6 RISK ASSESSMENT RESULTS, ANALYSIS, AND RECOMMENDATIONS

This section presents the results of the risk assessment, analyzes them, and makes recommendations to be used as input to the land use regulation to mitigate damage from permanent ground movement.

This is a qualitative rather than a quantitative study. It is intended to be a planning level document. The study used existing data to quantify the seismic environment and site-specific ground motion. Ground-failure modeling was based on data in the literature. Detailed structural analysis was not included in the scope of work. The results can be considered qualitative estimates of the average potential effects of seismically-induced ground failure on the building damage and casualties in the downtown area. The damage and casualties associated with any one building could be much worse if the building was located directly over a graben or a pressure ridge.

Tables 6.1 - 6.3 summarize potential combined ground shaking and ground failure impacts to the 64 prototypical building variants in the IBC Design Level earthquake for Hazard Zones 5, 4, and 3, respectively. These three tables are sorted by Maximum Total Deaths (taking the maximum of day or night for each building). Hazard Zone 2 has nearly identical results and is not included. Refer to the full technical memorandum in the Appendix F for Zone 2 data if desired.

Table 6.4 presents the same data as in Table 6.1, except that it is sorted on Loss Ratio.

HAZUS' total direct economic loss is the sum of structural and non-structural building damage, contents damage, loss of commercial inventories, and building-related income or business interruption losses (relocation costs, rental losses, business income losses, and wage losses). As seen in Table 6.4, the largest losses (exceeding $70 million) occur in the large hotel, while the small apartment building suffers the smallest loss. Table 6.4 clearly points out that all buildings in Zone 5 with shallow foundations will have a higher Loss Ratio than buildings on mat foundations. Buildings in Zone 4 have a maximum Loss Ratio of 17.9 percent that is lower than two-thirds for all buildings in Zone 5. Stiffer buildings (masonry and concrete) suffer more damage than the more flexible building types (steel and wood frame). Deaths are rare, but more likely to occur in stiff, high occupancy buildings on shallow foundations.

As evidenced by the tables, the magnitude of loss and potential casualties is greatest in Zone 5, generally increases with building size, declines significantly for mat foundations relative to shallow foundations, and is larger for concrete and masonry structures, relative to more flexible steel and wood frame structures.

6.1 Contribution of Shaking and Ground Failure to Combined Risk

Table 6.5 provides a summary of economic impacts resulting from shaking alone, ground failure alone, and for the combined effect of ground shaking and ground failure, for buildings in Hazard Zone 5 in the IBC Design Level earthquake. This table demonstrates that ground failure loss is a significant component of overall loss when shallow foundations are used. When mat foundations are used, ground failure losses are greatly reduced, but the building may still suffer moderate damage as a result of ground shaking.

6.2 Sensitivity to Underlying Fragility Assumptions

To test the sensitivity of loss to the underlying assumption that mat foundations can essentially withstand five times the displacement of shallow foundations, alternative assessments were conducted. First, it was assumed there would be a smaller difference in foundation strength (mat foundations 50 percent weaker than original assumption, able to withstand 2.5x the displacement of a shallow foundation) and then it was assumed that there would be a larger difference in foundation strength (mat foundations 50 percent stronger than original assumption, able to withstand 7.5x the displacement of a shallow foundation). A comparison of economic losses for the sensitivity test runs are provided in Table 6.6. A similar comparison of the maximum expected number of deaths and casualties (for the time of day, either day or night, producing the higher estimate) is provided in Table 6.7. Overall, reducing the assumed strength of the mat foundation by 50 percent results in an average 42 percent increase in economic loss, while increasing the assumed strength by 50 percent reduces the average loss by 20 percent. Reducing the assumed strength of the mat foundation by 50 percent also results in an average 63 percent increase in deaths and a 49 percent increase in overall casualties, while a 50 percent increase in assumed strength results in a 29 percent reduction in estimated deaths and a 22 percent decrease in overall casualties. The conclusion was that even if the mat foundation could only withstand 2.5 times the displacement of the shallow foundation (as compared to 5 used in the study), the differentiation between shallow and mat foundations would be less dramatic, but would only have a limited impact in the results. Specifically, the first five buildings on mat foundations in the Moderate Vulnerability category with the highest "Total Deaths" would be recategorized as High Vulnerability. (See Table 6.1.)

6.3 Analysis

This section evaluates the potential loss of life (Injury Severity 4) due to shaking and PGD, and recommends mitigation measures using land use planning techniques. Note that in HAZUS, the Injury Severity 3 rate is directly proportional to the Injury Severity rate, being 66 percent of the value (Injury Severity 4 Rate x 66% = Injury Severity 3 rate). As a result, considering one or both rates will not impact the results.

Tables 6.1 through 6.3 show the expected deaths during the IBC Design Level earthquake event during the day or night. This data is presented in graphical format in the full Technical Memorandum found in the Appendix. The evaluation is done for new buildings built in accordance with the current International Building Code. The code does not address "acceptable" numbers of deaths in structures, but provides for a design that should be inherently safe. HAZUS provides casualty models based on empirical data as a function of building damage state. These models have been used to estimate the deaths shown in Tables 6.1 through 6.3.

It is assumed that the deaths estimated for buildings in Hazard Zone 2 (and essentially Hazard Zone 3, (with no or minimal PGD) would be considered "acceptable." That is, the analysis is performed for buildings that meet current code design requirements. These "acceptable" deaths are then used as a basis for recommending the types of buildings that are allowable to be sited in the higher Hazard Zones 4 and 5. From Table 6.3, the highest total number of deaths is 0.168 (occurring in the Large Hotel, S1H

structural system on a shallow foundation). This is a small number. To put it into perspective, should the earthquake event occur in the future, there would be an estimated one death in six large modern high rise hotels, each with night-time occupancies exceeding 1,000 people. The number of expected deaths is a function of both the building fragility and the number of people in the building. Prototypical buildings types that have estimated deaths that exceed this number (0.168) in other zones are considered to be "High Vulnerability" buildings, and are shown in cells shaded red and dark pink in Tables 6.1 and 6.2 for Hazard Zones 5 and 4, respectively. It is recommended that the 0.168 number be slightly adjusted upward to 0.23 to allow for easier implementation as there are several buildings that fall into that range. There are no high risk buildings in Hazard Zones 2 and 3. In general, these buildings tend to be large/high rise buildings on either shallow or mat foundations, or medium buildings on shallow foundations.

Within the High Vulnerability category, there is a break in the "Max Total Deaths" between 0.65 and 0.47. Eight buildings have a "Max Total Deaths" greater than 0.65. All have shallow foundations. These will be designated as "Very High Vulnerability" buildings and shown in red on Table 6.1. There are no Very High Vulnerability buildings in Hazard Zones 4, 3, or 2.

In Table 6.1, there is a slight break in the "Max Total Deaths" data between 0.07 and 0.06. This is selected as the next lower threshold. Prototypical building categories with expected deaths less than 0.23 but equal to or greater than 0.07 are categorized as "Moderate Vulnerability" buildings. They are shown shaded in yellow in Tables 6.1 through 6.3 for Hazard Zones 5 through 3, respectively. The number of buildings categorized as having a High or Moderate Vulnerability is significantly lower in progressively lower Hazard Zones 4, 3, and 2.

The relative estimated fatalities per building are higher for buildings in Hazard Zone 5 than in the lower hazard zones. Figure 6.1 shows this in a plot. Buildings are sorted by fatalities per building in Hazard Zone 5 and plotted for Hazard Zone 5, 4, and 2/3. The results show graphically that the expected number of fatalities for Hazard Zone 5 is on the order of 4 to 6 times as great for the same building as in Hazard Zone 4, and as high as 83 times as much for Zones 2/3. These numbers are driven by the magnitude of the expected ground displacements and the likelihood a particular piece of ground will undergo significant movement. The compelling conclusion is that high risk buildings should not be allowed in Seismic Hazard Zone 5 and Seismic Hazard Zone 4. This conclusion is used in the recommendations.

A similar analysis was undertaken to evaluate acceptable building losses in terms of "Loss Ratio" where Hazard Zone 2 (and effectively Hazard Zone 3) represent "shaking only" damage expected to a modern building designed in accordance with the IBC. The maximum Building Loss Ratio in Hazard Zones 2 and 3 is 13.9 percent. By comparison, only 1 of the 64 prototypical buildings in Hazard Zone 5 has Building Loss Ratio ***less*** than 13.9 percent, and it is only 13.7 percent. Examination of the Building Loss Ratio in Hazard Zone 4 shows only 12 buildings with a Loss Ratio greater than 13.9 percent, with the maximum being only 17.9 percent, so Hazard Zone 4 has a limited risk to economic impact. Table 6.4 uses the same data shown in Table 6.1 for Hazard Zone 5, but sorts it based on Loss Ratio and graphically for Hazard Zones 5, 4, and 2/3 in Figure 6.2. It very distinctly shows that all structures with shallow

foundations have a higher Loss Ratio than any buildings with mat foundations. The break point is 30 percent. If we assume that all of the Very High Risk (red) and High Risk (dark pink) buildings are addressed due to life safety issues, that leaves a series of 8 moderate risk and 8 low risk structures with shallow foundations. Tables 6.3 and 6.4 show the significance of the Loss Ratio for shallow versus mat founded buildings in Hazard Zone 5. The average Loss Ratio for buildings on shallow foundations in Hazard Zone 5 is two times that for the same buildings on mat foundations – 38 percent versus 19 percent, respectively. However, there is little difference in the other zones.

