Appendix E

Tasks 5 and 6, Technical Memorandum Loss Modeling

2100 Main Street, Suite 150
Huntington Beach, California 92648 USA
714.465.1390 *voice*
714.969.0820 *fax*

Memorandum

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To: David Tremont, Municipality of Anchorage Planning Department

From: Hope Seligson, MMI Engineering
Donald Ballantyne, MMI Engineering

Subject: Downtown Anchorage Seismic Risk Assessment
Task 5and 6 – Loss Modeling
MMI Project Number: MMW550

This memorandum describes the approach used to model building damage and casualties in the "prototypical buildings" (as defined for the current study), subject to ground motions from an IBC Design Level earthquake. It then uses that information to propose acceptable risk levels for loss of life and property damage in the higher hazard zones. The memorandum is divided into six sections, followed by References, as follows:

1. Geotechnical Setting
2. Prototypical Buildings
3. Risk Assessment Approach
4. Results
5. Analysis and Recommendations
6. Summary

1.0 GEOTECHNICAL SETTING

The downtown Anchorage study area is a geotechnically unstable area that underwent significant movement in the 1964 Alaska Earthquake. The area is underlain by a layer of gravel outwash approximately 50 feet thick, underlain by a layer of unstable Bootlegger Cove Clay, as shown in Figure 1. In a significant earthquake such as occurred in 1964, the unstable clay layer loses strength along a plane, and with each cycle of earthquake shaking the overlying block of soil moves towards the free surface (the bluff). In the volume behind the block of soil (towards the left in Figure 1), the ground collapses into the void forming a graben. In the area in front of the

block (towards the right in Figure 1), the block attempts to plow through the soil in its path, resulting in the formation of pressure ridges.

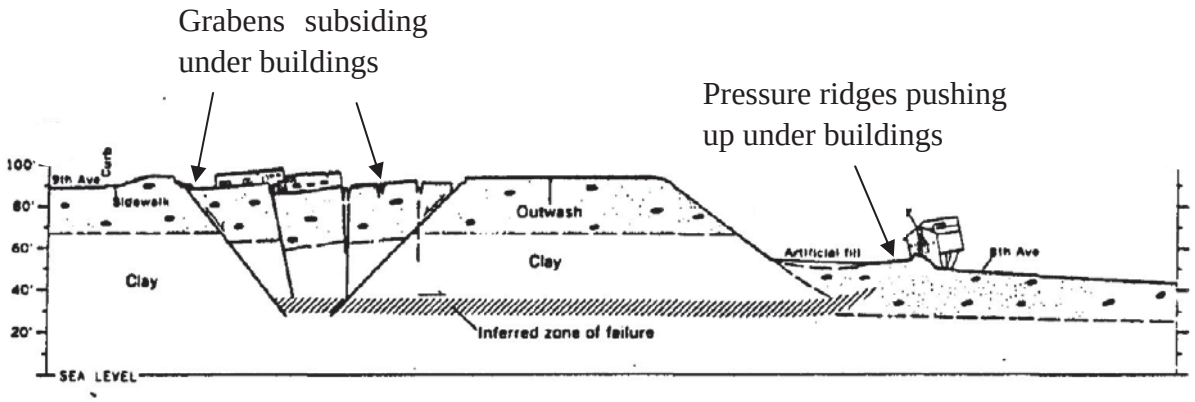

Figure 1. Cross section of soil strata in L Street slide area in 1964 Earthquake. (Moriwaki et al, 1985)

The described here was performed for seismic risk zones 1 (Lowest) through 5 (Very High), discussed in detail in the project memorandum defining seismic displacements for the project study area (dated June 12, 2009). Figure 1 generally shows a cross section of Zone 5 including potential subsidence, block lateral movement, and pressure ridges. The seismic risk zones had been previously mapped in accordance with expected permanent ground deformation (PGD) in future earthquakes. The "Seismic Displacements" memorandum quantified the expected net displacement of soil on the surface in each zone by percentage, where the displacement was a vector combining horizontal and vertical movement. In most cases, the predominant movement is expected to be horizontal, but in the areas over the grabens, the predominant movement is expected to be subsidence and over the pressure ridges, uplift. The methodology used in estimating the movements combined expected movements over the entire zone, and is presented as a percentage of the zone expecting the net movement. This displacement estimate serves as input into the building damage relationships and loss estimates in this memorandum.

2.0 PROTOTYPICAL BUILDINGS

Ten prototypical buildings have been defined for this study (described in the Task 2 Project memo dated March 20, 2009). Table 1 summarizes the 32 basic prototypical building variants and their associated structural configurations (HAZUS "Model Building Types"). Each variant has been modeled two ways; with a shallow foundation, and with a mat foundation, bringing the total number of modeled buildings to 64.

For the purpose of the seismic risk analysis, and for use in the HAZUS Advanced Engineering Building Module (AEBM), several additional parameters were determined for each prototype, as follows:

- Building area – typical building size was determined from the HAZUS occupancy model (FEMA/DHS, 2007) and/or underlying Means Square Foot Cost (Means, 2009) model. Assumed building sizes are included in Table 1.

- Building replacement cost – estimated from 2009 Means Square Foot Costs, using the Anchorage location factor. Estimated building replacement values are provided in Table 1.

- Number of daytime and nighttime building occupants –estimated from ATC-58 (ATC, 2009) peak building population model, or from ATC-13 (ATC, 1985) occupancy models when no ATC-58 model was available. Estimated daytime and nighttime building populations are included in Table 1.

- Content Value – estimated as a percent of structure replacement value, using HAZUS content value model percent by occupancy. For example, for residential structures, contents value is assumed to be equal to 50% of the total structure value.

- Business inventory value –estimated using HAZUS inventory value model, updated to 2009 costs (applies to multi-use building only).

- Economic parameters (daily business income, daily wages paid, relocation disruption cost, daily rental cost, ratio owner-occupied) – estimated according to the HAZUS methodology, with costs updated to 2009.

3.0 RISK ASSESSMENT APPROACH

3.1 Ground Shaking Damage

Damage to the 32 basic prototypical building variants due to ground motions from an IBC Design Level earthquake was estimated using the HAZUS Advanced Engineering Building Module (AEBM). It should be noted that the HAZUS model for estimating damage due to ground shaking does not consider multiple foundation types; the default configuration is a

shallow foundation (e.g., spread footings). It is assumed that building performance of other foundation types subject to ground shaking would be similar.

HAZUS AEBM Results include estimates of daytime and nighttime casualties defined by HAZUS according to 4 severity levels (FEMA/DHS, 2003, Chapter 13):

- Severity 1 – "Injuries requiring basic medical aid that could be administered by paraprofessionals. These types of injuries would require bandages or observation. Some examples are: a sprain, a severe cut requiring stitches, a minor burn (first degree or second degree on a small part of the body), or a bump on the head without loss of consciousness."

- Severity 2 – "Injuries requiring a greater degree of medical care and use of medical technology such as x-rays or surgery, but not expected to progress to a life threatening status. Some examples are third degree burns or second degree burns over large parts of the body, a bump on the head that causes loss of consciousness, fractured bone, dehydration or exposure."

- Severity 3 – "Injuries that pose an immediate life threatening condition if not treated adequately and expeditiously. Some examples are: uncontrolled bleeding, punctured organ, other internal injuries, spinal column injuries, or crush syndrome."

- Severity 4 – "Instantaneously killed or mortally injured"

For summary purposes, total casualties are reported as the sum of all 4 severity levels, with Deaths also reported separately.

Other AEBM results include estimates of dollar loss due to building damage (structural and non-structural damage), damage to building contents and commercial inventories, and building damage-related income or business interruption losses, including the cost of relocation, lost rental income, lost business income and lost wages.

3.2 Ground Failure Fragilities

Within the HAZUS methodological framework, there are five (5) potential damage states (None, Slight, Moderate, Extensive, Complete), which are applicable to the building's structural and non-structural components. Each structural or non-structural damage state is qualitatively described for each model building type within the HAZUS Earthquake Model Technical Manual

(DHS/FEMA, 2007). For example, structural damage state descriptions are provided in terms of expected structural damage mechanisms:

> **Steel Moment Frame Structures (S1) - Extensive Structural Damage:** Most steel members have exceeded their yield capacity, resulting in significant permanent lateral deformation of the structure. Some of the structural members or connections may have exceeded their ultimate capacity exhibited by major permanent member rotations at connections, buckled flanges and failed connections. Partial collapse of portions of structure is possible due to failed critical elements and/or connections. (DHS/FEMA, 2007)
>
> **Reinforced Concrete Moment Frame Structures (C1) - Complete Structural Damage:** Structure is collapsed or in imminent danger of collapse due to brittle failure of nonductile frame elements or loss of frame stability. Approximately 13% (low-rise), 10% (mid-rise) or 5% (high-rise) of the total area of C1 buildings with Complete damage is expected to be collapsed. (DHS/FEMA, 2007)

The sum of the probabilities of being in each of these five damage states must equal 100 percent. For example for a "typical" vulnerable building subjected to very low ground motion, the distribution might be: None – 90%, Slight – 10%, Moderate – 0%, Extensive – 0%, and Complete – 0%. If the same building was subjected to very strong ground motion, the damage state probability distribution might be: None – 10%, Slight – 10%, Moderate – 20%, Extensive – 30%, and Complete – 30%.

For the determination of economic loss, structural and non-structural damage state probabilities are multiplied by an assumed mean percent loss for each component's damage state. In general, "Complete" damage is expected to result in the total economic loss of the structure (i.e., the expected value of damage approaches the value of the structure). "Extensive" damage is expected to be repairable, but at a significant cost (e.g., on the order of 40 - 50% of replacement cost).

Discussion in the HAZUS Technical Manual of the topic of building damage due to ground failure is limited; there are only 1-1/2 pages of discussion on the topic in the 75 page chapter on Building Damage (Chapter 5). Regarding ground failure damage estimates employed within the HAZUS model, the Technical Manual (pp 5-64) states "No attempt is made to distinguish damage based on building type, since model building descriptions do not include foundation type." The HAZUS methodology has been used as the starting point in development of the ground deformation fragilities in this project. Accordingly, this project did not use HAZUS to directly estimate ground failure impacts on buildings.

As described in Section 5.5.1 of the HAZUS Technical Manual, the median and 10th percentile values of displacement (see below, from HAZUS TM Table 5.17) effectively define structural fragility functions for the "Extensive" and "Complete" damage states, for buildings on shallow foundations. (Ground failure is not expected to produce "Slight" or "Moderate" damage).

> 10% - PGD 2" V, 12" H – 8% buildings – extensive damage; 2% buildings – complete damage
>
> Median – PGD 10" V, 60" H – 40% buildings – extensive damage; 10% - complete damage

From these fragility curves, damage state probabilities for these two damage states may be determined for any level of peak ground deformation (PGD). For the current study, PGDs in the IBC Design Level earthquake have been developed as a vector combining horizontal and vertical displacements. The vector resulting from combining horizontal and vertical displacements used in HAZUS is less than 2% larger than the horizontal component. Thus, the horizontal component has been used in the current study.

In the graben zone and in the pressure ridge zone, it is likely that the vertical component of displacement (subsidence and uplift respectively) will be larger than the horizontal component. However, there is considerable uncertainty in calculating the width of the graben and pressure ridge areas. Because the fragilities need to be applicable across the entire zone, the ground deformation analysis was performed for the overall hazard zone, where the largest component of the deformation is horizontal due to the lateral movement of the block towards the bluff (see Figure 1).

The fragilities were developed taking into account the following three factors:

1. Foundation type – will affect the ability of the foundation to accommodate horizontal and vertical differential movement.

