5	15,903	0.2	0	0.0	90,491	1.6	90,491	0.8	23	1.3
	Facatativá	157.83	8.1	90,266	1.3	14,817	1.7	25,697	0.4	0	0.0	68,155	1.2	68,155	0.6	29	1.6
	Funza	70.29	3.6	51,808	0.7	9,246	1.1	66,958	1.0	0	0.0	141,510	2.5	141,510	1.2	83	4.6
	La Calera	317.93	16.3	24,188	0.3	4,800	0.5	18,661	0.3	0	0.0	94,364	1.6	94,364	0.8	17	0.9
	Madrid	119.44	6.1	52,110	0.7	10,249	1.2	49,869	0.7	0	0.0	45,499	0.8	45,499	0.4	48	2.6
	Mosquera	105.73	5.4	27,753	0.4	7,777	0.9	43,519	0.6	0	0.0	143,033	2.5	146,886	1.3	20	1.1
	Soacha	184.60	9.5	283,889	4.1	57,930	6.6	173,080	2.5	584,113	6.6	206,195	3.6	544,710	4.7	119	6.5
	Sub Total	1,089.65	55.9	***606,581***	8.7	***127,561***	14.5	536,048	7.9	766,657	8.7	843,730	14.6	1,196,524	10.2	388	21.4
	Total	1,949.68	100	**6,985,509**	100	**879,624**	100	6,789,741	100	8,790,457	100	5,764,947	100	11,699,770	100	1,817	100

Table 4.2.46 Summary of Estimated Damage (Case 1)