Analysis of the data for Zone 5 shows that all structures with shallow foundations have a higher Loss Ratio than any buildings with mat foundations. If we assume that none of the Very High Risk (red) and High Risk (dark pink) buildings (shown in Table 6.1) are allowed in Hazard Zone 5 due to life safety concerns, that leaves a group of 18 moderate and low risk structures with shallow foundations with Loss Ratios greater than 33%. In that the buildings with the highest Loss Ratio would already be eliminated, there is less compelling data to support not allowing additional building categories in Hazard Zone 5.

6.4 Recommendations

We recommend mitigation to limit the number of deaths by limiting the type of building use, foundation, and super structure using the following rules to limit:

Very High and High Vulnerability buildings in Seismic Hazard Zones 5 (red, and dark pink as shown in Table 6.1).

Do not allow the following types of buildings in Seismic Hazard Zone 5:

- Buildings with occupancies greater than 500 (all large hotel and offices) (all foundations).
- Large concrete moment frame or shearwall offices, hotels, or multi-family residences on shallow foundations (offices and hotels already included because occupancy is greater than 500)
- Medium concrete shearwall offices, hotels, multi-family residences, or multi-use buildings on shallow foundations

Buildings shown with moderate (yellow) and low (green) vulnerability are allowed in Zone 5.

High Vulnerability buildings in Hazard Zones 4 (red as shown in Table 6.2):

Do not allow the following types of buildings:

- Large concrete moment frame or shear wall offices or hotels on shallow foundations

All buildings except those shown in dark pink in Table 6.2 are allowed in Zone 4.

The above recommendations are incorporated in The Draft Ground Failure Susceptibility Hazard Overlay District.

The economic impact can be further mitigated over and above the level of damage that would be expected by implementing the above recommendations by not allowing any buildings on shallow foundations in Zone 5. While many of these are limited by the rules above, there are some remaining building categories that have relatively high Loss Ratios even though they would have relatively few expected fatalities. As the buildings with the highest Loss Ratios have been addressed by the above rules, it is not recommended to limit any additional building types to control Loss Ratios.

Table 6.1 Impacts to Prototypical Buildings Due to Shaking & Ground Failure in an IBC Design Level Earthquake- Ground Failure Hazard Zone 5 Sorted on Maximum Total Deaths.

Sequence	Use	Size	HAZUS Model Bldg Type	Foundation	Total Casualties Day (inc deaths)	Total Casualties Night (inc deaths)	Max Total Deaths (Day or Night)	Total Building Damage ($M)	Loss Ratio	Total Economic Loss ($M)
26	Hotel	Large	C1H	Shallow	18.8	37.5	1.69	$ 44.0	47.9%	$74.0
27	Hotel	Large	C2H	Shallow	18.2	36.3	1.63	$ 43.3	47.2%	$72.9
19	Offices	Large	C1H	Shallow	34.7	1.7	1.56	$ 22.3	47.5%	$39.8
20	Offices	Large	C2H	Shallow	33.6	1.7	1.51	$ 22.0	46.9%	$39.4
23	Hotel	Medium	C2M	Shallow	6.2	12.5	0.85	$ 11.7	42.5%	$19.6
16	Offices	Medium	C2M	Shallow	11.8	0.6	0.80	$ 6.9	42.2%	$12.2
9	MFR	Large	C1H	Shallow	3.0	15.0	0.68	$ 16.8	47.9%	$22.8
10	MFR	Large	C2H	Shallow	2.9	14.5	0.65	$ 16.5	47.2%	$22.5
58	Hotel	Large	C1H	Mat	7.3	14.5	0.47	$ 20.4	22.2%	$36.3
51	Offices	Large	C1H	Mat	13.4	0.7	0.44	$ 10.3	22.0%	$18.8
59	Hotel	Large	C2H	Mat	6.3	12.6	0.40	$ 19.2	21.0%	$34.3
25	Hotel	Large	S1H	Shallow	9.7	19.4	0.40	$ 35.4	38.5%	$62.4
30	Multi-Use	Medium	C2M	Shallow	5.9	3.7	0.40	$ 5.3	42.4%	$9.4
52	Offices	Large	C2H	Mat	11.7	0.6	0.37	$ 9.8	20.9%	$18.2
57	Hotel	Large	S1H	Mat	8.3	16.5	0.37	$ 24.3	26.5%	$43.5
18	Offices	Large	S1H	Shallow	18.0	0.9	0.37	$ 17.8	37.9%	$32.8
50	Offices	Large	S1H	Mat	15.3	0.8	0.35	$ 12.3	26.2%	$22.0
6	MFR	Medium	C2M	Shallow	0.9	4.6	0.31	$ 3.5	42.5%	$4.9
24	Hotel	Large	S2H	Shallow	8.1	16.2	0.29	$ 32.6	35.6%	$57.9
17	Offices	Large	S2H	Shallow	14.9	0.7	0.27	$ 16.4	35.0%	$30.7
56	Hotel	Large	S2H	Mat	6.1	12.2	0.26	$ 20.0	21.8%	$35.8
49	Offices	Large	S2H	Mat	11.3	0.6	0.24	$ 10.1	21.6%	$18.6
13	Offices	Small	RM1L	Shallow	2.9	0.1	0.22	$ 1.5	37.3%	$2.7
41	MFR	Large	C1H	Mat	1.2	5.8	0.19	$ 7.8	22.1%	$10.6
42	MFR	Large	C2H	Mat	1.0	5.1	0.16	$ 7.3	20.9%	$10.2
8	MFR	Large	S1H	Shallow	1.6	7.8	0.16	$ 13.5	38.5%	$18.5
55	Hotel	Medium	C2M	Mat	1.5	3.1	0.15	$ 4.5	16.3%	$7.8
40	MFR	Large	S1H	Mat	1.3	6.6	0.15	$ 9.3	26.4%	$12.5
48	Offices	Medium	C2M	Mat	2.9	0.1	0.15	$ 2.7	16.3%	$4.9
22	Hotel	Medium	S4M	Shallow	2.3	4.7	0.13	$ 8.8	32.1%	$15.6
21	Hotel	Medium	S2M	Shallow	2.3	4.6	0.12	$ 9.0	32.6%	$15.8
15	Offices	Medium	S4M	Shallow	4.4	0.2	0.12	$ 5.2	31.6%	$9.5
14	Offices	Medium	S2M	Shallow	4.4	0.2	0.12	$ 5.2	32.0%	$9.6
7	MFR	Large	S2H	Shallow	1.3	6.5	0.12	$ 12.4	35.5%	$17.3
39	MFR	Large	S2H	Mat	1.0	4.9	0.10	$ 7.6	21.7%	$10.5
3	MFR	Small	RM1L	Shallow	0.3	1.3	0.10	$ 0.9	37.6%	$1.3
54	Hotel	Medium	S4M	Mat	1.5	2.9	0.09	$ 4.6	16.6%	$8.2
53	Hotel	Medium	S2M	Mat	1.4	2.9	0.09	$ 4.9	17.7%	$8.5
47	Offices	Medium	S4M	Mat	2.8	0.1	0.09	$ 2.7	16.6%	$5.0
46	Offices	Medium	S2M	Mat	2.7	0.1	0.09	$ 2.9	17.5%	$5.1
32	Parking Struc	Medium	C1M	Shallow	1.1	0.0	0.08	$ 4.8	45.5%	$6.3
31	Parking Struc	Medium	C2M	Shallow	1.1	0.0	0.07	$ 4.7	44.2%	$6.2