2. Building height– will affect the stability of the building if subjected to a vertical offset though the foot print (taller buildings would also tend to have a large footprint), and will affect the opportunity to repair the building if subjected to PGD.

3. Building structural system – more ductile structural systems would tend to have a lower percentage of buildings suffering compete damage, as compared to brittle structural systems, if the foundation suffers differential movement.

The median PGD values are used with a lognormal standard deviation value of 1.2 for buildings on shallow foundations. Shallow foundations are taken to be spread footings with grade beams.

Comparable damage to buildings on heavy mat foundations is not expected to occur until the PGD is on the order of 5 times greater than that for spread footings with grade beams. It is expected that the mat foundations will carry differential vertical and horizontal displacements. Failure would not occur until the building tips or rotates.

Mid-rise buildings are taken to be the baseline for this study. Low-rise buildings are expected to perform better than mid-rise buildings requiring 1.5x the median PGD to result in the same level of damage. Similarly, high-rise buildings are expected to have comparable damage when undergoing 0.67x the median PGD. This is applicable to buildings both on spread footings and mat foundations.

Buildings of differing structural systems on spread footings with grade beams are expected to perform differently when subjected to the same level of PGD. The default assumption used by HAZUS to differentiate between "Extensive" and "Complete" damage was an 80%/20% distribution. This is the "baseline" applied to wood frame buildings in the current study. It is expected that relatively fewer steel frame buildings (both braced steel frame and moment frame buildings) will suffer "Complete" damage, with an assumed distribution of 90 percent "Extensive" and 10 percent "Complete" (50% less "Complete"). Concrete frame, concrete shear wall, and masonry buildings are expected to perform relatively worse, with an assumed distribution of 60 percent "Extensive" damage and 40 percent "Complete" damage (2x more "Complete" damage. This differentiation relates to the capability of the structure to hold together and resist collapse.

All building structure types are expected to perform similarly when constructed on a heavy mat foundation; the baseline 80%/20% distribution is applied across all structure types when built on mat foundations.

These fragility relationships were developed based on expert opinion from three project team members, as listed below. To the best of the project team's knowledge, there is no other ongoing work in this technical area (as per discussions with building officials with the cities of Seattle and San Francisco). It is understood that there is a high level of uncertainty associated with these relationships. Observation of buildings subjected to PGD would seem to provide the best source of information for supporting the assumed fragility relationships. Each of the team members has extensive experience in post earthquake reconnaissance, particularly in the 1989 Loma Prieta, 1994 Northridge, and 1995 Kobe earthquakes. The three contributors are:

- Paul Summers, SE – MMI Engineering
- Charles Kircher, SE – Charles Kircher and Associates

- Donald Ballantyne, PE – MMI Engineering

It should also be noted that there was not complete concurrence among the contributors on the final fragility relationships. However, the items where there was disagreement tended to be insignificant relative to the overall methodology, and the application of the fragilities was evaluated using sensitivity analyses.

3.3 Ground Failure Damage

Damage to the full set of 64 prototypical buildings due to ground failure in the IBC Design Level earthquake was estimated in a customized spreadsheet model. Ground failure fragilities, as described above, were combined (according to the HAZUS ground failure estimation methodology) with ground failure probabilities by Hazard Zone (as documented in the displacement Memo dated June 12, 2009) to arrive at building-specific damage state probabilities. The ground failure damage state probability distributions were then used to estimate the same damage and loss measures utilized in the HAZUS AEBM.

The probability of failure of buildings was evaluated as a function of PGD. These probabilities were related to Hazard Zones by the distribution of PGDs within each hazard zone. A building with the same design parameters subjected to 12-inches of PGD would have the same probability of extensive damage whether it was in Hazard Zone 2 or Hazard Zone 5.

3.4 Combined Damage due to Ground Shaking and Ground Failure

As in the HAZUS methodology (see Section 5.6.3 of the HAZUS Technical Manual), it has been assumed for this study that damage due to ground shaking is independent of damage due to ground failure. To find the total damage, and avoid double-counting, the combined damage state probabilities are determined using standard probability theory for independent events. In this case:

$P_{combined}[DS \geq DS_i] = P_{GroundShaking}[DS \geq DSi] + P_{GroundFailure}[DS \geq DSi] - (P_{GroundShaking}[DS \geq DSi] \times P_{GroundFailure}[DS \geq DSi])$

Where:

$P_{GroundShaking}[DS \geq DSi]$ = probability of being in or exceeding damage state (i) as a result of ground shaking

$P_{GroundFailure}[DS \geq DSi]$ = probability of being in or exceeding damage state (i) as a result of ground failure.

$P_{combined}[DS \geq DS_i]$ = probability of being in or exceeding damage state (i) as a result of ground shaking and ground failure

The combined damage state probability distributions were used to estimate the same damage and loss measures utilized in the HAZUS AEBM.

4.0 RESULTS

Tables 2 – 5 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, 3 and 2, respectively.

Similar information is provided graphically in Figures 1 – 12. Figure 1 depicts total direct economic loss resulting from shaking and ground failure, for each prototypical building variant for Hazard Zone 5. 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 the figure, the largest losses (as high as $70 million) occur in the large hotel, while the small apartment building suffers the smallest loss. Figure 2 plots each building's loss ratio (total building damage divided by building value). As expected, shallow foundations suffer significantly more damage than mat foundations, with stiffer buildings (masonry and concrete) suffering more damage than the more flexible building types (steel and wood frame). Figures 3 and 4 plot expected day and night deaths, respectively. Deaths are rare, but more likely to occur in stiff, high occupancy buildings on shallow foundations. Daytime and nighttime casualties (the sum of all injuries, from minor injuries to deaths) are shown in Figures 5 and 6, with patterns similar to that for deaths. Death and casualty rates (number of casualties divided by the number of occupants) are provided in Figures 7 and 8. Here, the impact of building size is eliminated, and the rates reflect the inherent injury risk related to each type of construction. Figures 9 - 12 provide death and casualty rates normalized by building size (number of deaths or casualties per 1000 square feet).

In addition to the detailed charts presented for Zone 5, Figures 13 – 34 have been provided to demonstrate the variation in loss and casualties for the 10 prototypical buildings (and their variants) *across* the four ground failure hazard zones. For each prototypical building, the first bar chart (e.g., Figure 13 for Prototypical Building #1, the small multi-family residence) depicts the variation in total direct economic loss for buildings constructed using the various HAZUS model building types and proposed foundation types, across the four ground failure zones. The second bar chart (e.g., Figure 14 for Prototypical Building #1) illustrates the variation in

casualties for the different building and foundation types, in the various hazard zones. In these figures, casualties in each of HAZUS' four severity levels are plotted as a "stacked" bar chart. For prototype #1 – 7 and #10, the casualties chart is presented for the time of day expected to result in the maximum number of casualties. For prototype #8 (the large hotel) and #9 (the multi-use building), charts for both times of day are presented because a significant number of casualties are expected in either a daytime and nighttime event.

As evidenced by the charts and 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.

4.1 Contribution of Shaking and Ground Failure to Combined Risk

Table 6 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.

4.2 Sensitivity to Underlying Fragility Assumptions

To test the sensitivity of loss to the underlying assumption that mat foundations can essentially withstand 5 times the displacement of shallow foundations, alternative assessments were conducted, first assuming a smaller difference in foundation strength (mat foundations 50% weaker than original assumption, able to withstand 2.5x the displacement of a shallow foundation) and then assuming a larger difference in foundation strength (mat foundations 50% 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 7. 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 8. Overall, reducing the assumed strength of the mat foundation by 50% results in an average 42% increase in economic loss, while increasing the assumed strength by 50% reduces the average loss by 20%. Reducing the assumed strength of the mat foundation by 50% also results in an average 63% increase in deaths and a 49% increase in overall casualties, while a 50% increase in assumed strength results in a 29% reduction in estimated deaths and a 22% decrease in overall casualties.

5.0 ANALYSIS AND RECOMMENDATIONS

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.

Tables 2 through 5 show the expected deaths during the IBC Design Level earthquake event during the day or night. Table 5 shows the expected deaths in Hazard Zone 2 for each building category. As Hazard Zone 2 does not undergo significant PGD, these deaths are the result of earthquake shaking. 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 2 through 5.

It is assumed that the deaths estimated for buildings in Hazard Zone 2 (no 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 5, the highest total number of deaths is 0.169 (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 (0.169) in other zones are considered to be "high vulnerability" buildings, and are shown in cells shaded pink in Tables 2 and 3 for Hazard Zones 5 and 4 respectively. Consideration should be given to adjusting the 0.169 number slightly upward to 0.2 or 02.5 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 matt foundations, or medium buildings on shallow foundations.

Within the high vulnerability category, there is a break in the "Max Total Deaths" between 0.653 and 0.474. 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 2. There are no very high vulnerability buildings in Hazard Zones 4, 3, or 2.

In Table 2, there is a distinct break in the "Max Total Deaths" data between 0.118 and 0.068, with only 8 building categories exceeding the 0.068 threshold. This is a 40 percent decrease.

This is selected as the next lower threshold is 0.068. Prototypical building categories with expected deaths less than 0.169 but greater than 0.068 are categorized as "moderate vulnerability" buildings. They are shown shaded in yellow in Tables 2 through 5 for Hazard Zones 5 through 2 respectively. The number of buildings categorized as having a high or moderate vulnerability is significantly lower in progressively lower Hazard Zone 4, 3, and 2.

A similar analysis was undertaken to evaluate acceptable building losses where Hazard Zone 2 represents "shaking only" damage expected to a modern building designed in accordance with the IBC. The maximum Building Loss Ratio in Hazard Zone 2 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%, and it is only 13.7%. It is not recommended to employ a fourth level of vulnerability that would be more conservative than the IBC design for shaking.

Therefore, we recommend three possible levels of mitigation by limiting the type of building use, foundation, and super structure to limit: 1) very high vulnerability buildings, 2) high vulnerability buildings, and 3) moderate vulnerability buildings in Hazard Zones 5 though 2.

These three levels of mitigation can be achieved by implementing a set of rules.

> To limit Very High Vulnerability Buildings in Hazard Zone 5 (see Table 2): 1) Do not allow the following HAZUS Model Building types of buildings on shallow foundations: C1H or C2H Large Offices, Large Hotels, Large MFRs, or Medium C2M Hotels or Offices. (There are no Very High Vulnerability Buildings in Hazard Zones 4, 3, or 2.)
>
> To limit High Vulnerability Buildings in Hazard Zones 5 (see Table 2): 1) Do not allow the following HAZUS Model Building types of buildings on shallow foundations: C1H or C2H Large Offices, Large Hotels, Large MFRs, or Medium C2M Hotels, Offices or Multi-Use. 2) Do not allow buildings with occupancies greater than 500. These two rules exclude two building categories with Maximum Deaths of less than 0.25, but greater than 0.169.
>
> To limit High Vulnerability Buildings in Hazard Zones 4 (see Table 3): 1) Do not allow the following HAZUS Model Building types of buildings on shallow foundations: C1H or C2H Large Offices or Large Hotels. Note that this rule does not address 5 building types with Max Total Deaths below 0.25. (There are no High Vulnerability Buildings in Hazard Zones 3, or 2.)

Limiting Moderate Vulnerability building types in all hazard zones becomes more complicated because of the mix of building types. Rules could be developed if a decision is made to implement this level of mitigation.