		Peak Ground		Liquefaction	Heavily Damaged		Human Death		Human Injury		Water Pipeline		Gas Pipeline (60psi)		Electricity Cable (11kv)		Telephone line		Indust. Facilities
	Locarity or Municipality	Min (g)	Max (g)	Potential	Number (nos)	Ratio (%)	Number (persons)	Ratio (%)	Number (persons)	Ratio (%)	Damage (point)	Ratio (point/km)	Damage (point)	Ratio (point/km)	Length (m)	Ratio (%)	Length (m)	Ratio (%)	Seismic Risk
Bogota	Usaquen	0.120	0.370	None	11,070	30	1,081	0.3	7,651	1.8	55	0.11	3	0.01	64	0.01	91	0.01	Low
	Chapinero	0.162	0.436	None	5,771	35	336	0.3	2,426	2.0	81	0.32	5	0.03	75	0.05	249	0.04	Low
	Santa Fe	0.196	0.487	Possible	10,418	66	641	0.6	4,580	4.3	98	0.53	7	0.04	68	0.06	219	0.08	Low
	San Cristobal	0.241	0.605	Possible	43,281	80	5,104	1.1	35,136	7.7	519	1.32	53	0.09	139	0.13	498	0.11	Low
	Usme	0.213	0.754	None	33,740	95	3,027	1.2	21,028	8.6	517	3.15	71	0.19	1,038	0.47	1,471	0.46	Low
	Tunjuelito	0.169	0.384	Probable	13,959	76	1,544	0.8	10,854	5.3	129	0.77	10	0.05	57	0.06	112	0.05	Low
	Bosa	0.135	0.533	Probable	25,666	51	2,529	0.6	17,629	4.3	194	0.74	21	0.04	49	0.04	241	0.05	Low
	Kennedy	0.129	0.338	Probable	46,229	50	6,564	0.7	44,985	4.9	312	0.47	28	0.03	110	0.02	206	0.02	Medium
	Fontibón	0.125	0.280	None	4,153	15	299	0.1	2,162	0.8	3	0.01	0	0.00	0	0.00	1	0.00	Low
	Engativá	0.125	0.163	None	11,873	14	1,014	0.1	7,181	1.0	6	0.01	1	0.00	0	0.00	0	0.00	Low
	Suba	0.118	0.361	None	16,786	20	1,460	0.2	10,273	1.5	14	0.02	1	0.00	4	0.00	7	0.00	Low
	Barrios Unidos	0.130	0.163	None	4,854	17	213	0.1	1,552	0.9	4	0.01	0	0.00	0	0.00	0	0.00	Low
	Teusaquillo	0.163	0.453	None	4,989	29	269	0.2	1,947	1.5	62	0.23	4	0.02	100	0.03	127	0.03	Low
	Mártires	0.290	0.468	Possible	7,500	48	378	0.4	2,727	2.9	88	0.47	7	0.04	47	0.05	156	0.04	High
	Antonio Nariño	0.320	0.341	Possible	7,273	53	428	0.4	3,076	3.1	71	0.53	6	0.04	27	0.04	86	0.04	Low
	Puente Aranda	0.174	0.338	Pos.-Prob.	18,575	49	1,497	0.5	10,529	3.7	178	0.43	15	0.04	76	0.03	198	0.03	High
	La Candelaria	0.307	0.487	Possible	2,122	74	115	0.4	843	3.1	41	0.73	2	0.07	14	0.10	93	0.10	Low
	Rafael Uribe	0.266	0.625	Pos.-Prob.	38,244	74	3,848	1.0	26,622	6.9	342	1.03	48	0.09	212	0.12	584	0.11	Low
	Ciudad Bolívar	0.159	0.908	Probable	55,569	84	7,280	1.3	49,806	8.7	789	2.05	107	0.15	238	0.15	747	0.14	Low
	Sub Total				362,072	48	37,627	0.6	261,005	4.1	3,504	0.56	388	0.05	2,319	0.05	5,088	0.05	
Cundinamarca	Chia	0.112	0.263	None	3,725	20	85	0.1	628	1.0	1	0.01	0	0.00	1	0.00	1	0.00	Low
	Cota	0.118	0.153	None	1,460	32	23	0.2	177	1.2	0	0.02	0	0.00	0	0.00	0	0.00	Low
	Facatativá	0.109	0.210	None	5,078	34	227	0.3	1,650	1.8	0	0.02	0	0.00	0	0.00	0	0.00	Low
	Funza	0.123	0.130	None	1,555	16	45	0.1	334	0.6	1	0.01	0	0.00	0	0.00	0	0.00	Low
	La Calera	0.121	0.322	None	1,746	36	47	0.2	349	1.4	6	0.31	0	0.00	2	0.00	2	0.00	Low
	Madrid	0.118	0.158	None	2,089	21	60	0.1	443	0.9	0	0.01	0	0.00	0	0.00	0	0.00	Low
	Mosquera	0.125	0.185	None	1,329	17	23	0.1	175	0.6	0	0.01	0	0.00	0	0.00	0	0.00	Low
	Soacha	0.142	0.572	None	20,330	35	1,112	0.4	7,865	2.8	240	1.39	39	0.07	86	0.04	492	0.09	Medium
	Sub Total				37,312	29	1,622	0.3	11,621	1.9	249	0.46	39	0.05	90	0.01	495	0.04	
	Total	0.109	0.908		399,384	45	39,249	0.6	272,627	3.9	3,753	0.55	428	0.05	2,409	0.04	5,583	0.05	

Table 4.2.47 Summary of Estimated Damage (Case 2)