Sequence	Use	Size	HAZUS Model Bldg Type	Foundation	Total Casualties Day (inc deaths)	Total Casualties Night (inc deaths)	Max Total Deaths (Day or Night)	Total Building Damage ($M)	Loss Ratio	Total Economic Loss ($M)
62	Multi-Use	Medium	C2M	Mat	1.4	0.9	0.07	$ 2.1	16.3%	$3.7
29	Multi-Use	Medium	S4M	Shallow	2.2	1.4	0.06	$ 4.0	31.9%	$7.3
28	Multi-Use	Medium	S2M	Shallow	2.2	1.4	0.06	$ 4.1	32.4%	$7.4
38	MFR	Medium	C2M	Mat	0.2	1.1	0.06	$ 1.4	16.3%	$1.9
5	MFR	Medium	S4M	Shallow	0.3	1.7	0.05	$ 2.7	32.0%	$3.7
4	MFR	Medium	S2M	Shallow	0.3	1.7	0.05	$ 2.7	32.6%	$3.8
61	Multi-Use	Medium	S4M	Mat	1.4	0.9	0.04	$ 2.1	16.7%	$3.8
60	Multi-Use	Medium	S2M	Mat	1.4	0.9	0.04	$ 2.2	17.7%	$4.0
12	Offices	Small	S2L	Shallow	1.1	0.1	0.04	$ 1.2	30.0%	$2.2
45	Offices	Small	RM1L	Mat	0.6	0.0	0.04	$ 0.6	13.7%	$1.0
37	MFR	Medium	S4M	Mat	0.2	1.1	0.03	$ 1.4	16.6%	$2.0
36	MFR	Medium	S2M	Mat	0.2	1.1	0.03	$ 1.5	17.7%	$2.0
11	Offices	Small	W2	Shallow	1.1	0.1	0.03	$ 1.3	31.4%	$2.3
44	Offices	Small	S2L	Mat	0.6	0.0	0.02	$ 0.7	16.8%	$1.2
2	MFR	Small	S2L	Shallow	0.1	0.5	0.02	$ 0.8	30.8%	$1.1
35	MFR	Small	RM1L	Mat	0.1	0.3	0.02	$ 0.3	13.9%	$0.5
64	Parking Struc	Medium	C1M	Mat	0.3	0.0	0.02	$ 2.1	19.7%	$2.7
63	Parking Struc	Medium	C2M	Mat	0.3	0.0	0.01	$ 1.8	17.3%	$2.5
1	MFR	Small	W2	Shallow	0.1	0.5	0.01	$ 0.8	32.0%	$1.1
34	MFR	Small	S2L	Mat	0.1	0.3	0.01	$ 0.4	17.5%	$0.6
43	Offices	Small	W2	Mat	0.4	0.0	0.01	$ 0.6	14.1%	$1.0
33	MFR	Small	W2	Mat	0.0	0.2	0.00	$ 0.4	14.6%	$0.5

Legend:

Color	Vulnerability
	Low
	Moderate
	High
	Very High

Table 6.2 Impacts to Prototypical Buildings Due to Shaking & Ground Failure in an IBC Design Level Earthquake- Ground Failure Hazard Zone 4 Sorted on Maximum Total Deaths.

Sequence	Use	Size	HAZUS Model Bldg Type	Foundation	Total Casualties Day (inc deaths)	Total Casualties Night (inc deaths)	Max Total Deaths (Day or Night)	Total Building Damage ($M)	Loss Ratio	Total Economic Loss ($M)
26	Hotel	Large	C1H	Shallow	5.8	11.5	0.39	$13.5	14.7%	$24.6
19	Offices	Large	C1H	Shallow	10.7	0.5	0.36	$6.9	14.7%	$12.3
27	Hotel	Large	C2H	Shallow	4.7	9.5	0.32	$12.2	13.3%	$22.1
20	Offices	Large	C2H	Shallow	8.8	0.4	0.29	$6.3	13.4%	$11.7
25	Hotel	Large	S1H	Shallow	5.8	11.6	0.21	$16.5	17.9%	$30.8
57	Hotel	Large	S1H	Mat	5.6	11.1	0.20	$14.6	15.9%	$27.5
18	Offices	Large	S1H	Shallow	10.8	0.5	0.19	$8.3	17.8%	$14.7
50	Offices	Large	S1H	Mat	10.3	0.5	0.19	$7.4	15.7%	$12.8
58	Hotel	Large	C1H	Mat	3.8	7.7	0.18	$9.5	10.3%	$18.2
51	Offices	Large	C1H	Mat	7.1	0.4	0.17	$4.8	10.3%	$8.8
9	MFR	Large	C1H	Shallow	0.9	4.6	0.16	$5.2	14.7%	$6.9
23	Hotel	Medium	C2M	Shallow	1.3	2.7	0.15	$3.4	12.4%	$5.9
16	Offices	Medium	C2M	Shallow	2.5	0.1	0.14	$2.0	12.5%	$3.8
10	MFR	Large	C2H	Shallow	0.8	3.8	0.13	$4.7	13.3%	$6.5
59	Hotel	Large	C2H	Mat	2.7	5.5	0.11	$8.1	8.9%	$15.6
52	Offices	Large	C2H	Mat	5.1	0.3	0.10	$4.2	9.0%	$8.1
24	Hotel	Large	S2H	Shallow	3.4	6.7	0.09	$11.3	12.3%	$21.4
8	MFR	Large	S1H	Shallow	0.9	4.7	0.08	$6.3	17.9%	$8.3
56	Hotel	Large	S2H	Mat	3.0	6.0	0.08	$9.1	9.9%	$17.6
17	Offices	Large	S2H	Shallow	6.2	0.3	0.08	$5.8	12.3%	$10.7
40	MFR	Large	S1H	Mat	0.9	4.4	0.08	$5.5	15.8%	$7.2
49	Offices	Large	S2H	Mat	5.5	0.3	0.08	$4.7	10.0%	$8.6
41	MFR	Large	C1H	Mat	0.6	3.1	0.07	$3.6	10.3%	$4.9
30	Multi-Use	Medium	C2M	Shallow	1.3	0.8	0.07	$1.6	12.5%	$2.8
6	MFR	Medium	C2M	Shallow	0.2	1.0	0.05	$1.0	12.4%	$1.5
42	MFR	Large	C2H	Mat	0.4	2.2	0.04	$3.1	8.9%	$4.4
13	Offices	Small	RM1L	Shallow	0.6	0.0	0.04	$0.5	12.6%	$0.9
22	Hotel	Medium	S4M	Shallow	0.9	1.7	0.04	$3.0	11.0%	$5.6
7	MFR	Large	S2H	Shallow	0.5	2.7	0.04	$4.3	12.3%	$5.9
21	Hotel	Medium	S2M	Shallow	0.8	1.7	0.04	$3.4	12.2%	$6.0
15	Offices	Medium	S4M	Shallow	1.7	0.1	0.04	$1.8	11.0%	$3.4
14	Offices	Medium	S2M	Shallow	1.6	0.1	0.03	$2.0	12.0%	$3.6
55	Hotel	Medium	C2M	Mat	0.6	1.1	0.03	$2.2	8.1%	$4.0
39	MFR	Large	S2H	Mat	0.5	2.4	0.03	$3.5	9.9%	$4.7
48	Offices	Medium	C2M	Mat	1.0	0.1	0.03	$1.3	8.2%	$2.6
54	Hotel	Medium	S4M	Mat	0.7	1.5	0.03	$2.3	8.4%	$4.3
47	Offices	Medium	S4M	Mat	1.4	0.1	0.03	$1.4	8.5%	$2.6
53	Hotel	Medium	S2M	Mat	0.7	1.4	0.03	$2.7	9.7%	$4.8
46	Offices	Medium	S2M	Mat	1.3	0.1	0.03	$1.6	9.6%	$2.8
3	MFR	Small	RM1L	Shallow	0.1	0.3	0.02	$0.3	12.7%	$0.4
29	Multi-Use	Medium	S4M	Shallow	0.8	0.5	0.02	$1.4	11.1%	$2.6
28	Multi-Use	Medium	S2M	Shallow	0.8	0.5	0.02	$1.5	12.2%	$2.8

Sequence	Use	Size	HAZUS Model Bldg Type	Foundation	Total Casualties Day (inc deaths)	Total Casualties Night (inc deaths)	Max Total Deaths (Day or Night)	Total Building Damage ($M)	Loss Ratio	Total Economic Loss ($M)
62	Multi-Use	Medium	C2M	Mat	0.5	0.3	0.02	$1.0	8.1%	$1.9
32	Parking Struc	Medium	C1M	Shallow	0.3	0.0	0.02	$1.7	15.7%	$2.1
61	Multi-Use	Medium	S4M	Mat	0.7	0.4	0.01	$1.1	8.5%	$2.0
60	Multi-Use	Medium	S2M	Mat	0.7	0.4	0.01	$1.2	9.7%	$2.2
5	MFR	Medium	S4M	Shallow	0.1	0.6	0.01	$0.9	11.0%	$1.3
4	MFR	Medium	S2M	Shallow	0.1	0.6	0.01	$1.0	12.2%	$1.4
31	Parking Struc	Medium	C2M	Shallow	0.2	0.0	0.01	$1.4	13.0%	$1.9
38	MFR	Medium	C2M	Mat	0.1	0.4	0.01	$0.7	8.1%	$1.0
45	Offices	Small	RM1L	Mat	0.3	0.0	0.01	$0.4	8.7%	$0.7
37	MFR	Medium	S4M	Mat	0.1	0.5	0.01	$0.7	8.4%	$1.0
12	Offices	Small	S2L	Shallow	0.4	0.0	0.01	$0.6	14.3%	$1.0
36	MFR	Medium	S2M	Mat	0.1	0.5	0.01	$0.8	9.7%	$1.1
44	Offices	Small	S2L	Mat	0.3	0.0	0.01	$0.5	12.1%	$0.8
35	MFR	Small	RM1L	Mat	0.0	0.1	0.01	$0.2	8.8%	$0.3
64	Parking Struc	Medium	C1M	Mat	0.1	0.0	0.01	$1.2	11.4%	$1.5
2	MFR	Small	S2L	Shallow	0.0	0.2	0.01	$0.4	15.0%	$0.5
11	Offices	Small	W2	Shallow	0.3	0.0	0.01	$0.5	12.0%	$0.9
34	MFR	Small	S2L	Mat	0.0	0.1	0.00	$0.3	12.8%	$0.4
63	Parking Struc	Medium	C2M	Mat	0.1	0.0	0.00	$0.9	8.5%	$1.2
1	MFR	Small	W2	Shallow	0.0	0.1	0.00	$0.3	12.5%	$0.4
43	Offices	Small	W2	Mat	0.1	0.0	0.00	$0.4	9.1%	$0.7
33	MFR	Small	W2	Mat	0.0	0.1	0.00	$0.2	9.6%	$0.3

Legend:

Color	Vulnerability
	Low
	Moderate
	High
	Very High

Table 6.3 Impacts to Prototypical Buildings Due to Shaking & Ground Failure in an IBC Design Level Earthquake- Ground Failure Hazard Zone 3 Sorted on Maximum Total Deaths.