7.0 REFERENCES:

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Table 1: Structural Classifications for the Ten Prototypical Buildings

Bldg. No.	Proto-type No.	Use Description	Size (sq ft)	HAZUS Occupancy Class	Estimated # Occupants (Day/Night)	Est. Bldg Value ($1,000)	HAZUS Model Building Types
1	1	MFR (Multi-Family Residence)	Small (12,000)	RES3D	Jul-37	2,473	W2
2							S2L
3							RM1L
4	2	MFR	Medium (40,000)	RES3E	25/124	8,293	S2M
5							S4M
6							C2M
7	3	MFR	Large (145,000)	RES3F	90/450	35,050	S2H
8							S1H
9							C1H
10							C2H
11	4	Office	Small (20,000)	COM4	80/4	4,128	W2
12							S2L
13							RM1L
14	5	Office	Medium (80,000)	COM4	320/16	16,314	S2M
15							S4M
16							C2M
17	6	Office	Large (260,000)	COM4	1,040/52	46,929	S2H
18							S1H
19							C1H
20							C2H
21	7	Hotel	Medium (135,000)	RES4	169/338	27,452	S2M
22							S4M
23							C2M
24	8	Hotel	Large (450,000)	RES4	563/1,125	91,761	S2H
25							S1H
26							C1H
27							C2H
28	9	Multi-Use	Medium (60,000)	M-U: 1/6 COM1, 2/6 COM4, 3/6 RES3E	159/100	12,597	S2M
29							S4M
30							C2M
31	10	Parking Structure	Medium (145,000)	COM10	29/1	10,602	C2M
32							C1M

HAZUS Model Building Type Key:
C1x = Concrete moment frame
C2x = Concrete shear wall
RM1x = Reinf. msnry bearing wall w/ wood or metal diphragm.
S1x = Steel moment frame
S2x = Braced steel frame
S4x = Steel frame with cast-in-place concrete shear walls
W2 = Wood frame
Height Key: xxL = Low-rise, xxM = Mid-rise, xxH = High-rise

Table 2: Impacts to Prototypical Buildings Due to Shaking & Ground Failure in an IBC Design Level Earthquake- Ground Failure Hazard Zone 5

Use	Size	HAZUS Model Bldg Type	Foun-dation	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)
Hotel	Large	C1H	Shallow	18.8	37.5	1.687	$ 44.0	47.9%	$74.0
Hotel	Large	C2H	Shallow	18.2	36.3	1.633	$ 43.3	47.2%	$72.9
Offices	Large	C1H	Shallow	34.7	1.7	1.560	$ 22.3	47.5%	$39.8
Offices	Large	C2H	Shallow	33.6	1.7	1.510	$ 22.0	46.9%	$39.4
Hotel	Medium	C2M	Shallow	6.2	12.5	0.849	$ 11.7	42.5%	$19.6
Offices	Medium	C2M	Shallow	11.8	0.6	0.804	$ 6.9	42.2%	$12.2
MFR	Large	C1H	Shallow	3.0	15.0	0.675	$ 16.8	47.9%	$22.8
MFR	Large	C2H	Shallow	2.9	14.5	0.653	$ 16.5	47.2%	$22.5
Hotel	Large	C1H	Mat	7.3	14.5	0.474	$ 20.4	22.2%	$36.3
Offices	Large	C1H	Mat	13.4	0.7	0.438	$ 10.3	22.0%	$18.8
Hotel	Large	C2H	Mat	6.3	12.6	0.404	$ 19.2	21.0%	$34.3
Hotel	Large	S1H	Shallow	9.7	19.4	0.402	$ 35.4	38.5%	$62.4
Multi-Use	Medium	C2M	Shallow	5.9	3.7	0.399	$ 5.3	42.4%	$9.4
Offices	Large	C2H	Mat	11.7	0.6	0.373	$ 9.8	20.9%	$18.2
Hotel	Large	S1H	Mat	8.3	16.5	0.373	$ 24.3	26.5%	$43.5
Offices	Large	S1H	Shallow	18.0	0.9	0.372	$ 17.8	37.9%	$32.8
Offices	Large	S1H	Mat	15.3	0.8	0.345	$ 12.3	26.2%	$22.0
MFR	Medium	C2M	Shallow	0.9	4.6	0.311	$ 3.5	42.5%	$4.9
Hotel	Large	S2H	Shallow	8.1	16.2	0.291	$ 32.6	35.6%	$57.9
Offices	Large	S2H	Shallow	14.9	0.7	0.269	$ 16.4	35.0%	$30.7
Hotel	Large	S2H	Mat	6.1	12.2	0.260	$ 20.0	21.8%	$35.8
Offices	Large	S2H	Mat	11.3	0.6	0.241	$ 10.1	21.6%	$18.6
Offices	Small	RM1L	Shallow	2.9	0.1	0.223	$ 1.5	37.3%	$2.7
MFR	Large	C1H	Mat	1.2	5.8	0.190	$ 7.8	22.1%	$10.6
MFR	Large	C2H	Mat	1.0	5.1	0.161	$ 7.3	20.9%	$10.2
MFR	Large	S1H	Shallow	1.6	7.8	0.161	$ 13.5	38.5%	$18.5
Hotel	Medium	C2M	Mat	1.5	3.1	0.154	$ 4.5	16.3%	$7.8
MFR	Large	S1H	Mat	1.3	6.6	0.149	$ 9.3	26.4%	$12.5
Offices	Medium	C2M	Mat	2.9	0.1	0.145	$ 2.7	16.3%	$4.9
Hotel	Medium	S4M	Shallow	2.3	4.7	0.126	$ 8.8	32.1%	$15.6
Hotel	Medium	S2M	Shallow	2.3	4.6	0.124	$ 9.0	32.6%	$15.8
Offices	Medium	S4M	Shallow	4.4	0.2	0.119	$ 5.2	31.6%	$9.5
Offices	Medium	S2M	Shallow	4.4	0.2	0.118	$ 5.2	32.0%	$9.6
MFR	Large	S2H	Shallow	1.3	6.5	0.117	$ 12.4	35.5%	$17.3

Use	Size	HAZUS Model Bldg Type	Foun-dation	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)
MFR	Large	S2H	Mat	1.0	4.9	0.104	$ 7.6	21.7%	$10.5
MFR	Small	RM1L	Shallow	0.3	1.3	0.103	$ 0.9	37.6%	$1.3
Hotel	Medium	S4M	Mat	1.5	2.9	0.091	$ 4.6	16.6%	$8.2
Hotel	Medium	S2M	Mat	1.4	2.9	0.090	$ 4.9	17.7%	$8.5
Offices	Medium	S4M	Mat	2.8	0.1	0.086	$ 2.7	16.6%	$5.0
Offices	Medium	S2M	Mat	2.7	0.1	0.085	$ 2.9	17.5%	$5.1
Parking Struc	Medium	C1M	Shallow	1.1	0.0	0.075	$ 4.8	45.5%	$6.3
Parking Struc	Medium	C2M	Shallow	1.1	0.0	0.073	$ 4.7	44.2%	$6.2
Multi-Use	Medium	C2M	Mat	1.4	0.9	0.072	$ 2.1	16.3%	$3.7
Multi-Use	Medium	S4M	Shallow	2.2	1.4	0.059	$ 4.0	31.9%	$7.3
Multi-Use	Medium	S2M	Shallow	2.2	1.4	0.058	$ 4.1	32.4%	$7.4
MFR	Medium	C2M	Mat	0.2	1.1	0.056	$ 1.4	16.3%	$1.9
MFR	Medium	S4M	Shallow	0.3	1.7	0.046	$ 2.7	32.0%	$3.7
MFR	Medium	S2M	Shallow	0.3	1.7	0.046	$ 2.7	32.6%	$3.8
Multi-Use	Medium	S4M	Mat	1.4	0.9	0.043	$ 2.1	16.7%	$3.8
Multi-Use	Medium	S2M	Mat	1.4	0.9	0.042	$ 2.2	17.7%	$4.0
Offices	Small	S2L	Shallow	1.1	0.1	0.039	$ 1.2	30.0%	$2.2
Offices	Small	RM1L	Mat	0.6	0.0	0.035	$ 0.6	13.7%	$1.0
MFR	Medium	S4M	Mat	0.2	1.1	0.033	$ 1.4	16.6%	$2.0
MFR	Medium	S2M	Mat	0.2	1.1	0.033	$ 1.5	17.7%	$2.0
Offices	Small	W2	Shallow	1.1	0.1	0.026	$ 1.3	31.4%	$2.3
Offices	Small	S2L	Mat	0.6	0.0	0.022	$ 0.7	16.8%	$1.2
MFR	Small	S2L	Shallow	0.1	0.5	0.018	$ 0.8	30.8%	$1.1
MFR	Small	RM1L	Mat	0.1	0.3	0.016	$ 0.3	13.9%	$0.5
Parking Struc	Medium	C1M	Mat	0.3	0.0	0.015	$ 2.1	19.7%	$2.7
Parking Struc	Medium	C2M	Mat	0.3	0.0	0.013	$ 1.8	17.3%	$2.5
MFR	Small	W2	Shallow	0.1	0.5	0.012	$ 0.8	32.0%	$1.1
MFR	Small	S2L	Mat	0.1	0.3	0.010	$ 0.4	17.5%	$0.6
Offices	Small	W2	Mat	0.4	0.0	0.007	$ 0.6	14.1%	$1.0
MFR	Small	W2	Mat	0.0	0.2	0.003	$ 0.4	14.6%	$0.5

Legend:

Color	Vulnerability
	Low
	Moderate
	High
	Very High

Table 3: Impacts to Prototypical Buildings Due to Shaking & Ground Failure in an IBC Design Level Earthquake- Ground Failure Hazard Zone 4

Use	Size	HAZUS Model Bldg Type	Foun-dation	*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)*
Hotel	Large	C1H	Shallow	5.8	11.5	0.387	$13.5	14.7%	$24.6
Offices	Large	C1H	Shallow	10.7	0.5	0.358	$6.9	14.7%	$12.3
Hotel	Large	C2H	Shallow	4.7	9.5	0.315	$12.2	13.3%	$22.1
Offices	Large	C2H	Shallow	8.8	0.4	0.291	$6.3	13.4%	$11.7
Hotel	Large	S1H	Shallow	5.8	11.6	0.207	$16.5	17.9%	$30.8
Hotel	Large	S1H	Mat	5.6	11.1	0.201	$14.6	15.9%	$27.5
Offices	Large	S1H	Shallow	10.8	0.5	0.191	$8.3	17.8%	$14.7
Offices	Large	S1H	Mat	10.3	0.5	0.185	$7.4	15.7%	$12.8
Hotel	Large	C1H	Mat	3.8	7.7	0.183	$9.5	10.3%	$18.2
Offices	Large	C1H	Mat	7.1	0.4	0.169	$4.8	10.3%	$8.8
MFR	Large	C1H	Shallow	0.9	4.6	0.155	$5.2	14.7%	$6.9
Hotel	Medium	C2M	Shallow	1.3	2.7	0.148	$3.4	12.4%	$5.9
Offices	Medium	C2M	Shallow	2.5	0.1	0.140	$2.0	12.5%	$3.8
MFR	Large	C2H	Shallow	0.8	3.8	0.126	$4.7	13.3%	$6.5
Hotel	Large	C2H	Mat	2.7	5.5	0.109	$8.1	8.9%	$15.6
Offices	Large	C2H	Mat	5.1	0.3	0.100	$4.2	9.0%	$8.1
Hotel	Large	S2H	Shallow	3.4	6.7	0.088	$11.3	12.3%	$21.4
MFR	Large	S1H	Shallow	0.9	4.7	0.083	$6.3	17.9%	$8.3
Hotel	Large	S2H	Mat	3.0	6.0	0.081	$9.1	9.9%	$17.6
Offices	Large	S2H	Shallow	6.2	0.3	0.081	$5.8	12.3%	$10.7
MFR	Large	S1H	Mat	0.9	4.4	0.080	$5.5	15.8%	$7.2
Offices	Large	S2H	Mat	5.5	0.3	0.075	$4.7	10.0%	$8.6
MFR	Large	C1H	Mat	0.6	3.1	0.073	$3.6	10.3%	$4.9
Multi-Use	Medium	C2M	Shallow	1.3	0.8	0.070	$1.6	12.5%	$2.8
MFR	Medium	C2M	Shallow	0.2	1.0	0.054	$1.0	12.4%	$1.5
MFR	Large	C2H	Mat	0.4	2.2	0.043	$3.1	8.9%	$4.4
Offices	Small	RM1L	Shallow	0.6	0.0	0.042	$0.5	12.6%	$0.9
Hotel	Medium	S4M	Shallow	0.9	1.7	0.037	$3.0	11.0%	$5.6
MFR	Large	S2H	Shallow	0.5	2.7	0.035	$4.3	12.3%	$5.9
Hotel	Medium	S2M	Shallow	0.8	1.7	0.035	$3.4	12.2%	$6.0
Offices	Medium	S4M	Shallow	1.7	0.1	0.035	$1.8	11.0%	$3.4
Offices	Medium	S2M	Shallow	1.6	0.1	0.033	$2.0	12.0%	$3.6
Hotel	Medium	C2M	Mat	0.6	1.1	0.033	$2.2	8.1%	$4.0
MFR	Large	S2H	Mat	0.5	2.4	0.032	$3.5	9.9%	$4.7