		Peak Ground Acceleration		Liquefaction	Heavily Damaged Building		Human Death		Human Injury		Water Pipeline		Gas Pipeline (60psi)		Electricity Cable (11kv)		Telephone line		Indust. Facilities
	Locarity or Municipality	Min (g)	Max (g)	Potential	Number (nos)	Ratio (%)	Number (persons)	Ratio (%)	Number (persons)	Ratio (%)	Damage (point)	Ratio (point/km)	Damage (point)	Ratio (point/km)	Length (m)	Ratio (%)	Length (m)	Ratio (%)	Seismic Risk
Bogota	Usaquen	0.105	0.309	None	14,697	39	1,564	0.4	10,996	2.6	69	0.14	4	0.01	84	0.02	156	0.02	Medium
	Chapinero	0.122	0.311	None	5,158	31	290	0.1	2,101	0.5	40	0.16	2	0.01	34	0.02	146	0.02	Low
	Santa Fe	0.134	0.336	Possible	8,232	52	472	0.1	3,388	0.8	41	0.22	3	0.02	28	0.02	68	0.02	Low
	San Cristobal	0.135	0.338	Possible	30,561	56	3,243	0.8	22,507	5.3	100	0.25	9	0.02	25	0.02	107	0.02	Low
	Usme	0.141	0.361	None	27,135	77	2,279	0.5	15,911	3.8	57	0.35	8	0.02	91	0.04	118	0.04	Low
	Tunjuelito	0.204	0.331	Probable	12,995	71	1,406	0.3	9,904	2.4	85	0.51	7	0.03	36	0.03	68	0.03	Low
	Bosa	0.184	0.306	Probable	28,442	57	2,892	0.7	20,106	4.8	39	0.15	5	0.01	11	0.01	43	0.01	Low
	Kennedy	0.186	0.311	Probable	49,964	54	7,263	1.7	49,688	11.8	290	0.43	25	0.03	94	0.02	181	0.02	Medium
	Fontibón	0.176	0.305	None	11,269	42	1,097	0.3	7,757	1.8	31	0.11	2	0.01	47	0.01	56	0.01	Medium
	Engativá	0.176	0.304	None	35,197	42	4,177	1.0	28,859	6.8	55	0.09	5	0.01	55	0.01	108	0.01	Low
	Suba	0.107	0.296	None	37,336	44	4,137	1.0	28,582	6.8	68	0.10	5	0.01	82	0.01	131	0.01	Low
	Barrios Unidos	0.245	0.312	None	13,242	46	788	0.2	5,608	1.3	47	0.17	4	0.01	67	0.03	148	0.02	Medium
	Teusaquillo	0.295	0.316	None	7,365	43	446	0.1	3,205	0.8	51	0.19	3	0.02	89	0.03	104	0.03	Medium
	Mártires	0.297	0.325	Possible	7,285	47	364	0.1	2,627	0.6	71	0.37	5	0.03	35	0.03	122	0.03	High
	Antonio Nariño	0.317	0.329	Possible	7,153	52	419	0.1	3,011	0.7	65	0.48	6	0.04	25	0.04	77	0.03	Low
	Puente Aranda	0.304	0.318	Pos.-Prob.	18,697	49	1,510	0.4	10,617	2.5	191	0.46	15	0.04	76	0.03	220	0.03	High
	La Candelaria	0.310	0.327	Possible	1,925	67	101	0.0	744	0.2	17	0.31	1	0.03	5	0.03	30	0.03	Low
	Rafael Uribe	0.132	0.338	Pos.-Prob.	29,062	56	2,691	0.6	18,733	4.4	107	0.32	13	0.02	50	0.03	143	0.03	Low
	Ciudad Bolívar	0.122	0.359	Probable	31,870	48	3,528	0.8	24,448	5.8	64	0.17	9	0.01	17	0.01	58	0.01	Low
	Sub Total				377,585	50	38,667	9.2	268,792	63.8	1,488	0.24	132	0.02	950	0.02	2,083	0.02	
Cundinamarca	Chia	0.100	0.263	None	8,014	44	230	0.1	1,674	0.4	14	0.10	1	0.01	7	0.01	8	0.01	Low
	Cota	0.096	0.267	None	2,447	53	46	0.0	343	0.1	2	0.14	0	0.01	5	0.01	4	0.00	Low
	Facatativá	0.078	0.243	None	5,325	36	241	0.1	1,753	0.4	1	0.03	0	0.01	2	0.00	2	0.00	Low
	Funza	0.209	0.225	None	3,329	37	120	0.0	885	0.2	4	0.06	0	0.01	6	0.00	5	0.00	Low
	La Calera	0.109	0.287	None	1,435	30	36	0.0	272	0.1	4	0.20	0	0.01	2	0.00	1	0.00	Low
	Madrid	0.088	0.260	None	4,069	40	142	0.0	1,040	0.2	3	0.06	0	0.01	4	0.01	4	0.01	Low
	Mosquera	0.103	0.223	None	2,436	32	51	0.0	381	0.1	2	0.05	0	0.01	2	0.00	2	0.00	Low
	Soacha	0.113	0.307	None	17,349	30	905	0.2	6,420	1.5	27	0.16	6	0.01	23	0.01	80	0.01	Medium
	Sub Total				44,404	35	1,771	0.4	12,768	3.0	57	0.11	7	0.01	51	0.01	106	0.01	
	Total	0.078	0.361		421,989	48	40,438	9.6	281,560	66.8	1,545	0.23	139	0.02	1,001	0.02	2,189	0.02	