Sequence	Use	Size	HAZUS Model Bldg Type	Foundation	Total Casualties Day	Total Casualties Night	Max Total Deaths (Day or Night)	Total Building Damage (M$)	Loss Ratio	Total Economic Loss ($M)
25	Hotel	Large	S1H	Shallow	5.0	10.1	0.17	$12.7	13.9%	$24.5
57	Hotel	Large	S1H	Mat	5.0	10.1	0.17	$12.7	13.8%	$24.5
18	Offices	Large	S1H	Shallow	9.3	0.5	0.16	$6.5	13.8%	$11.1
50	Offices	Large	S1H	Mat	9.3	0.5	0.16	$6.5	13.8%	$11.1
26	Hotel	Large	C1H	Shallow	3.2	6.4	0.13	$7.4	8.1%	$14.7
58	Hotel	Large	C1H	Mat	3.2	6.4	0.13	$7.4	8.1%	$14.7
19	Offices	Large	C1H	Shallow	5.9	0.3	0.12	$3.8	8.1%	$6.9
51	Offices	Large	C1H	Mat	5.9	0.3	0.12	$3.8	8.1%	$6.9
8	MFR	Large	S1H	Shallow	0.8	4.0	0.07	$4.8	13.8%	$6.3
40	MFR	Large	S1H	Mat	0.8	4.0	0.07	$4.8	13.8%	$6.3
27	Hotel	Large	C2H	Shallow	2.1	4.1	0.05	$6.0	6.6%	$12.0
59	Hotel	Large	C2H	Mat	2.1	4.1	0.05	$6.0	6.6%	$12.0
9	MFR	Large	C1H	Shallow	0.5	2.5	0.05	$2.8	8.1%	$3.8
41	MFR	Large	C1H	Mat	0.5	2.5	0.05	$2.8	8.1%	$3.8
20	Offices	Large	C2H	Shallow	3.8	0.2	0.05	$3.2	6.8%	$6.1
52	Offices	Large	C2H	Mat	3.8	0.2	0.05	$3.2	6.8%	$6.1
24	Hotel	Large	S2H	Shallow	2.4	4.8	0.05	$7.0	7.7%	$14.2
56	Hotel	Large	S2H	Mat	2.4	4.8	0.05	$7.0	7.7%	$14.2
17	Offices	Large	S2H	Shallow	4.5	0.2	0.04	$3.7	7.8%	$6.7
49	Offices	Large	S2H	Mat	4.5	0.2	0.04	$3.7	7.8%	$6.7
10	MFR	Large	C2H	Shallow	0.3	1.7	0.02	$2.3	6.6%	$3.3
42	MFR	Large	C2H	Mat	0.3	1.7	0.02	$2.3	6.6%	$3.3
22	Hotel	Medium	S4M	Shallow	0.6	1.2	0.02	$1.9	6.8%	$3.6
54	Hotel	Medium	S4M	Mat	0.6	1.2	0.02	$1.9	6.8%	$3.6
7	MFR	Large	S2H	Shallow	0.4	1.9	0.02	$2.7	7.7%	$3.7
39	MFR	Large	S2H	Mat	0.4	1.9	0.02	$2.7	7.7%	$3.7
15	Offices	Medium	S4M	Shallow	1.1	0.1	0.02	$1.1	7.0%	$2.2
47	Offices	Medium	S4M	Mat	1.1	0.1	0.02	$1.1	7.0%	$2.2
21	Hotel	Medium	S2M	Shallow	0.6	1.1	0.02	$2.3	8.2%	$4.1
53	Hotel	Medium	S2M	Mat	0.6	1.1	0.02	$2.3	8.2%	$4.1
14	Offices	Medium	S2M	Shallow	1.1	0.1	0.02	$1.3	8.1%	$2.4
46	Offices	Medium	S2M	Mat	1.1	0.1	0.02	$1.3	8.1%	$2.4
23	Hotel	Medium	C2M	Shallow	0.4	0.7	0.01	$1.8	6.5%	$3.2
55	Hotel	Medium	C2M	Mat	0.4	0.7	0.01	$1.8	6.5%	$3.2
16	Offices	Medium	C2M	Shallow	0.7	0.0	0.01	$1.1	6.6%	$2.1
48	Offices	Medium	C2M	Mat	0.7	0.0	0.01	$1.1	6.6%	$2.1
29	Multi-Use	Medium	S4M	Shallow	0.6	0.3	0.01	$0.9	7.0%	$1.7
61	Multi-Use	Medium	S4M	Mat	0.6	0.3	0.01	$0.9	7.0%	$1.7
28	Multi-Use	Medium	S2M	Shallow	0.5	0.3	0.01	$1.0	8.2%	$1.8
60	Multi-Use	Medium	S2M	Mat	0.5	0.3	0.01	$1.0	8.2%	$1.8
13	Offices	Small	RM1L	Shallow	0.2	0.0	0.01	$0.3	7.8%	$0.6
45	Offices	Small	RM1L	Mat	0.2	0.0	0.01	$0.3	7.8%	$0.6

Sequence	Use	Size	HAZUS Model Bldg Type	Foundation	Total Casualties Day	Total Casualties Night	Max Total Deaths (Day or Night)	Total Building Damage (M$)	Loss Ratio	Total Economic Loss ($M)
5	MFR	Medium	S4M	Shallow	0.1	0.4	0.01	$0.6	6.8%	$0.8
37	MFR	Medium	S4M	Mat	0.1	0.4	0.01	$0.6	6.8%	$0.8
4	MFR	Medium	S2M	Shallow	0.1	0.4	0.01	$0.7	8.2%	$1.0
36	MFR	Medium	S2M	Mat	0.1	0.4	0.01	$0.7	8.2%	$1.0
12	Offices	Small	S2L	Shallow	0.3	0.0	0.01	$0.5	11.3%	$0.8
44	Offices	Small	S2L	Mat	0.3	0.0	0.01	$0.5	11.3%	$0.8
30	Multi-Use	Medium	C2M	Shallow	0.3	0.2	0.01	$0.8	6.6%	$1.5
62	Multi-Use	Medium	C2M	Mat	0.3	0.2	0.01	$0.8	6.6%	$1.5
6	MFR	Medium	C2M	Shallow	0.1	0.3	0.00	$0.5	6.5%	$0.8
38	MFR	Medium	C2M	Mat	0.1	0.3	0.00	$0.5	6.5%	$0.8
3	MFR	Small	RM1L	Shallow	0.0	0.1	0.00	$0.2	7.9%	$0.3
35	MFR	Small	RM1L	Mat	0.0	0.1	0.00	$0.2	7.9%	$0.3
32	Parking Struc	Medium	C1M	Shallow	0.1	0.0	0.00	$1.0	9.8%	$1.3
64	Parking Struc	Medium	C1M	Mat	0.1	0.0	0.00	$1.0	9.8%	$1.3
2	MFR	Small	S2L	Shallow	0.0	0.1	0.00	$0.3	11.9%	$0.4
34	MFR	Small	S2L	Mat	0.0	0.1	0.00	$0.3	11.9%	$0.4
31	Parking Struc	Medium	C2M	Shallow	0.1	0.0	0.00	$0.7	6.9%	$1.0
63	Parking Struc	Medium	C2M	Mat	0.1	0.0	0.00	$0.7	6.9%	$1.0
11	Offices	Small	W2	Shallow	0.1	0.0	0.00	$0.3	8.2%	$0.6
43	Offices	Small	W2	Mat	0.1	0.0	0.00	$0.3	8.2%	$0.6
1	MFR	Small	W2	Shallow	0.0	0.0	0.00	$0.2	8.7%	$0.3
33	MFR	Small	W2	Mat	0.0	0.0	0.00	$0.2	8.7%	$0.3

Legend:

Color	Vulnerability
	Low
	Moderate
	High
	Very High

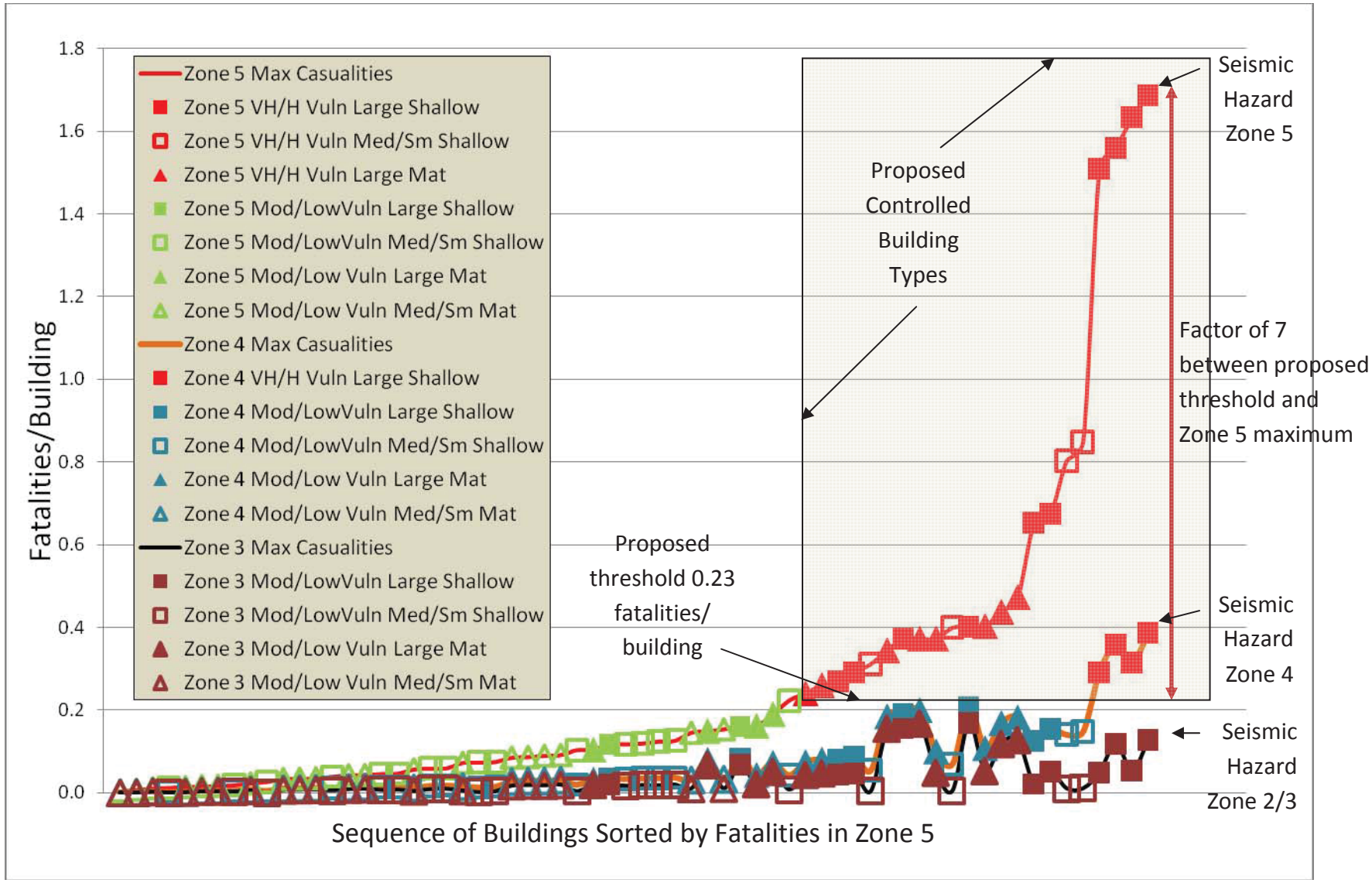

Figure 6.1. Fatalities by Building Type for Seismic Hazard Zones 2/3, 4, and 5

Table 6.4 Impacts to Prototypical Buildings Due to Shaking & Ground Failure in an IBC Design Level Earthquake- Ground Failure Hazard Zone 5 Sorted on Loss Ratio.

Sequence	Use	Size	HAZUS Model Bldg Type	Foundation	Total Casualties Day (inc deaths)	Total Casualties Night (inc deaths)	Max Total Deaths (Day or Night)	Total Building Damage ($M)	Loss Ratio	Total Economic Loss ($M)
26	Hotel	Large	C1H	Shallow	18.8	37.5	1.69	$44.00	47.90%	$74.00
9	MFR	Large	C1H	Shallow	3	15	0.68	$16.80	47.90%	$22.80
19	Offices	Large	C1H	Shallow	34.7	1.7	1.56	$22.30	47.50%	$39.80
27	Hotel	Large	C2H	Shallow	18.2	36.3	1.63	$43.30	47.20%	$72.90
10	MFR	Large	C2H	Shallow	2.9	14.5	0.65	$16.50	47.20%	$22.50
20	Offices	Large	C2H	Shallow	33.6	1.7	1.51	$22.00	46.90%	$39.40
32	Parking Struc	Medium	C1M	Shallow	1.1	0	0.08	$4.80	45.50%	$6.30
31	Parking Struc	Medium	C2M	Shallow	1.1	0	0.07	$4.70	44.20%	$6.20
23	Hotel	Medium	C2M	Shallow	6.2	12.5	0.85	$11.70	42.50%	$19.60
6	MFR	Medium	C2M	Shallow	0.9	4.6	0.31	$3.50	42.50%	$4.90
30	Multi-Use	Medium	C2M	Shallow	5.9	3.7	0.4	$5.30	42.40%	$9.40
16	Offices	Medium	C2M	Shallow	11.8	0.6	0.8	$6.90	42.20%	$12.20
25	Hotel	Large	S1H	Shallow	9.7	19.4	0.4	$35.40	38.50%	$62.40
8	MFR	Large	S1H	Shallow	1.6	7.8	0.16	$13.50	38.50%	$18.50
18	Offices	Large	S1H	Shallow	18	0.9	0.37	$17.80	37.90%	$32.80
3	MFR	Small	RM1L	Shallow	0.3	1.3	0.1	$0.90	37.60%	$1.30
13	Offices	Small	RM1L	Shallow	2.9	0.1	0.22	$1.50	37.30%	$2.70
24	Hotel	Large	S2H	Shallow	8.1	16.2	0.29	$32.60	35.60%	$57.90
7	MFR	Large	S2H	Shallow	1.3	6.5	0.12	$12.40	35.50%	$17.30
17	Offices	Large	S2H	Shallow	14.9	0.7	0.27	$16.40	35.00%	$30.70
21	Hotel	Medium	S2M	Shallow	2.3	4.6	0.12	$9.00	32.60%	$15.80
4	MFR	Medium	S2M	Shallow	0.3	1.7	0.05	$2.70	32.60%	$3.80
28	Multi-Use	Medium	S2M	Shallow	2.2	1.4	0.06	$4.10	32.40%	$7.40
22	Hotel	Medium	S4M	Shallow	2.3	4.7	0.13	$8.80	32.10%	$15.60
14	Offices	Medium	S2M	Shallow	4.4	0.2	0.12	$5.20	32.00%	$9.60
5	MFR	Medium	S4M	Shallow	0.3	1.7	0.05	$2.70	32.00%	$3.70
1	MFR	Small	W2	Shallow	0.1	0.5	0.01	$0.80	32.00%	$1.10
29	Multi-Use	Medium	S4M	Shallow	2.2	1.4	0.06	$4.00	31.90%	$7.30
15	Offices	Medium	S4M	Shallow	4.4	0.2	0.12	$5.20	31.60%	$9.50
11	Offices	Small	W2	Shallow	1.1	0.1	0.03	$1.30	31.40%	$2.30
2	MFR	Small	S2L	Shallow	0.1	0.5	0.02	$0.80	30.80%	$1.10
12	Offices	Small	S2L	Shallow	1.1	0.1	0.04	$1.20	30.00%	$2.20
57	Hotel	Large	S1H	Mat	8.3	16.5	0.37	$24.30	26.50%	$43.50
40	MFR	Large	S1H	Mat	1.3	6.6	0.15	$9.30	26.40%	$12.50
50	Offices	Large	S1H	Mat	15.3	0.8	0.35	$12.30	26.20%	$22.00
58	Hotel	Large	C1H	Mat	7.3	14.5	0.47	$20.40	22.20%	$36.30
41	MFR	Large	C1H	Mat	1.2	5.8	0.19	$7.80	22.10%	$10.60
51	Offices	Large	C1H	Mat	13.4	0.7	0.44	$10.30	22.00%	$18.80
56	Hotel	Large	S2H	Mat	6.1	12.2	0.26	$20.00	21.80%	$35.80
39	MFR	Large	S2H	Mat	1	4.9	0.1	$7.60	21.70%	$10.50