Use	Size	HAZUS Model Bldg Type	Foun-dation	*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)*
Offices	Medium	C2M	Mat	1.0	0.1	0.031	$1.3	8.2%	$2.6
Hotel	Medium	S4M	Mat	0.7	1.5	0.031	$2.3	8.4%	$4.3
Offices	Medium	S4M	Mat	1.4	0.1	0.029	$1.4	8.5%	$2.6
Hotel	Medium	S2M	Mat	0.7	1.4	0.029	$2.7	9.7%	$4.8
Offices	Medium	S2M	Mat	1.3	0.1	0.027	$1.6	9.6%	$2.8
MFR	Small	RM1L	Shallow	0.1	0.3	0.020	$0.3	12.7%	$0.4
Multi-Use	Medium	S4M	Shallow	0.8	0.5	0.017	$1.4	11.1%	$2.6
Multi-Use	Medium	S2M	Shallow	0.8	0.5	0.016	$1.5	12.2%	$2.8
Multi-Use	Medium	C2M	Mat	0.5	0.3	0.015	$1.0	8.1%	$1.9
Parking Struc	Medium	C1M	Shallow	0.3	0.0	0.015	$1.7	15.7%	$2.1
Multi-Use	Medium	S4M	Mat	0.7	0.4	0.014	$1.1	8.5%	$2.0
Multi-Use	Medium	S2M	Mat	0.7	0.4	0.014	$1.2	9.7%	$2.2
MFR	Medium	S4M	Shallow	0.1	0.6	0.013	$0.9	11.0%	$1.3
MFR	Medium	S2M	Shallow	0.1	0.6	0.013	$1.0	12.2%	$1.4
Parking Struc	Medium	C2M	Shallow	0.2	0.0	0.013	$1.4	13.0%	$1.9
MFR	Medium	C2M	Mat	0.1	0.4	0.012	$0.7	8.1%	$1.0
Offices	Small	RM1L	Mat	0.3	0.0	0.012	$0.4	8.7%	$0.7
MFR	Medium	S4M	Mat	0.1	0.5	0.011	$0.7	8.4%	$1.0
Offices	Small	S2L	Shallow	0.4	0.0	0.011	$0.6	14.3%	$1.0
MFR	Medium	S2M	Mat	0.1	0.5	0.011	$0.8	9.7%	$1.1
Offices	Small	S2L	Mat	0.3	0.0	0.008	$0.5	12.1%	$0.8
MFR	Small	RM1L	Mat	0.0	0.1	0.005	$0.2	8.8%	$0.3
Parking Struc	Medium	C1M	Mat	0.1	0.0	0.005	$1.2	11.4%	$1.5
MFR	Small	S2L	Shallow	0.0	0.2	0.005	$0.4	15.0%	$0.5
Offices	Small	W2	Shallow	0.3	0.0	0.005	$0.5	12.0%	$0.9
MFR	Small	S2L	Mat	0.0	0.1	0.004	$0.3	12.8%	$0.4
Parking Struc	Medium	C2M	Mat	0.1	0.0	0.003	$0.9	8.5%	$1.2
MFR	Small	W2	Shallow	0.0	0.1	0.002	$0.3	12.5%	$0.4
Offices	Small	W2	Mat	0.1	0.0	0.001	$0.4	9.1%	$0.7
MFR	Small	W2	Mat	0.0	0.1	0.001	$0.2	9.6%	$0.3

Legend:

Color	Vulnerability
	Low
	Moderate
	High
	Very High

Table 4: Impacts to Prototypical Buildings Due to Shaking & Ground Failure in an IBC Design Level Earthquake- Ground Failure Hazard Zone 3

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)*
Hotel	Large	S1H	Shallow	5.0	10.1	0.168	$12.7	13.9%	$24.5
Hotel	Large	S1H	Mat	5.0	10.1	0.168	$12.7	13.8%	$24.5
Offices	Large	S1H	Shallow	9.3	0.5	0.155	$6.5	13.8%	$11.1
Offices	Large	S1H	Mat	9.3	0.5	0.155	$6.5	13.8%	$11.1
Hotel	Large	C1H	Shallow	3.2	6.4	0.128	$7.4	8.1%	$14.7
Hotel	Large	C1H	Mat	3.2	6.4	0.128	$7.4	8.1%	$14.7
Offices	Large	C1H	Shallow	5.9	0.3	0.118	$3.8	8.1%	$6.9
Offices	Large	C1H	Mat	5.9	0.3	0.118	$3.8	8.1%	$6.9
MFR	Large	S1H	Shallow	0.8	4.0	0.067	$4.8	13.8%	$6.3
MFR	Large	S1H	Mat	0.8	4.0	0.067	$4.8	13.8%	$6.3
Hotel	Large	C2H	Shallow	2.1	4.1	0.053	$6.0	6.6%	$12.0
Hotel	Large	C2H	Mat	2.1	4.1	0.053	$6.0	6.6%	$12.0
MFR	Large	C1H	Shallow	0.5	2.5	0.051	$2.8	8.1%	$3.8
MFR	Large	C1H	Mat	0.5	2.5	0.051	$2.8	8.1%	$3.8
Offices	Large	C2H	Shallow	3.8	0.2	0.049	$3.2	6.8%	$6.1
Offices	Large	C2H	Mat	3.8	0.2	0.049	$3.2	6.8%	$6.1
Hotel	Large	S2H	Shallow	2.4	4.8	0.047	$7.0	7.7%	$14.2
Hotel	Large	S2H	Mat	2.4	4.8	0.047	$7.0	7.7%	$14.2
Offices	Large	S2H	Shallow	4.5	0.2	0.044	$3.7	7.8%	$6.7
Offices	Large	S2H	Mat	4.5	0.2	0.044	$3.7	7.8%	$6.7
MFR	Large	C2H	Shallow	0.3	1.7	0.021	$2.3	6.6%	$3.3
MFR	Large	C2H	Mat	0.3	1.7	0.021	$2.3	6.6%	$3.3
Hotel	Medium	S4M	Shallow	0.6	1.2	0.019	$1.9	6.8%	$3.6
Hotel	Medium	S4M	Mat	0.6	1.2	0.019	$1.9	6.8%	$3.6
MFR	Large	S2H	Shallow	0.4	1.9	0.019	$2.7	7.7%	$3.7
MFR	Large	S2H	Mat	0.4	1.9	0.019	$2.7	7.7%	$3.7
Offices	Medium	S4M	Shallow	1.1	0.1	0.018	$1.1	7.0%	$2.2
Offices	Medium	S4M	Mat	1.1	0.1	0.018	$1.1	7.0%	$2.2
Hotel	Medium	S2M	Shallow	0.6	1.1	0.018	$2.3	8.2%	$4.1
Hotel	Medium	S2M	Mat	0.6	1.1	0.018	$2.3	8.2%	$4.1
Offices	Medium	S2M	Shallow	1.1	0.1	0.017	$1.3	8.1%	$2.4
Offices	Medium	S2M	Mat	1.1	0.1	0.017	$1.3	8.1%	$2.4
Hotel	Medium	C2M	Shallow	0.4	0.7	0.010	$1.8	6.5%	$3.2
Hotel	Medium	C2M	Mat	0.4	0.7	0.010	$1.8	6.5%	$3.2

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)*
Offices	Medium	C2M	Shallow	0.7	0.0	0.010	$1.1	6.6%	$2.1
Offices	Medium	C2M	Mat	0.7	0.0	0.010	$1.1	6.6%	$2.1
Multi-Use	Medium	S4M	Shallow	0.6	0.3	0.009	$0.9	7.0%	$1.7
Multi-Use	Medium	S4M	Mat	0.6	0.3	0.009	$0.9	7.0%	$1.7
Multi-Use	Medium	S2M	Shallow	0.5	0.3	0.008	$1.0	8.2%	$1.8
Multi-Use	Medium	S2M	Mat	0.5	0.3	0.008	$1.0	8.2%	$1.8
Offices	Small	RM1L	Shallow	0.2	0.0	0.007	$0.3	7.8%	$0.6
Offices	Small	RM1L	Mat	0.2	0.0	0.007	$0.3	7.8%	$0.6
MFR	Medium	S4M	Shallow	0.1	0.4	0.007	$0.6	6.8%	$0.8
MFR	Medium	S4M	Mat	0.1	0.4	0.007	$0.6	6.8%	$0.8
MFR	Medium	S2M	Shallow	0.1	0.4	0.006	$0.7	8.2%	$1.0
MFR	Medium	S2M	Mat	0.1	0.4	0.006	$0.7	8.2%	$1.0
Offices	Small	S2L	Shallow	0.3	0.0	0.005	$0.5	11.3%	$0.8
Offices	Small	S2L	Mat	0.3	0.0	0.005	$0.5	11.3%	$0.8
Multi-Use	Medium	C2M	Shallow	0.3	0.2	0.005	$0.8	6.6%	$1.5
Multi-Use	Medium	C2M	Mat	0.3	0.2	0.005	$0.8	6.6%	$1.5
MFR	Medium	C2M	Shallow	0.1	0.3	0.004	$0.5	6.5%	$0.8
MFR	Medium	C2M	Mat	0.1	0.3	0.004	$0.5	6.5%	$0.8
MFR	Small	RM1L	Shallow	0.0	0.1	0.003	$0.2	7.9%	$0.3
MFR	Small	RM1L	Mat	0.0	0.1	0.003	$0.2	7.9%	$0.3
Parking Struc	Medium	C1M	Shallow	0.1	0.0	0.003	$1.0	9.8%	$1.3
Parking Struc	Medium	C1M	Mat	0.1	0.0	0.003	$1.0	9.8%	$1.3
MFR	Small	S2L	Shallow	0.0	0.1	0.002	$0.3	11.9%	$0.4
MFR	Small	S2L	Mat	0.0	0.1	0.002	$0.3	11.9%	$0.4
Parking Struc	Medium	C2M	Shallow	0.1	0.0	0.001	$0.7	6.9%	$1.0
Parking Struc	Medium	C2M	Mat	0.1	0.0	0.001	$0.7	6.9%	$1.0
Offices	Small	W2	Shallow	0.1	0.0	0.000	$0.3	8.2%	$0.6
Offices	Small	W2	Mat	0.1	0.0	0.000	$0.3	8.2%	$0.6
MFR	Small	W2	Shallow	0.0	0.0	0.000	$0.2	8.7%	$0.3
MFR	Small	W2	Mat	0.0	0.0	0.000	$0.2	8.7%	$0.3