Table 4.2.48 Summary of Estimated Damage (Case 3)

		Peak Ground Acceleration		Liquefaction	Heavily Damaged Building		Human Death		Human Injury		Water Pipeline		Gas Pipeline (60psi)		Electricity Cable (11kv)		Telephone line		Indust. Facilities
	Locarity or Municipality	Min (g)	Max (g)	Potential	Number (nos)	Ratio (%)	Number (persons)	Ratio (%)	Number (persons)	Ratio (%)	Damage (point)	Ratio (point/km)	Damage (point)	Ratio (point/km)	Length (m)	Ratio (%)	Length (m)	Ratio (%)	Seismic Risk
Bogota	Usaquen	0.038	0.125	None	2,404	6	148	0.0	1,083	0.3	2	0.00	0	0.00	0	0.00	0	0.00	Low
	Chapinero	0.038	0.125	None	481	3	13	0.0	101	0.0	1	0.00	0	0.00	0	0.00	0	0.00	Low
	Santa Fe	0.038	0.108	None	1,035	7	32	0.0	238	0.1	0	0.00	0	0.00	0	0.00	0	0.00	Low
	San Cristobal	0.038	0.108	None	2,506	5	125	0.0	916	0.2	0	0.00	0	0.00	0	0.00	0	0.00	Low
	Usme	0.038	0.092	None	2,305	6	92	0.0	678	0.2	0	0.00	0	0.00	0	0.00	0	0.00	Low
	Tunjuelito	0.086	0.108	None	2,144	12	134	0.0	987	0.2	0	0.00	0	0.00	0	0.00	0	0.00	Low
	Bosa	0.086	0.108	None	3,466	7	186	0.0	1,359	0.3	0	0.00	0	0.00	0	0.00	0	0.00	Low
	Kennedy	0.086	0.125	None	7,387	8	602	0.1	4,302	1.0	2	0.00	0	0.00	0	0.00	0	0.00	Low
	Fontibón	0.086	0.125	None	2,217	8	132	0.0	968	0.2	1	0.00	0	0.00	0	0.00	0	0.00	Low
	Engativá	0.086	0.125	None	6,796	8	490	0.1	3,516	0.8	2	0.00	0	0.00	0	0.00	0	0.00	Low
	Suba	0.038	0.125	None	7,628	9	522	0.1	3,743	0.9	2	0.00	0	0.00	0	0.00	0	0.00	Low
	Barrios Unidos	0.108	0.125	None	2,642	9	97	0.0	713	0.2	1	0.01	0	0.00	0	0.00	0	0.00	Low
	Teusaquillo	0.092	0.125	None	1,144	7	39	0.0	296	0.1	1	0.00	0	0.00	0	0.00	0	0.00	Low
	Mártires	0.092	0.108	None	937	6	25	0.0	190	0.0	0	0.00	0	0.00	0	0.00	0	0.00	Low
	Antonio Nariño	0.108	0.108	None	932	7	29	0.0	222	0.1	0	0.00	0	0.00	0	0.00	0	0.00	Low
	Puente Aranda	0.108	0.125	None	2,493	7	109	0.0	805	0.2	1	0.00	0	0.00	0	0.00	0	0.00	Low
	La Candelaria	0.092	0.108	None	287	10	8	0.0	65	0.0	0	0.00	0	0.00	0	0.00	0	0.00	Low
	Rafael Uribe	0.038	0.108	None	3,066	6	144	0.0	1,053	0.2	0	0.00	0	0.00	0	0.00	0	0.00	Low
	Ciudad Bolívar	0.038	0.092	None	2,038	3	98	0.0	724	0.2	0	0.00	0	0.00	0	0.00	0	0.00	Low
	Sub Total				51,908	7	3,026	0.7	21,959	5.2	15	0.00	1	0.00	0	0.00	0	0.00	
Cundinamarca	Chia	0.038	0.125	None	2,370	13	47	0.0	352	0.1	1	0.01	0	0.00	0	0.00	0	0.00	Low
	Cota	0.038	0.125	None	722	16	9	0.0	72	0.0	0	0.01	0	0.00	0	0.00	0	0.00	Low
	Facatativá	0.038	0.125	None	1,372	9	41	0.0	309	0.1	0	0.00	0	0.00	0	0.00	0	0.00	Low
	Funza	0.108	0.108	None	897	10	22	0.0	165	0.0	0	0.00	0	0.00	0	0.00	0	0.00	Low
	La Calera	0.038	0.092	None	71	1	1	0.0	6	0.0	0	0.00	0	0.00	0	0.00	0	0.00	Low
	Madrid	0.038	0.125	None	1,240	12	30	0.0	227	0.1	0	0.00	0	0.00	0	0.00	0	0.00	Low
	Mosquera	0.038	0.108	None	486	6	6	0.0	48	0.0	0	0.00	0	0.00	0	0.00	0	0.00	Low
	Soacha	0.038	0.125	None	2,763	5	83	0.0	611	0.1	0	0.00	0	0.00	0	0.00	0	0.00	Low
	Sub Total				9,921	8	239	0.1	1,790	0.4	2	0.00	0	0.00	0	0.00	0	0.00	
	Total	0.038	0.125		61,829	7	3,265	0.8	23,749	5.6	16	0.00	1	0.00	0	0.00	0	0.00	