Sequence	Use	Size	HAZUS Model Bldg Type	Foundation	Total Casualties Day (inc deaths)	Total Casualties Night (inc deaths)	Max Total Deaths (Day or Night)	Total Building Damage ($M)	Loss Ratio	Total Economic Loss ($M)
49	Offices	Large	S2H	Mat	11.3	0.6	0.24	$10.10	21.60%	$18.60
59	Hotel	Large	C2H	Mat	6.3	12.6	0.4	$19.20	21.00%	$34.30
52	Offices	Large	C2H	Mat	11.7	0.6	0.37	$9.80	20.90%	$18.20
42	MFR	Large	C2H	Mat	1	5.1	0.16	$7.30	20.90%	$10.20
64	Parking Struc	Medium	C1M	Mat	0.3	0	0.02	$2.10	19.70%	$2.70
53	Hotel	Medium	S2M	Mat	1.4	2.9	0.09	$4.90	17.70%	$8.50
60	Multi-Use	Medium	S2M	Mat	1.4	0.9	0.04	$2.20	17.70%	$4.00
36	MFR	Medium	S2M	Mat	0.2	1.1	0.03	$1.50	17.70%	$2.00
46	Offices	Medium	S2M	Mat	2.7	0.1	0.09	$2.90	17.50%	$5.10
34	MFR	Small	S2L	Mat	0.1	0.3	0.01	$0.40	17.50%	$0.60
63	Parking Struc	Medium	C2M	Mat	0.3	0	0.01	$1.80	17.30%	$2.50
44	Offices	Small	S2L	Mat	0.6	0	0.02	$0.70	16.80%	$1.20
61	Multi-Use	Medium	S4M	Mat	1.4	0.9	0.04	$2.10	16.70%	$3.80
54	Hotel	Medium	S4M	Mat	1.5	2.9	0.09	$4.60	16.60%	$8.20
47	Offices	Medium	S4M	Mat	2.8	0.1	0.09	$2.70	16.60%	$5.00
37	MFR	Medium	S4M	Mat	0.2	1.1	0.03	$1.40	16.60%	$2.00
55	Hotel	Medium	C2M	Mat	1.5	3.1	0.15	$4.50	16.30%	$7.80
48	Offices	Medium	C2M	Mat	2.9	0.1	0.15	$2.70	16.30%	$4.90
62	Multi-Use	Medium	C2M	Mat	1.4	0.9	0.07	$2.10	16.30%	$3.70
38	MFR	Medium	C2M	Mat	0.2	1.1	0.06	$1.40	16.30%	$1.90
33	MFR	Small	W2	Mat	0	0.2	0	$0.40	14.60%	$0.50
43	Offices	Small	W2	Mat	0.4	0	0.01	$0.60	14.10%	$1.00
35	MFR	Small	RM1L	Mat	0.1	0.3	0.02	$0.30	13.90%	$0.50
45	Offices	Small	RM1L	Mat	0.6	0	0.04	$0.60	13.70%	$1.00

Legend:

Color	Vulnerability
	Low
	Moderate
	High
	Very High

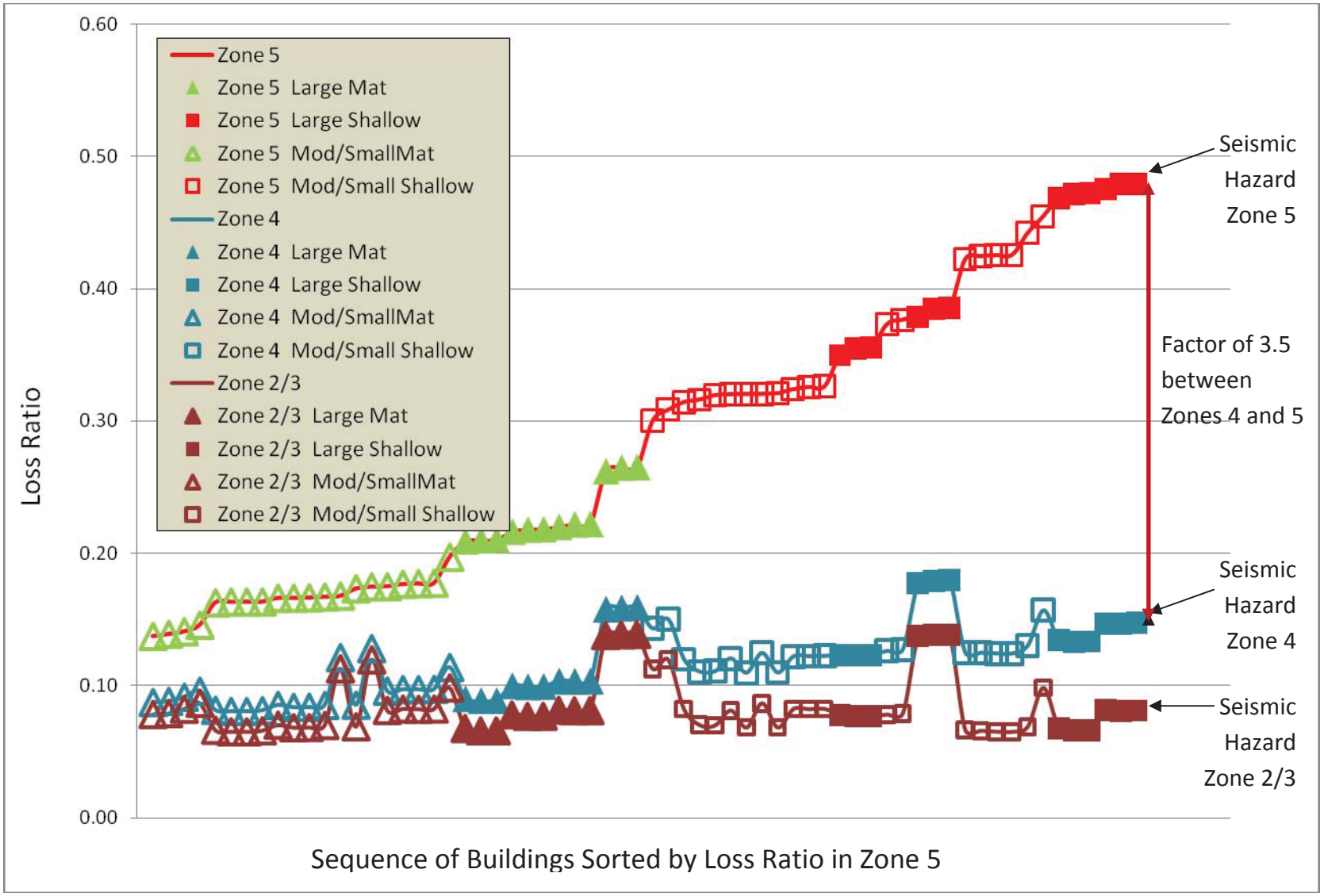

Figure 6.2. Loss Ratio by Building Type for Seismic Hazard Zones 2/3, 4, and 5

Table 6.5 Economic Impacts to Prototypical Buildings in an IBC Design Level Earthquake- Ground Failure Hazard Zone 5 (Note (a) – Includes Building Damage).