Legend:

Color	Vulnerability
	Low
	Moderate
	High
	Very High

Table 5: Impacts to Prototypical Buildings Due to Shaking & Ground Failure in an IBC Design Level Earthquake- Ground Failure Hazard Zone 2

Use	Size	HAZUS Model Bldg Type	Foun-dation	*Total Casualties Day*	*Total Casualties Night*	Max Total Deaths *(Day or Night)*	*Total Building Damage ($M)*	*Loss Ratio*	*Total Economic Loss ($M)*
Hotel	Large	S1H	Shallow	5.1	10.1	0.169	$12.8	13.9%	$24.6
Hotel	Large	S1H	Mat	5.0	10.1	0.168	$12.7	13.9%	$24.5
Offices	Large	S1H	Shallow	9.4	0.5	0.156	$6.5	13.9%	$11.2
Offices	Large	S1H	Mat	9.3	0.5	0.155	$6.5	13.8%	$11.1
Hotel	Large	C1H	Shallow	3.2	6.5	0.134	$7.6	8.3%	$15.0
Hotel	Large	C1H	Mat	3.2	6.4	0.128	$7.4	8.1%	$14.7
Offices	Large	C1H	Shallow	6.0	0.3	0.124	$3.9	8.3%	$7.0
Offices	Large	C1H	Mat	5.9	0.3	0.118	$3.8	8.1%	$6.9
MFR	Large	S1H	Shallow	0.8	4.0	0.068	$4.9	13.9%	$6.3
MFR	Large	S1H	Mat	0.8	4.0	0.067	$4.8	13.8%	$6.3
Hotel	Large	C2H	Shallow	2.1	4.3	0.059	$6.2	6.7%	$12.3
Offices	Large	C2H	Shallow	3.9	0.2	0.054	$3.2	6.9%	$6.3
MFR	Large	C1H	Shallow	0.5	2.6	0.054	$2.9	8.2%	$3.8
Hotel	Large	C2H	Mat	2.1	4.1	0.053	$6.0	6.6%	$12.0
MFR	Large	C1H	Mat	0.5	2.5	0.051	$2.8	8.1%	$3.8
Offices	Large	C2H	Mat	3.8	0.2	0.049	$3.2	6.8%	$6.1
Hotel	Large	S2H	Shallow	2.4	4.9	0.048	$7.1	7.8%	$14.3
Hotel	Large	S2H	Mat	2.4	4.8	0.047	$7.0	7.7%	$14.2
Offices	Large	S2H	Shallow	4.5	0.2	0.044	$3.7	7.9%	$6.8
Offices	Large	S2H	Mat	4.5	0.2	0.044	$3.7	7.8%	$6.7
MFR	Large	C2H	Shallow	0.3	1.7	0.024	$2.4	6.7%	$3.3
MFR	Large	C2H	Mat	0.3	1.7	0.021	$2.3	6.6%	$3.3
Hotel	Medium	S4M	Shallow	0.6	1.2	0.019	$1.9	6.9%	$3.6
Hotel	Medium	S4M	Mat	0.6	1.2	0.019	$1.9	6.8%	$3.6
MFR	Large	S2H	Shallow	0.4	1.9	0.019	$2.7	7.8%	$3.7
MFR	Large	S2H	Mat	0.4	1.9	0.019	$2.7	7.7%	$3.7
Offices	Medium	S4M	Shallow	1.1	0.1	0.018	$1.2	7.1%	$2.2
Offices	Medium	S4M	Mat	1.1	0.1	0.018	$1.1	7.0%	$2.2
Hotel	Medium	S2M	Shallow	0.6	1.1	0.018	$2.3	8.3%	$4.1
Hotel	Medium	S2M	Mat	0.6	1.1	0.018	$2.3	8.2%	$4.1
Offices	Medium	S2M	Shallow	1.1	0.1	0.017	$1.3	8.2%	$2.4
Offices	Medium	S2M	Mat	1.1	0.1	0.017	$1.3	8.1%	$2.4
Hotel	Medium	C2M	Shallow	0.4	0.8	0.012	$1.8	6.6%	$3.3
Offices	Medium	C2M	Shallow	0.7	0.0	0.011	$1.1	6.7%	$2.1

Use	Size	HAZUS Model Bldg Type	Foun-dation	*Total Casualties Day*	*Total Casualties Night*	Max Total Deaths *(Day or Night)*	*Total Building Damage ($M)*	*Loss Ratio*	*Total Economic Loss ($M)*
Hotel	Medium	C2M	Mat	0.4	0.7	0.010	$1.8	6.5%	$3.2
Offices	Medium	C2M	Mat	0.7	0.0	0.010	$1.1	6.6%	$2.1
Multi-Use	Medium	S4M	Shallow	0.6	0.3	0.009	$0.9	7.0%	$1.7
Multi-Use	Medium	S4M	Mat	0.6	0.3	0.009	$0.9	7.0%	$1.7
Multi-Use	Medium	S2M	Shallow	0.5	0.3	0.008	$1.0	8.3%	$1.9
Multi-Use	Medium	S2M	Mat	0.5	0.3	0.008	$1.0	8.2%	$1.8
Offices	Small	RM1L	Shallow	0.2	0.0	0.008	$0.3	7.8%	$0.6
Offices	Small	RM1L	Mat	0.2	0.0	0.007	$0.3	7.8%	$0.6
MFR	Medium	S4M	Shallow	0.1	0.4	0.007	$0.6	6.9%	$0.8
MFR	Medium	S4M	Mat	0.1	0.4	0.007	$0.6	6.8%	$0.8
MFR	Medium	S2M	Shallow	0.1	0.4	0.007	$0.7	8.3%	$1.0
MFR	Medium	S2M	Mat	0.1	0.4	0.006	$0.7	8.2%	$1.0
Multi-Use	Medium	C2M	Shallow	0.4	0.2	0.006	$0.8	6.7%	$1.5
Offices	Small	S2L	Shallow	0.3	0.0	0.005	$0.5	11.3%	$0.8
Offices	Small	S2L	Mat	0.3	0.0	0.005	$0.5	11.3%	$0.8
Multi-Use	Medium	C2M	Mat	0.3	0.2	0.005	$0.8	6.6%	$1.5
MFR	Medium	C2M	Shallow	0.1	0.3	0.004	$0.5	6.6%	$0.8
MFR	Medium	C2M	Mat	0.1	0.3	0.004	$0.5	6.5%	$0.8
MFR	Small	RM1L	Shallow	0.0	0.1	0.004	$0.2	7.9%	$0.3
MFR	Small	RM1L	Mat	0.0	0.1	0.003	$0.2	7.9%	$0.3
Parking Struc	Medium	C1M	Shallow	0.1	0.0	0.003	$1.0	9.9%	$1.3
Parking Struc	Medium	C1M	Mat	0.1	0.0	0.003	$1.0	9.8%	$1.3
MFR	Small	S2L	Shallow	0.0	0.1	0.002	$0.3	11.9%	$0.4
MFR	Small	S2L	Mat	0.0	0.1	0.002	$0.3	11.9%	$0.4
Parking Struc	Medium	C2M	Shallow	0.1	0.0	0.001	$0.7	7.0%	$1.0
Parking Struc	Medium	C2M	Mat	0.1	0.0	0.001	$0.7	6.9%	$1.0
Offices	Small	W2	Shallow	0.1	0.0	0.000	$0.3	8.2%	$0.6
Offices	Small	W2	Mat	0.1	0.0	0.000	$0.3	8.2%	$0.6
MFR	Small	W2	Shallow	0.0	0.0	0.000	$0.2	8.7%	$0.3
MFR	Small	W2	Mat	0.0	0.0	0.000	$0.2	8.7%	$0.3

Legend:

Color	Vulnerability
	Low
	Moderate
	High
	Very High

Table 6: Economic Impacts to Prototypical Buildings in an IBC Design Level Earthquake- Ground Failure Hazard Zone 5

				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) *(includes building damage)*	Total Bldg Damage ($M)	Bldg Loss Ratio	Total Direct Econ. Loss ($M) *(includes building damage)*	Total Bldg Damage ($M)	Bldg Loss Ratio	Total Direct Econ. Loss ($M) *(includes building damage)*
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
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 7: 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

			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) *(inc. building damage)*	Total Bldg Damage ($M)	Bldg Loss Ratio	Total Direct Econ. Loss ($M) *(inc. building damage)*	Total Bldg Damage ($M)	Bldg Loss Ratio	Total Direct Econ. Loss ($M) *(inc. building damage)*
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 8: 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	Max. # 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

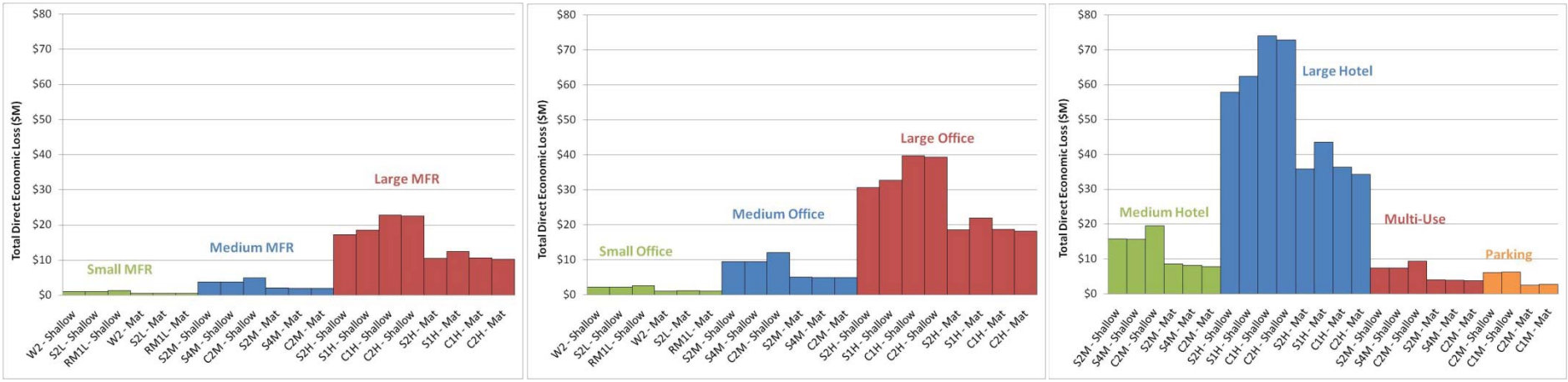


Figure 1: Total Direct Economic Losses Due to Shaking & Ground Failure in an IBC Design Level Earthquake- Ground Failure Hazard Zone 5