5) Damage cost estimation

(1) Buildings

The cost estimation of building damages has been carried out based on the cadastral values of the buildings. The damage ratios are derived from the damage estimation made by this study and each locality's or municipality's damage ratio is used accordingly. Only heavily damaged buildings are included in the calculation. The results of the estimation is shown as follows:

Table 4.2.49 Results of Damage Estimation

Name of Locality/Municipality	Building Damage Estimation (million Peso)		
	Case 1	Case 2	Case 3
Usaquen	1,527,466	2,198,765	416,495
Chapinero	959,667	1,227,096	144,505
Santa Fe	678,325	563,973	54,870
San Cristobal	963,621	721,133	61,432
Usme	471,341	371,193	29,098
Tunjuelito	628,678	601,803	104,671
Bosa	624,525	640,458	77,628
Kennedy	1,989,013	2,215,676	389,212
Fontibon	535,652	1,272,761	262,041
Engativa	821,082	2,136,084	435,318
Suba	1,475,195	2,533,829	705,022
Barrios Unidos	455,671	1,573,371	262,240
Teusaquillo	777,019	1,072,914	286,910
Maritires	822,409	803,029	134,039
Antonio Narino	592,323	582,041	90,375
Puente Aranda	1,333,960	1,506,143	312,727
La Candelaria	152,563	141,222	22,225
Rafael Uribe	1,138,378	956,086	94,604
Ciudad Bolivar	865,916	584,903	44,540
SubTotal	16,812,803	21,702,482	3,927,954
Chia	96,043	91,780	65,580
Cota	29,847	58,617	16,949
Facatativa	45,673	49,241	12,476
Funza	8,601	19,211	4,908
La Calera	185,599	135,594	1,911
Madrid	13,292	25,478	8,257
Mosquera	6,577	12,414	3,054
Soacha	117,725	103,822	15,684
SubTotal	503,357	496,157	128,820
Total	17,316,160	22,198,638	4,056,774

Source: JICA Study Team

The result shows that the building damage is approximately 22 trillion pesos for the medium case, which expects the most damage in the Study Area. It means that more than 32 percent of total buildings would lose their values and total damaged value would exceed this amount because it includes only severely damaged buildings. In the Armenia case, the number of partially damaged houses is 2.5 times more, compared with the number of totally destroyed houses. Therefore, the amount of damage would be more than that of severely damaged buildings.

(2) Infrastructure and lifeline

Rough unit price for reconstruction of one bridge is estimated based on information of the actual construction costs of several bridges from IDU and the rough amount of the damaged bridges is calculated as the amount equal to the product of number of damaged bridges and unit cost.