				Shaking Only			Ground Failure Only			Shaking & Ground Failure Combined		
Use	Size	HAZUS Model Bldg. Type	Foun-dation	Total Bldg Damage ($M)	Bldg Loss Ratio	Total Direct Econ. Loss ($M) ***(a)***	Total Bldg Damage ($M)	Bldg Loss Ratio	Total Direct Econ. Loss ($M) ***(a)***	Total Bldg Damag e ($M)	Bldg Loss Ratio	Total Direct Econ. Loss ($M)(a***)***
MFR	Small	W2	Shallow	$0.21	11.0%	$0.29	$0.68	27.5%	$0.95	$0.79	32.0%	$1.10
MFR	Small	S2L	Shallow	$0.29	14.2%	$0.39	$0.61	24.5%	$0.85	$0.76	30.8%	$1.06
MFR	Small	RM1L	Shallow	$0.20	10.4%	$0.28	$0.83	33.6%	$1.15	$0.93	37.6%	$1.29
MFR	Small	W2	Mat	$0.21	11.0%	$0.29	$0.17	7.0%	$0.24	$0.36	14.6%	$0.50
MFR	Small	S2L	Mat	$0.29	14.2%	$0.39	$0.17	7.0%	$0.24	$0.43	17.5%	$0.58
MFR	Small	RM1L	Mat	$0.20	10.4%	$0.28	$0.17	7.0%	$0.24	$0.34	13.9%	$0.49
MFR	Medium	S2M	Shallow	$0.68	10.0%	$0.94	$2.41	29.0%	$3.39	$2.70	32.6%	$3.79
MFR	Medium	S4M	Shallow	$0.56	8.5%	$0.82	$2.41	29.0%	$3.39	$2.66	32.0%	$3.75
MFR	Medium	C2M	Shallow	$0.54	8.6%	$0.79	$3.31	39.9%	$4.55	$3.53	42.5%	$4.88
MFR	Medium	S2M	Mat	$0.68	10.0%	$0.94	$0.92	11.1%	$1.29	$1.47	17.7%	$2.05
MFR	Medium	S4M	Mat	$0.56	8.5%	$0.82	$0.92	11.1%	$1.29	$1.38	16.6%	$1.96
MFR	Medium	C2M	Mat	$0.54	8.6%	$0.79	$0.92	11.1%	$1.29	$1.35	16.3%	$1.93
MFR	Large	S2H	Shallow	$2.69	8.7%	$3.63	$11.47	32.7%	$15.96	$12.44	35.5%	$17.27
MFR	Large	S1H	Shallow	$4.85	15.2%	$6.26	$11.47	32.7%	$15.96	$13.48	38.5%	$18.54
MFR	Large	C1H	Shallow	$2.83	9.0%	$3.75	$15.75	44.9%	$21.45	$16.78	47.9%	$22.81
MFR	Large	C2H	Shallow	$2.30	7.9%	$3.22	$15.75	44.9%	$21.45	$16.53	47.2%	$22.54
MFR	Large	S2H	Mat	$2.69	8.7%	$3.63	$5.70	16.3%	$7.87	$7.62	21.7%	$10.47
MFR	Large	S1H	Mat	$4.85	15.2%	$6.26	$5.70	16.3%	$7.87	$9.27	26.4%	$12.46
MFR	Large	C1H	Mat	$2.83	9.0%	$3.75	$5.70	16.3%	$7.87	$7.76	22.1%	$10.60
MFR	Large	C2H	Mat	$2.30	7.9%	$3.22	$5.70	16.3%	$7.87	$7.34	20.9%	$10.19
Office	Small	W2	Shallow	$0.34	12.9%	$0.60	$1.12	27.2%	$2.02	$1.30	31.4%	$2.33
Office	Small	S2L	Shallow	$0.46	15.9%	$0.80	$0.99	24.1%	$1.83	$1.24	30.0%	$2.23
Office	Small	RM1L	Shallow	$0.32	12.8%	$0.62	$1.38	33.3%	$2.41	$1.54	37.3%	$2.72
Office	Small	W2	Mat	$0.34	12.9%	$0.60	$0.28	6.9%	$0.51	$0.58	14.1%	$1.04
Office	Small	S2L	Mat	$0.46	15.9%	$0.80	$0.28	6.9%	$0.51	$0.69	16.8%	$1.19
Office	Small	RM1L	Mat	$0.32	12.8%	$0.62	$0.28	6.9%	$0.51	$0.57	13.7%	$1.04
Office	Medium	S2M	Shallow	$1.33	11.6%	$2.47	$4.66	28.5%	$8.59	$5.22	32.0%	$9.59
Office	Medium	S4M	Shallow	$1.14	10.5%	$2.24	$4.66	28.5%	$8.59	$5.16	31.6%	$9.52
Office	Medium	C2M	Shallow	$1.08	10.9%	$2.15	$6.45	39.5%	$11.33	$6.89	42.2%	$12.19
Office	Medium	S2M	Mat	$1.33	11.6%	$2.47	$1.79	11.0%	$3.24	$2.85	17.5%	$5.14
Office	Medium	S4M	Mat	$1.14	10.5%	$2.24	$1.79	11.0%	$3.24	$2.71	16.6%	$4.98
Office	Medium	C2M	Mat	$1.08	10.9%	$2.15	$1.79	11.0%	$3.24	$2.66	16.3%	$4.94
Office	Large	S2H	Shallow	$3.65	9.9%	$7.17	$15.10	32.2%	$28.35	$16.41	35.0%	$30.71

				Shaking Only			Ground Failure Only			Shaking & Ground Failure Combined		
Use	Size	HAZUS Model Bldg. Type	Foun-dation	Total Bldg Damage ($M)	Bldg Loss Ratio	Total Direct Econ. Loss ($M) ***(a)***	Total Bldg Damage ($M)	Bldg Loss Ratio	Total Direct Econ. Loss ($M) ***(a)***	Total Bldg Damag e ($M)	Bldg Loss Ratio	Total Direct Econ. Loss ($M)(a***)***
Office	Large	S1H	Shallow	$6.47	16.6%	$12.04	$15.10	32.2%	$28.35	$17.78	37.9%	$32.82
Office	Large	C1H	Shallow	$3.81	9.9%	$7.32	$20.92	44.6%	$37.33	$22.30	47.5%	$39.75
Office	Large	C2H	Shallow	$3.16	9.4%	$6.40	$20.92	44.6%	$37.33	$21.99	46.9%	$39.36
Office	Large	S2H	Mat	$3.65	9.9%	$7.17	$7.53	16.1%	$13.86	$10.14	21.6%	$18.65
Office	Large	S1H	Mat	$6.47	16.6%	$12.04	$7.53	16.1%	$13.86	$12.29	26.2%	$21.98
Office	Large	C1H	Mat	$3.81	9.9%	$7.32	$7.53	16.1%	$13.86	$10.30	22.0%	$18.80
Office	Large	C2H	Mat	$3.16	9.4%	$6.40	$7.53	16.1%	$13.86	$9.79	20.9%	$18.21
Hotel	Medium	S2M	Shallow	$2.26	10.0%	$4.80	$7.99	29.1%	$14.07	$8.95	32.6%	$15.77
Hotel	Medium	S4M	Shallow	$1.86	8.5%	$4.26	$7.99	29.1%	$14.07	$8.81	32.1%	$15.60
Hotel	Medium	C2M	Shallow	$1.78	8.6%	$3.58	$10.96	39.9%	$18.30	$11.68	42.5%	$19.59
Hotel	Medium	S2M	Mat	$2.26	10.0%	$4.80	$3.06	11.1%	$5.27	$4.87	17.7%	$8.53
Hotel	Medium	S4M	Mat	$1.86	8.5%	$4.26	$3.06	11.1%	$5.27	$4.57	16.6%	$8.17
Hotel	Medium	C2M	Mat	$1.78	8.6%	$3.58	$3.06	11.1%	$5.27	$4.48	16.3%	$7.85
Hotel	Large	S2H	Shallow	$7.05	8.7%	$17.82	$30.09	32.8%	$52.98	$32.63	35.6%	$57.86
Hotel	Large	S1H	Shallow	$12.73	15.3%	$31.62	$30.09	32.8%	$52.98	$35.35	38.5%	$62.43
Hotel	Large	C1H	Shallow	$7.42	9.0%	$18.56	$41.28	45.0%	$68.91	$43.98	47.9%	$74.02
Hotel	Large	C2H	Shallow	$6.02	7.9%	$14.59	$41.28	45.0%	$68.91	$43.32	47.2%	$72.86
Hotel	Large	S2H	Mat	$7.05	8.7%	$17.82	$14.95	16.3%	$25.77	$19.99	21.8%	$35.80
Hotel	Large	S1H	Mat	$12.73	15.3%	$31.62	$14.95	16.3%	$25.77	$24.30	26.5%	$43.53
Hotel	Large	C1H	Mat	$7.42	9.0%	$18.56	$14.95	16.3%	$25.77	$20.36	22.2%	$36.33
Hotel	Large	C2H	Mat	$6.02	7.9%	$14.59	$14.95	16.3%	$25.77	$19.25	21.0%	$34.27
Multi-Use	Medium	S2M	Shallow	$1.07	11.0%	$1.64	$3.64	28.9%	$6.63	$4.08	32.4%	$7.41
Multi-Use	Medium	S4M	Shallow	$0.94	9.9%	$1.49	$3.64	28.9%	$6.63	$4.02	31.9%	$7.34
Multi-Use	Medium	C2M	Shallow	$0.84	9.8%	$1.39	$5.01	39.8%	$8.81	$5.35	42.4%	$9.42
Multi-Use	Medium	S2M	Mat	$1.07	11.0%	$1.64	$1.40	11.1%	$2.51	$2.23	17.7%	$3.98
Multi-Use	Medium	S4M	Mat	$0.94	9.9%	$1.49	$1.40	11.1%	$2.51	$2.11	16.7%	$3.84
Multi-Use	Medium	C2M	Mat	$0.84	9.8%	$1.39	$1.40	11.1%	$2.51	$2.06	16.3%	$3.73
Parking Str.	Medium	C2M	Shallow	$0.73	9.0%	$1.01	$4.40	41.5%	$5.76	$4.69	44.2%	$6.17
Parking Str.	Medium	C1M	Shallow	$1.04	11.4%	$1.29	$4.40	41.5%	$5.76	$4.82	45.5%	$6.29
Parking Str.	Medium	C2M	Mat	$0.73	9.0%	$1.01	$1.26	11.8%	$1.65	$1.84	17.3%	$2.46
Parking Str.	Medium	C1M	Mat	$1.04	11.4%	$1.29	$1.26	11.8%	$1.65	$2.09	19.7%	$2.68

Table 6.6 Sensitivity Test Results: Economic Impacts to Prototypical Buildings (with Mat Foundations) Subject to Ground Shaking & Ground Failure in an IBC Design Level Earthquake- Ground Failure Hazard Zone 5 (Note (a) – Includes Building Damage).