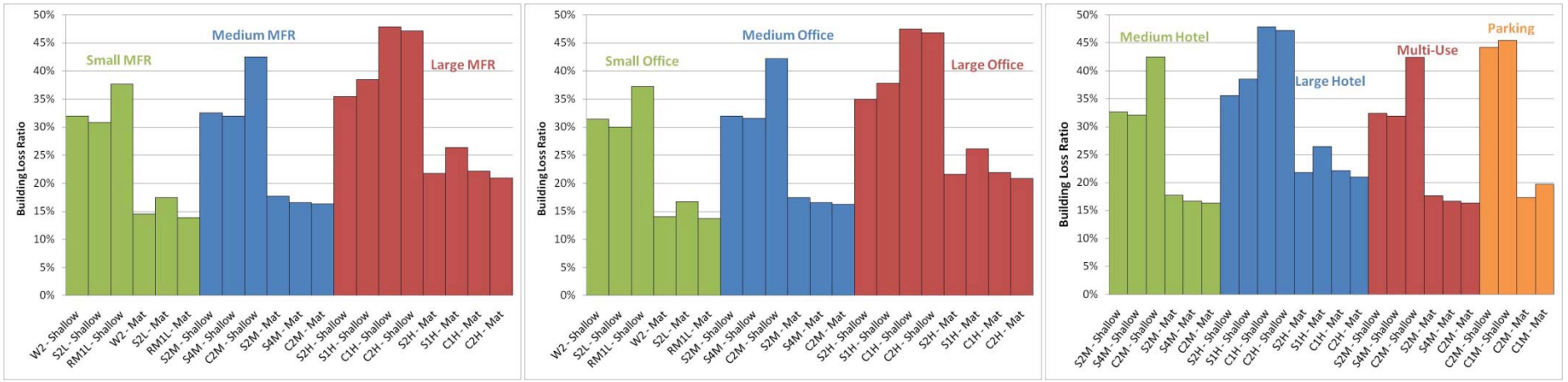


Figure 2: Building Loss Ratio Due to Shaking & Ground Failure in an IBC Design Level Earthquake- Ground Failure Hazard Zone 5

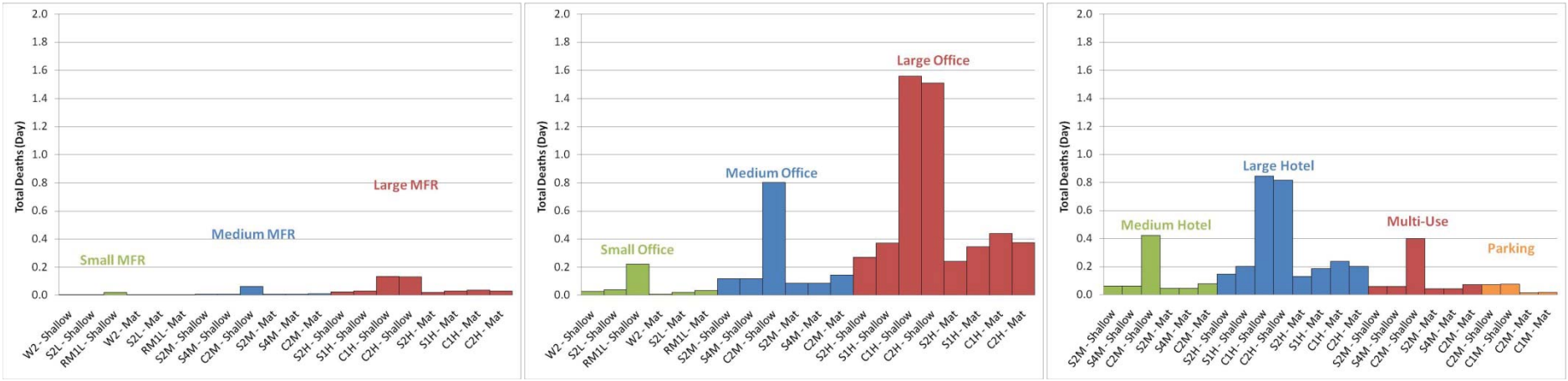


Figure 3: Total Day Time Deaths Due to Shaking & Ground Failure in an IBC Design Level Earthquake- Ground Failure Hazard Zone 5

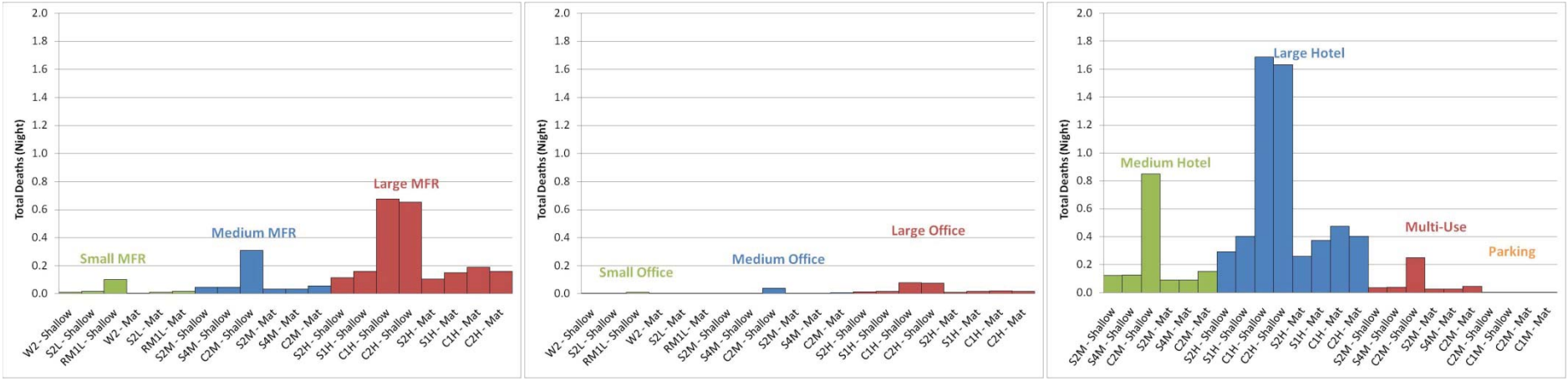


Figure 4: Total Night Time Deaths Due to Shaking & Ground Failure in an IBC Design Level Earthquake- Ground Failure Hazard Zone 5

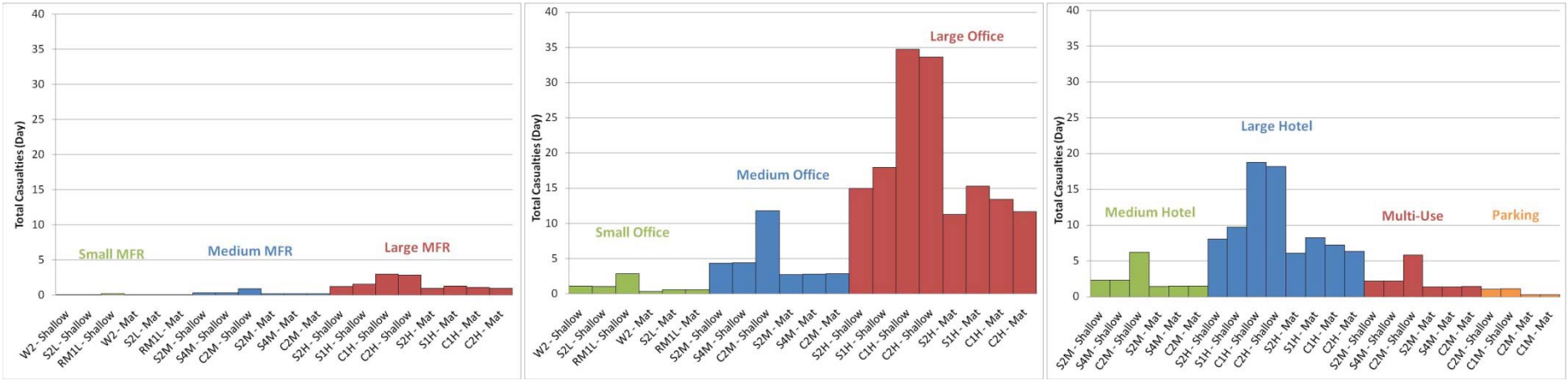


Figure 5: Total Day Time Casualties Due to Shaking & Ground Failure in an IBC Design Level Earthquake- Ground Failure Hazard Zone 5

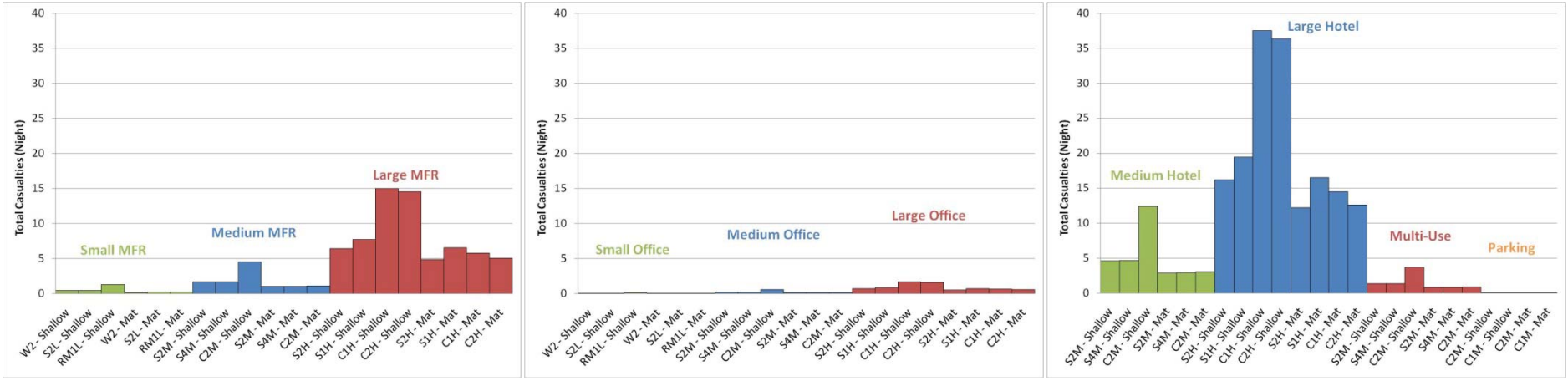


Figure 6: Total Night Time Casualties Due to Shaking & Ground Failure in an IBC Design Level Earthquake- Ground Failure Hazard Zone 5

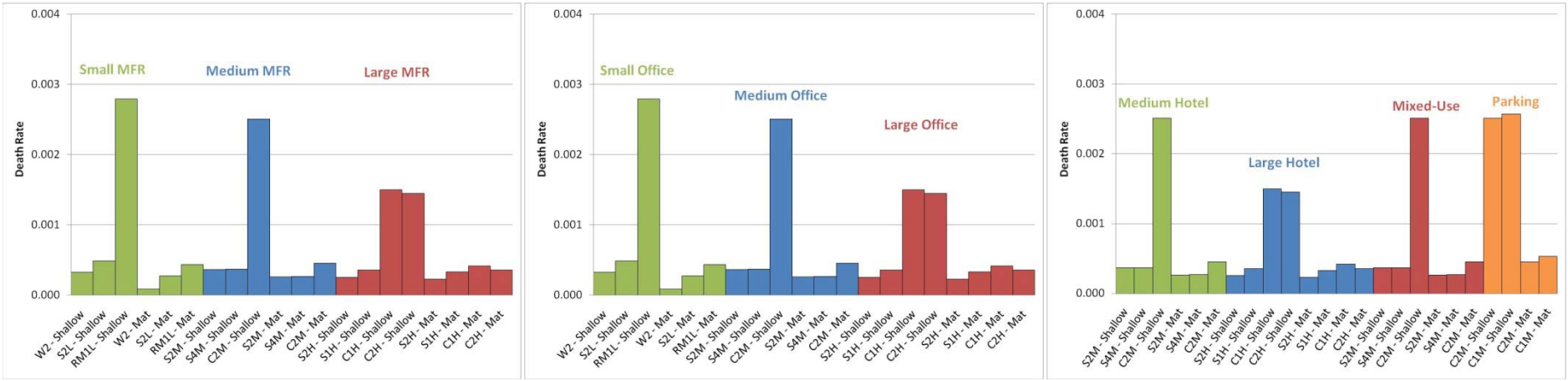


Figure 7: Death Rate Due to Shaking & Ground Failure in an IBC Design Level Earthquake- Ground Failure Hazard Zone 5