Also, the damage amount of each lifeline is estimated it like according to the rough unit price for each lifeline facility obtained from related institutions.

A. Unit price

Unit prices used to estimate damage amount is as shown in Table 4.2.50. Unit prices are sourced from concerned institutions. Pipe materials of the water supply pipeline shown in Table 4.2.50 are those incurring almost all damages of water supply pipeline.

Table 4.2.50 Unit Price of Pipe Cable and Bridge

Item	Description	Unit Price (1000pesos)	Unit	Source
Water supply pipes	ACP	300	1 damaged point	EAAB
	CIP	350	Ditto	
	GIP	350	Ditto	
	PVC	300	Ditto	
	RC	30,000	Ditto	
Gas supply pipes	Polyethylene	1,000	Ditto	Natural Gas Company
Electrical cable	Overhead	1,300	1 meter	CODENSA
	Underground	400	Ditto	
Telephone cable	Overhead (pole)	400	1 pole	ETB
	Underground	220	1 meter	
Bridge	RC bridge	7,000,000	1 bridge	IDU

B. Amount of damage of lifelines and bridges

Tables 4.2.51, Table 4.2.52 and Table 4.2.53 show the total amount of damaged bridges and lifeline facilities in case 1, 2 and 3 scenario earthquakes respectively. Unit of the amount is million Pesos.

About 380 billion pesos of damages are anticipated in Case 1 scenario earthquake. The amount of 410 billion pesos is anticipated in Case 2 scenario earthquake. While only 5 million pesos is anticipated in Case 3 scenario earthquake. Figures in the tables are rounded to million units.

The damage amount is almost due to that of the bridge damages.

Table 4.2.51 Case 1 (La Cajita: Near) Total Damage Amount

	Amount of Damage (Million pesos)		
	Bogotá	Cundinamarca	Total
Bridge	371,000	0	371,000
Water supply pipe	3,515	253	3,768
Gas supply pipe	388	39	427
Electric cable	2,715	117	2,832
Telephone cable	605	51	656
Total	**378,223**	**460**	**378,683**

Table 4.2.52 Case 2 (Guayuriba: Medium) Total Damage Amount

	Amount of Damage (Million pesos)		
	Bogotá	Cundinamarca	Total
Bridge	406,000	0	406,000
Water supply pipe	1,494	46	1,540
Gas supply pipe	132	7	139
Electric cable	912	66	978
Telephone cable	255	9	264
Total	**408,793**	**128**	**408,921**

Table 4.2.53 Case 3 (Subduction) Total Damage Amount

	Amount of Damaged (Million pesos)		
	Bogotá	Cundinamarca	Total
Bridge	0	0	0
Water supply pipe	4	0	4
Gas supply pipe	1	0	1
Electric cable	0	0	0
Telephone cable	0	0	0
Total	**5**	**0**	**5**

4.2.2 Landslide

The landslides are triggered by man-made causes and/or natural causes. Deterioration of slope stability by changing topographic conditions such as quarry, rising groundwater tables because of lack of drainage facilities, are examples of man-made causes. On the other hand, increment of groundwater tables by rainfall and lateral forces by earthquakes are examples of the natural causes.

All these causes except for earthquakes are regular phenomena.

1) Regular Scenario

Slope failures triggered by rainfall frequently occur in the rainy season in general. In Bogotá, rainy season lasts from March to May and from October to November. However, monitoring results at El Espino show that the landslides began in the dry season, in August and in September, and that the landslide movements and the rainfalls were not necessarily related. Any relationship is not found between rainy seasons and landslides.

The ground movement was rather related to the beginning of the sewage discharge due to the installation of water supply facilities. In the regular disaster scenario, it is not likely that many landslides occur at the same time in a particular season.

4.2.3 Flooding

The flood scenario should consider magnitudes of the external force and the probable flood of 100-year return period in the flood hazard areas.

The flood disaster scenario should consider magnitudes of the external force and estimate the extent of disaster under these conditions. The external force and disaster would be assumed as follows:

- External force: Amount of runoff.
- Disaster: Flooding and inundation including flash floods.