			Sensitivity Test #1 (mat foundation 2.5x "stronger")			Sensitivity Test #2 (mat foundation 7.5x "stronger")			Original Assumption (mat foundation 5x "stronger")		
Use	Size	HAZUS Model Bldg. Type	Total Bldg Damage ($M)	Bldg Loss Ratio	Total Direct Econ. Loss ($M) (a)	Total Bldg Damage ($M)	Bldg Loss Ratio	Total Direct Econ. Loss ($M) (a)	Total Bldg Damage ($M)	Bldg Loss Ratio	Total Direct Econ. Loss ($M) (a)
MFR	Sm.	W2	$0.52	21.1%	$0.72	$0.30	12.1%	$0.41	$0.36	14.6%	$0.50
MFR	Sm.	S2L	$0.58	23.6%	$0.80	$0.37	15.1%	$0.50	$0.43	17.5%	$0.58
MFR	Sm.	RM1L	$0.51	20.6%	$0.72	$0.28	11.3%	$0.40	$0.34	13.9%	$0.49
MFR	Med.	S2M	$2.12	25.6%	$2.96	$1.18	14.2%	$1.64	$1.47	17.7%	$2.05
MFR	Med.	S4M	$2.05	24.7%	$2.88	$1.08	13.0%	$1.54	$1.38	16.6%	$1.96
MFR	Med.	C2M	$2.03	24.4%	$2.86	$1.05	12.7%	$1.51	$1.35	16.3%	$1.93
MFR	Lrg.	S2H	$10.60	30.2%	$14.58	$6.06	17.3%	$8.31	$7.62	21.7%	$10.47
MFR	Lrg.	S1H	$11.93	34.0%	$16.20	$7.87	22.4%	$10.50	$9.27	26.4%	$12.46
MFR	Lrg.	C1H	$10.73	30.6%	$14.72	$6.20	17.7%	$8.44	$7.76	22.1%	$10.60
MFR	Lrg.	C2H	$10.38	29.6%	$14.36	$5.75	16.4%	$8.00	$7.34	20.9%	$10.19
Office	Sm.	W2	$0.85	20.6%	$1.52	$0.48	11.6%	$0.85	$0.58	14.1%	$1.04
Office	Sm.	S2L	$0.94	22.9%	$1.66	$0.60	14.4%	$1.02	$0.69	16.8%	$1.19
Office	Sm.	RM1L	$0.84	20.3%	$1.53	$0.46	11.2%	$0.86	$0.57	13.7%	$1.04
Office	Med.	S2M	$4.12	25.2%	$7.43	$2.28	14.0%	$4.12	$2.85	17.5%	$5.14
Office	Med.	S4M	$4.01	24.6%	$7.31	$2.13	13.0%	$3.94	$2.71	16.6%	$4.98
Office	Med.	C2M	$3.95	24.2%	$7.26	$2.07	12.7%	$3.89	$2.66	16.3%	$4.94
Office	Lrg.	S2H	$14.05	29.9%	$25.82	$8.09	17.2%	$14.88	$10.14	21.6%	$18.65
Office	Lrg.	S1H	$15.80	33.7%	$28.53	$10.44	22.3%	$18.54	$12.29	26.2%	$21.98
Office	Lrg.	C1H	$14.22	30.3%	$26.00	$8.25	17.6%	$15.02	$10.30	22.0%	$18.80
Office	Lrg.	C2H	$13.78	29.4%	$25.48	$7.70	16.4%	$14.39	$9.79	20.9%	$18.21
Hotel	Med.	S2M	$7.03	25.6%	$12.22	$3.90	14.2%	$6.87	$4.87	17.7%	$8.53
Hotel	Med.	S4M	$6.80	24.8%	$11.93	$3.57	13.0%	$6.47	$4.57	16.6%	$8.17
Hotel	Med.	C2M	$6.72	24.5%	$11.66	$3.48	12.7%	$6.13	$4.48	16.3%	$7.85
Hotel	Lrg.	S2H	$27.79	30.3%	$48.85	$15.89	17.3%	$28.95	$19.99	21.8%	$35.80
Hotel	Lrg.	S1H	$31.29	34.1%	$54.99	$20.63	22.5%	$37.50	$24.30	26.5%	$43.53
Hotel	Lrg.	C1H	$28.14	30.7%	$49.36	$16.27	17.7%	$29.49	$20.36	22.2%	$36.33
Hotel	Lrg.	C2H	$27.21	29.7%	$47.67	$15.07	16.4%	$27.23	$19.25	21.0%	$34.27
Multi-Use	Med.	S2M	$3.21	25.5%	$5.75	$1.78	14.2%	$3.19	$2.23	17.7%	$3.98
Multi-Use	Med.	S4M	$3.12	24.7%	$5.64	$1.65	13.1%	$3.03	$2.11	16.7%	$3.84
Multi-Use	Med.	C2M	$3.07	24.4%	$5.54	$1.60	12.7%	$2.91	$2.06	16.3%	$3.73
Parking Str.	Med.	C2M	$2.75	26.0%	$3.66	$1.42	13.4%	$1.92	$1.84	17.3%	$2.46
Parking Str.	Med.	C1M	$2.96	27.9%	$3.84	$1.70	16.0%	$2.16	$2.09	19.7%	$2.68

Table 6.7 Sensitivity Test Results: Expected Deaths and Total Casualties in Prototypical Buildings (with Mat Foundations) Subject to Ground Shaking & Ground Failure in an IBC Design Level Earthquake-Ground Failure Hazard Zone 5.

				Sensitivity Test #1 (mat foundation 2.5x "stronger")		Sensitivity Test #2 (mat foundation 7.5x "stronger")		Original Assumption (mat foundation 5x "stronger")	
Use	Size	HAZUS Model Bldg. Type	Time of Day for Expected Max. # of Casualties	Max. # Deaths	Total Casualties (Includes Deaths)	Max. # Deaths	Max. # Total Casualties (Includes Deaths)	Max. # Deaths	Max. # Total Casualties (Includes Deaths)
MFR	Sm	W2	Night	0.0	0.3	0.0	0.1	0.0	0.2
MFR	Sm	S2L	Night	0.0	0.4	0.0	0.2	0.0	0.3
MFR	Sm	RM1L	Night	0.0	0.5	0.0	0.2	0.0	0.3
MFR	Med	S2M	Night	0.1	1.6	0.0	0.8	0.0	1.1
MFR	Med	S4M	Night	0.1	1.6	0.0	0.8	0.0	1.1
MFR	Med	C2M	Night	0.1	1.8	0.0	0.8	0.1	1.1
MFR	Lrg	S2H	Night	0.2	6.7	0.1	4.0	0.1	4.9
MFR	Lrg	S1H	Night	0.2	8.2	0.1	5.8	0.1	6.6
MFR	Lrg	C1H	Night	0.3	7.8	0.1	4.8	0.2	5.8
MFR	Lrg	C2H	Night	0.2	7.1	0.1	4.0	0.2	5.1
Office	Sm	W2	Day	0.0	0.6	0.0	0.2	0.0	0.4
Office	Sm	S2L	Day	0.0	0.9	0.0	0.4	0.0	0.6
Office	Sm	RM1L	Day	0.1	1.0	0.0	0.4	0.0	0.6
Office	Med	S2M	Day	0.1	4.1	0.1	2.1	0.1	2.7
Office	Med	S4M	Day	0.1	4.2	0.1	2.2	0.1	2.8
Office	Med	C2M	Day	0.3	4.7	0.1	2.1	0.1	2.9
Office	Lrg	S2H	Day	0.4	15.4	0.2	9.1	0.2	11.3
Office	Lrg	S1H	Day	0.5	18.9	0.3	13.4	0.3	15.3
Office	Lrg	C1H	Day	0.6	17.9	0.3	11.0	0.4	13.4
Office	Lrg	C2H	Day	0.6	16.4	0.3	9.2	0.4	11.7
Hotel	Med	S2M	Night	0.1	4.4	0.1	2.2	0.1	2.9
Hotel	Med	S4M	Night	0.2	4.4	0.1	2.3	0.1	2.9
Hotel	Med	C2M	Night	0.3	5.0	0.1	2.2	0.2	3.1
Hotel	Lrg	S2H	Night	0.4	16.7	0.2	9.9	0.3	12.2
Hotel	Lrg	S1H	Night	0.5	20.4	0.3	14.5	0.4	16.5
Hotel	Lrg	C1H	Night	0.7	19.4	0.4	11.9	0.5	14.5
Hotel	Lrg	C2H	Night	0.6	17.8	0.3	10.0	0.4	12.6
Multi-Use	Med	S2M	Day	0.1	2.1	0.0	1.0	0.0	1.4
Multi-Use	Med	S4M	Day	0.1	2.1	0.0	1.1	0.0	1.4
Multi-Use	Med	C2M	Day	0.1	2.3	0.0	1.0	0.1	1.4
Parking Str.	Med.	C2M	Day	0.0	0.4	0.0	0.2	0.0	0.3
Parking Str.	Med.	C1M	Day	0.0	0.5	0.0	0.2	0.0	0.3