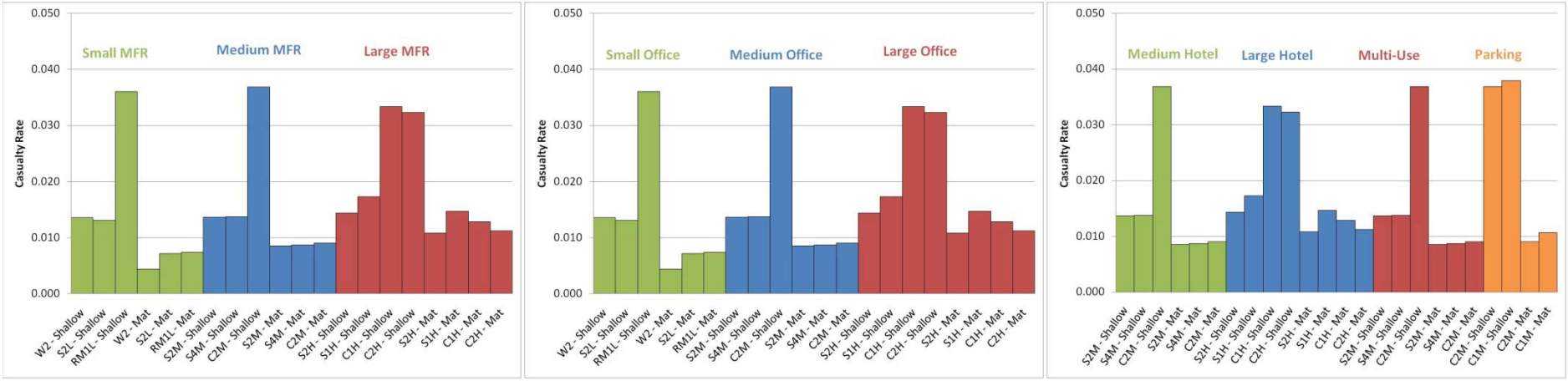


Figure 8: Casualty Rate Due to Shaking & Ground Failure in an IBC Design Level Earthquake- Ground Failure Hazard Zone 5

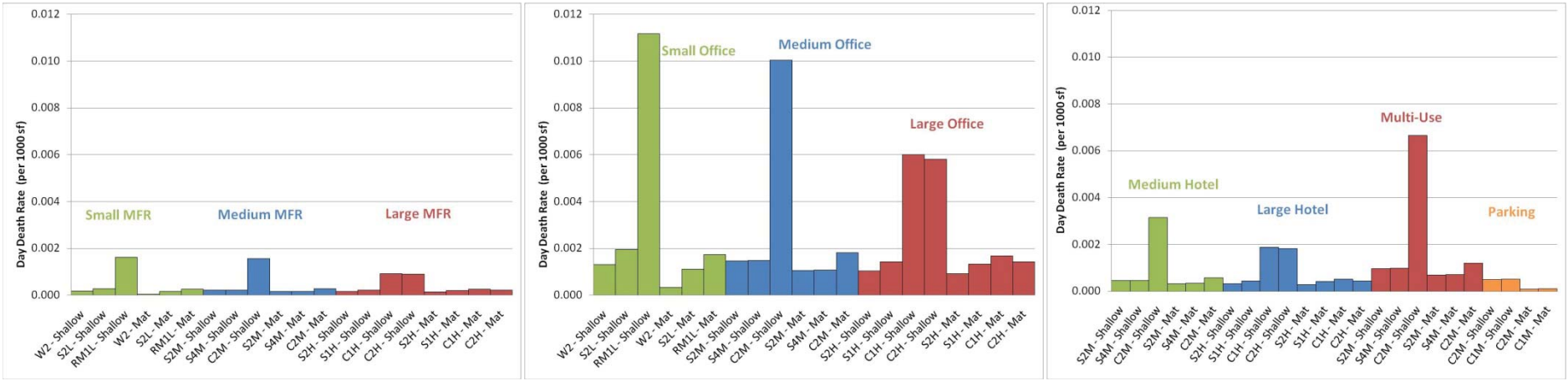


Figure 9: Day Death Rate per 1000 Square Feet Due to Shaking & Ground Failure in an IBC Design Level Earthquake- Ground Failure Hazard Zone 5

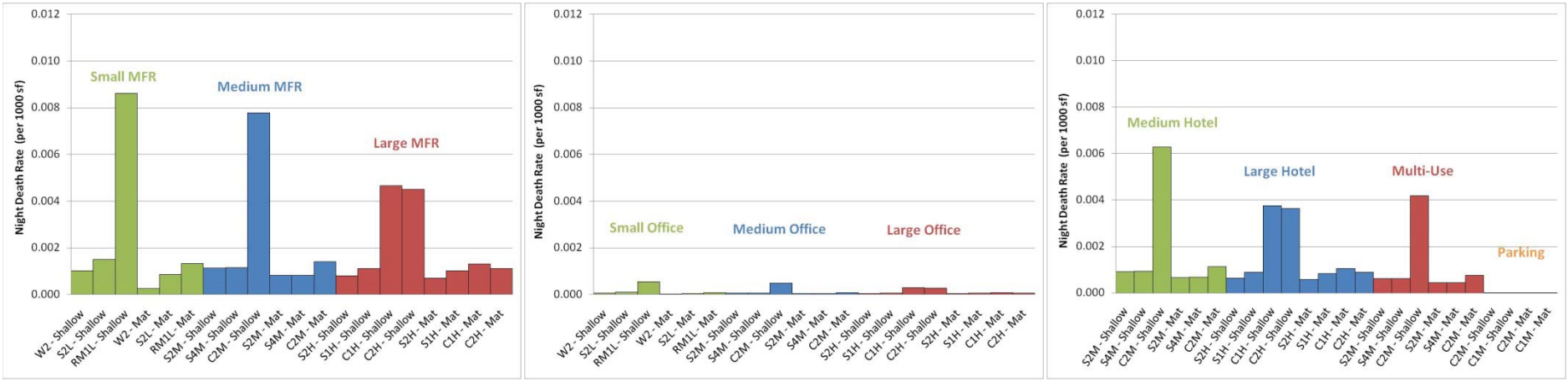


Figure 10: Night Death Rate per 1000 Square Feet Due to Shaking & Ground Failure in an IBC Design Level Earthquake - Ground Failure Hazard Zone 5

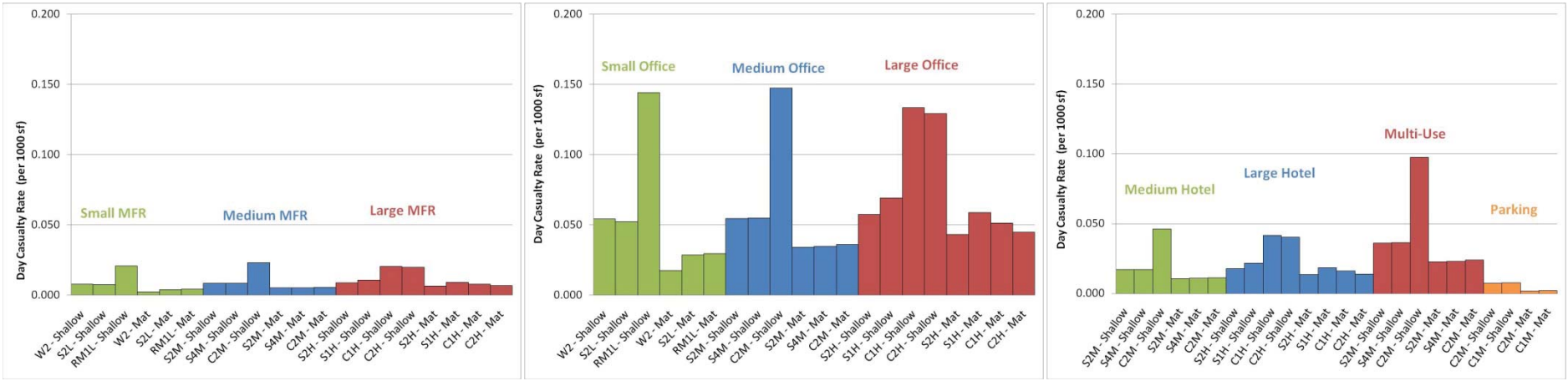


Figure 11: Day Casualty Rate per 1000 Square Feet Due to Shaking & Ground Failure in an IBC Design Level Earthquake - Ground Failure Hazard Zone 5

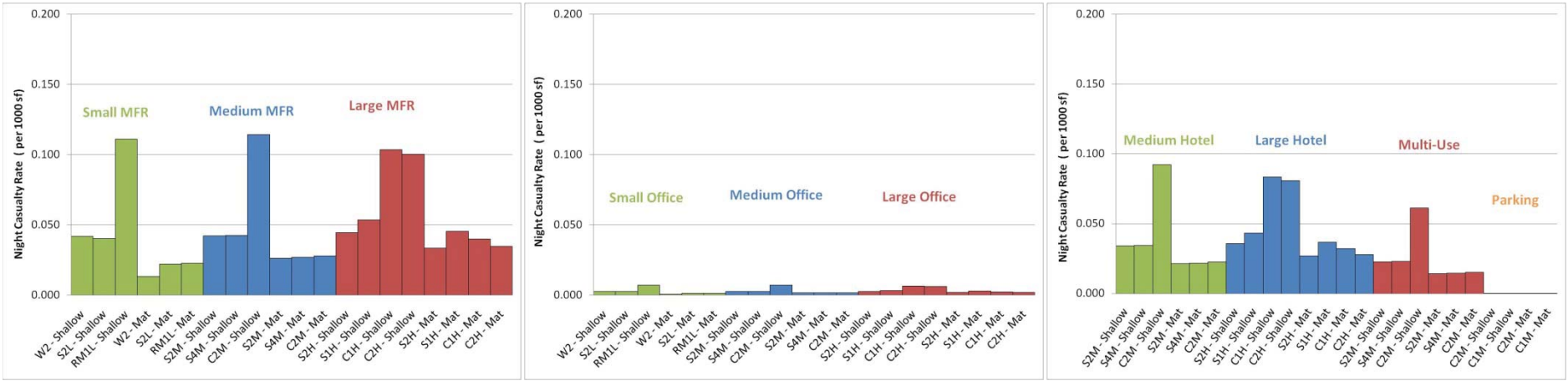


Figure 12: Night Casualty Rate per 1000 Square Feet Due to Shaking & Ground Failure in an IBC Design Level Earthquake - Ground Failure Hazard Zone 5

Figure 13: Total Direct Economic Loss for Prototypical Building #1 (Small Multi-Family Residential) due to Shaking and Ground Failure in an IBC Design Level Earthquake