It is necessary to conduct a flood analysis for the Bogotá City Area to set up the probable flood hazard areas, but it has not been done yet. The flood disaster scenario is to be formulated based on the existing flood risk maps of Bogotá and of the eight municipalities in Cundinamarca.

1) Scenario under Existing Conditions (without Project)

According to the study report of EAAB, the existing conveyance capacity of the Rio Bogotá is evaluated at between 5-year and 10-year return period floods, so that the run-off of 100-year return period flood will overtop the river banks. The flooding area and the affected population are estimated at 11,000 ha and 615,000 as mentioned in Chapter 3.1.3 of this report.

2) Countermeasures against the Scenario under Existing Conditions

There are two countermeasures, namely, structural measures and non-structural measures to reduce the flood damage. However, the non-structural measures cannot prevent the natural phenomena of flooding. Therefore, to prevent the disasters caused by the inundation, the structural measures will basically be applied. The design scales of preventive structures have been determined with the consideration of the importance and accumulation of the assets of the possible inundation areas.

- Rio Bogotá and Tributaries in Bogotá City: 100-year return period flood.
- Other tributaries: 10-year return period flood.

3) Scenario under Future Conditions after Completion of Structural Measures

Even though the structural countermeasures will be completed, there will still be flooding larger than the design scale along the river. It means that it is impossible to prevent all floods by the structural countermeasures. It is, therefore, necessary to consider the non-structural measures as well as structural measures to minimize the flood damage.

4.2.4 Industrial Facilities

The disaster scenario for industrial disasters is to prevent a disaster caused by dangerous materials.

1) Dangerous Materials

According to the investigation in Bogotá, the most frequent events in the past were fires followed by the explosions and these explosions were mostly linked to gunpowder and propane gas.

In terms of frequency and impact of the event, the dangerous materials are gunpowder (including Christmas hot air balloons), propane, gasoline, ammonia, solvents, natural gas, chloride and hydrochloride.

2) Localities and Company Size

The related industries are mostly located in the 8 localities of Puente Aranda, Fontibón, Kennedy, Enqativá, Barrios Unidos, and in lower rates in Usaquén, Los Mártires and Suba. These localities have 78% of the related industries in Bogotá and almost 80% of the companies are small, according to the size classification criteria based on the gross assets reported by the Chamber of Commerce.

4.3 Resources Requirement

4.3.1 Earthquake

To prevent the seismic disasters and reduce the damages estimated by the severe scenario earthquake and also to take proper emergency responses, the preparedness required is as follows:

(Basic measures)

- To conduct geological and geo-technical study on the eight municipalities in Cundinamarca.
- To establish seismic instrumentation in the eight municipalities in Cundinamarca.
- To establish emergency response measures against seismic disasters.
- To select important buildings and facilities like emergency centers, medical centers for emergency responses.
- To conduct seismic safety evaluation on the major buildings, facilities, infrastructure and lifeline structures, and to plan their countermeasures.
- To plan disaster prevention centers required for emergency responses, and
- To establish a unified structure for disaster prevention and emergency responses among the concerned entities.

(Preventive measures)

- To conduct preliminary seismic design for the major buildings, facilities, infrastructure and lifeline structures, and to implement their countermeasures.
- To conduct preliminary seismic design for historical buildings and to implement their countermeasures.
- To prepare a seismic hazard map.
- To prepare a location map for emergency responses.
- To prepare manuals for emergency responses, and
- To set up a communication system as a Disaster Management Information System.

(Preventive actions)

- To enhance public education for preventing seismic disasters and mitigating seismic damages and emergency responses.
- To enhance the technical education for seismic design of buildings and public facilities due to the Colombian Regulation for Earthquake Resistant Design and Construction.
- To review the Colombian Regulation for Earthquake Resistant Design and Construction for masonry structures.
- To establish the inspection process for the construction of buildings.
- To establish a standard seismic design for masonry buildings.
- To prepare standard remedial measures for the existing non-reinforced masonry structures.
- To enhance public education for law-abiding behaviors, and

- To publicize information on seismic hazards and required emergency responses in the Bogotá Metropolitan Area.

4.3.2 Landslide

In the regular scenario, landslide disasters occur sparsely in potential landslide areas, while an earthquake like in Case1- La Cajita will cause landslides at the areas close to the epicenter.

Therefore, the disaster prevention system should be quite different between the cases of regular time and earthquake time. In regular period, relatively small numbers of people will have to make some decisions, while large numbers of people will have to make some quick decisions in case of an earthquake. The expected cost will be mostly equal in both cases. However, in the case of an earthquake, commitment of the engineer or specialists from private consulting companies as disaster aid volunteers is indispensable in order to secure the qualified engineers or specialists.

4.3.3 Flooding

The basic concepts against flood disasters are as follows:

- No inundation will be occurred under the event of new disaster scenario.
- To minimize flood damages with the optimum combination of structural and non-structural measures.

The preparedness required is as follows:

(Basic measures)

- To establish a hydrological observation network for flood warning.
- To establish a flood warning and evacuation system for the Bogotá Metropolitan Area as a part of the Disaster Management Information System.
- To study flood hazard areas of the Bogotá Metropolitan Area, and
- To review the flood disaster prevention program in the POT.

(Preventive measures)

- To conduct river improvement works for the Rio Bogotá from Alicachin to Conejera to have a conveyance capacity of the flood discharges of 100-year return period.
- To conduct improvement works for the flood control facilities of the Rio Tunjuelo.
- To conduct river improvement works for the Rio Botello in Facatativa, and
- To conduct river improvement works and mudflow disaster prevention works at La Calera.

(Preventive actions)

- To study and to improve operation methods of the Alicachin Gates during floods.
- To enhance the control of the land use along the river from river management aspects.
- To enhance public education for prevention of flood disaster and mitigation of flood damages.

- To conduct proper operation and maintenance activities for the river facilities, and
- To enhance the management of the Rio Bogotá basin from water resources and environmental aspects.

4.3.4 Industrial Facilities

In order to prevent the urban area from the disasters related to dangerous materials and the industries handling them and to mitigate the damages, the measures required by the national, regional and company levels are suggested as follows:

(Basic measures)

- To identify hazardous materials and hazardous industries in the Bogotá Metropolitan Area.
- To prepare location maps of hazardous spots in the Bogotá Metropolitan Area, and
- To establish disaster prevention measures and emergency responses.

(Preventive measures of national and regional levels)

- To guide all companies to prepare information about hazardous materials that they are handling and to prepare a Material Safety Data Sheet (MSDS) for the hazardous materials.
- To guide all companies to conduct labeling of bottles containing hazardous materials.
- To start a qualification and training program on technological emergency management on hazardous materials.
- To reconsider the gunpowder restriction in Bogotá or to develop a prevention program for the safe management of hazardous materials based on international standards, and
- To prepare regulations for handling of hazardous materials, referring to the UNCED, US (NFPA Code, EPA RPM), Mexican Regulation, Japanese Fire Service Law etc.

(Preventive measures of regional level)

- To instruct small companies about industrial safety.
- To instruct all companies to establish a Reporting System.
- To instruct all companies to report technological accidents.
- To instruct all companies to report their industrial processes, raw materials or new projects development.
- To regulate the land use in the Bogotá City Area, and
- To relocate the high-risk facilities and industries.

(Preventive measures of company level)

- To prepare prevention plans of propane gas and natural gas disasters, and
- To reconsider the gunpowder restriction in Bogotá or to develop a prevention program for the safe management of hazardous materials based on international standards.

(Preventive actions)

- To enhance the public education of hazardous materials and hazardous industries, and
- To publicize the hazardous spots in the Bogotá Metropolitan Area.

4.3.5 Others

1) Emergency Health and Medical Services

(Basic measures)

- To establish an emergency medical response network of hospitals.
- To set up an emergency medical information system as a part of the Disaster Management Information System.
- To establish medical aide teams.
- To compile manuals on emergency disaster medical services.
- To identify core hospitals for emergency medical services, and
- To conduct preliminary seismic safety evaluation on the core hospitals.

(Preventive measures)

- To increase capacity and capability to receive patients in case of emergency, and
- To prepare temporary hospitals.

(Preventive actions)

- To enhance public education for emergency medical responses.