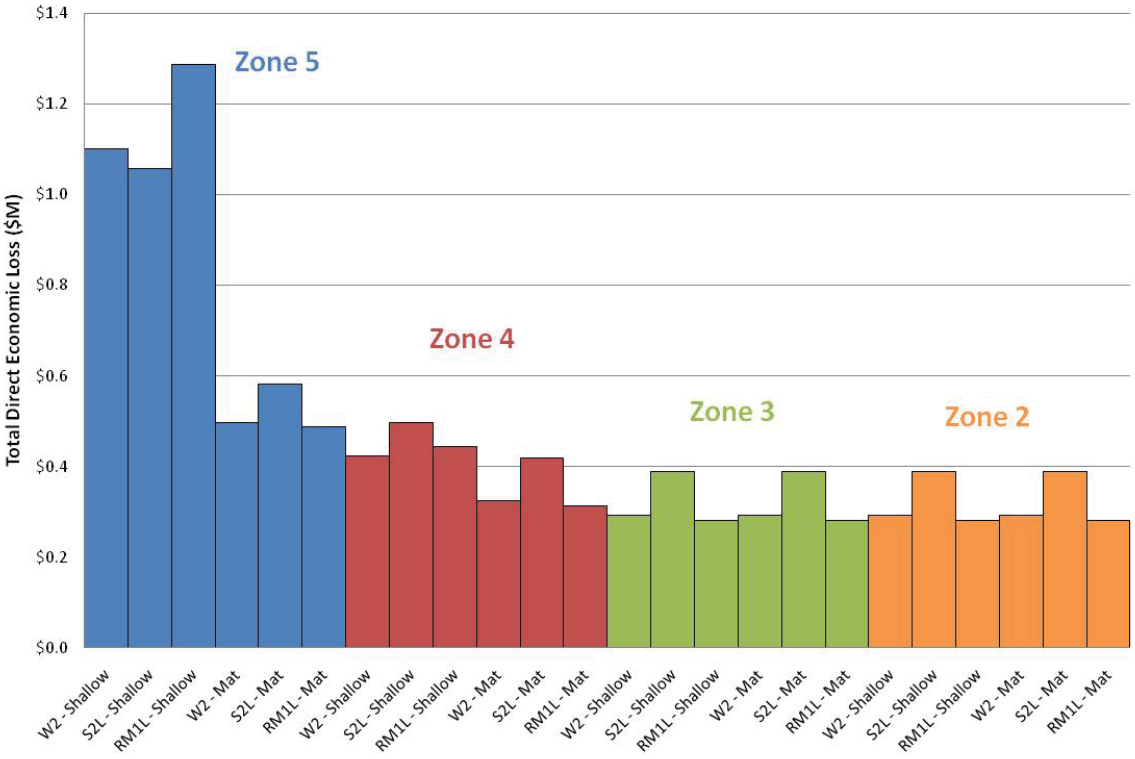


Figure 14: Total Night Casualties for Prototypical Building #1 (Small Multi-Family Residential) due to Shaking and Ground Failure in an IBC Design Level Earthquake

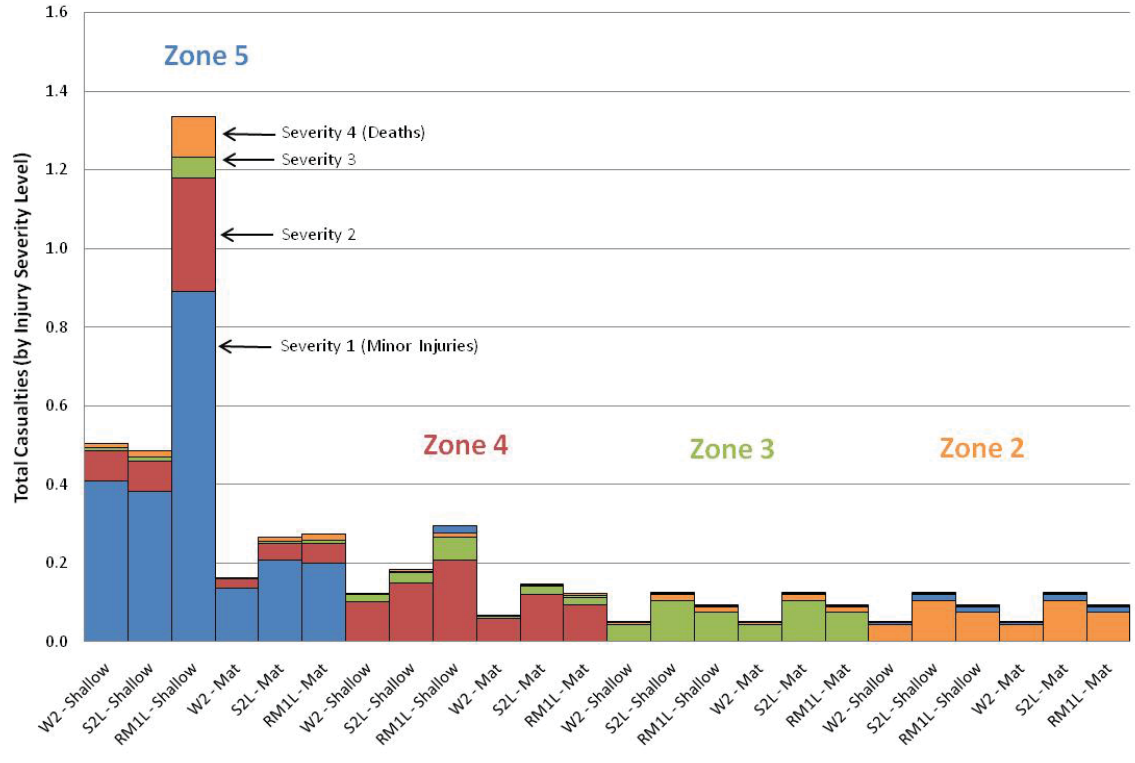


Figure 15: Total Direct Economic Loss for Prototypical Building #2 (Medium Multi-Family Residential) due to Shaking and Ground Failure in an IBC Design Level Earthquake

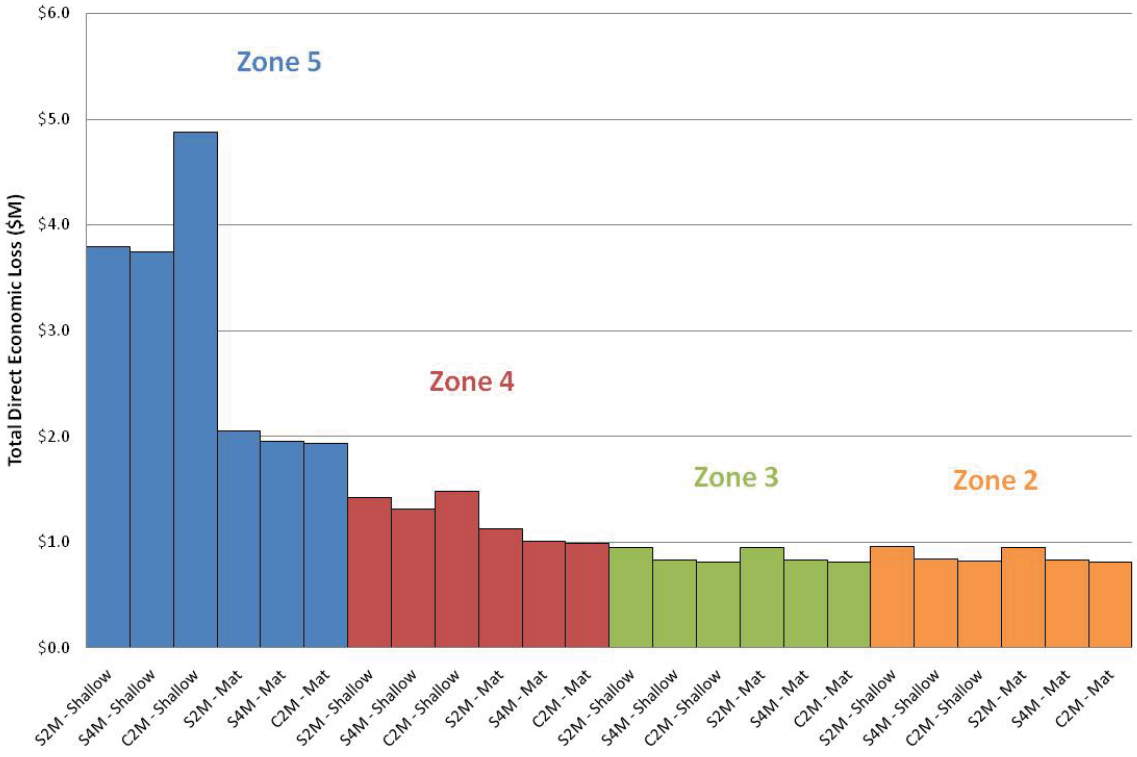


Figure 16: Total Night Casualties for Prototypical Building #2 (Medium Multi-Family Residential) due to Shaking and Ground Failure in an IBC Design Level Earthquake

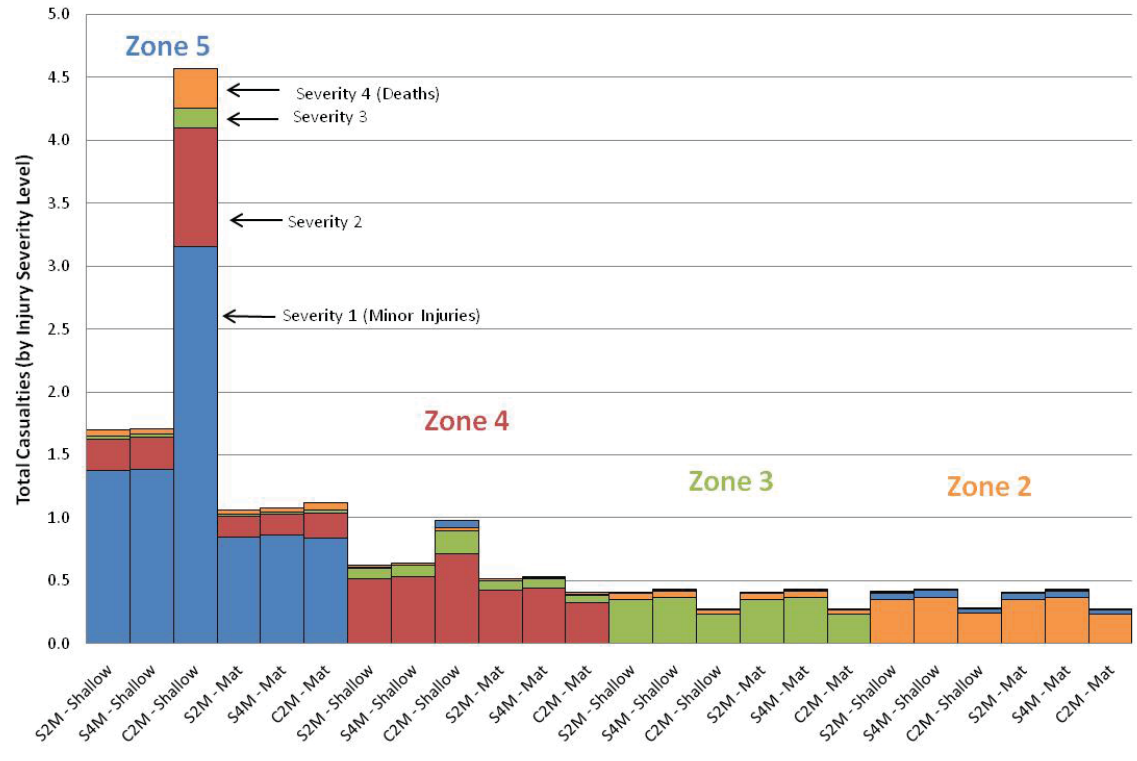


Figure 17: Total Direct Economic Loss for Prototypical Building #3 (Large Multi-Family Residential) due to Shaking and Ground Failure in an IBC Design Level Earthquake

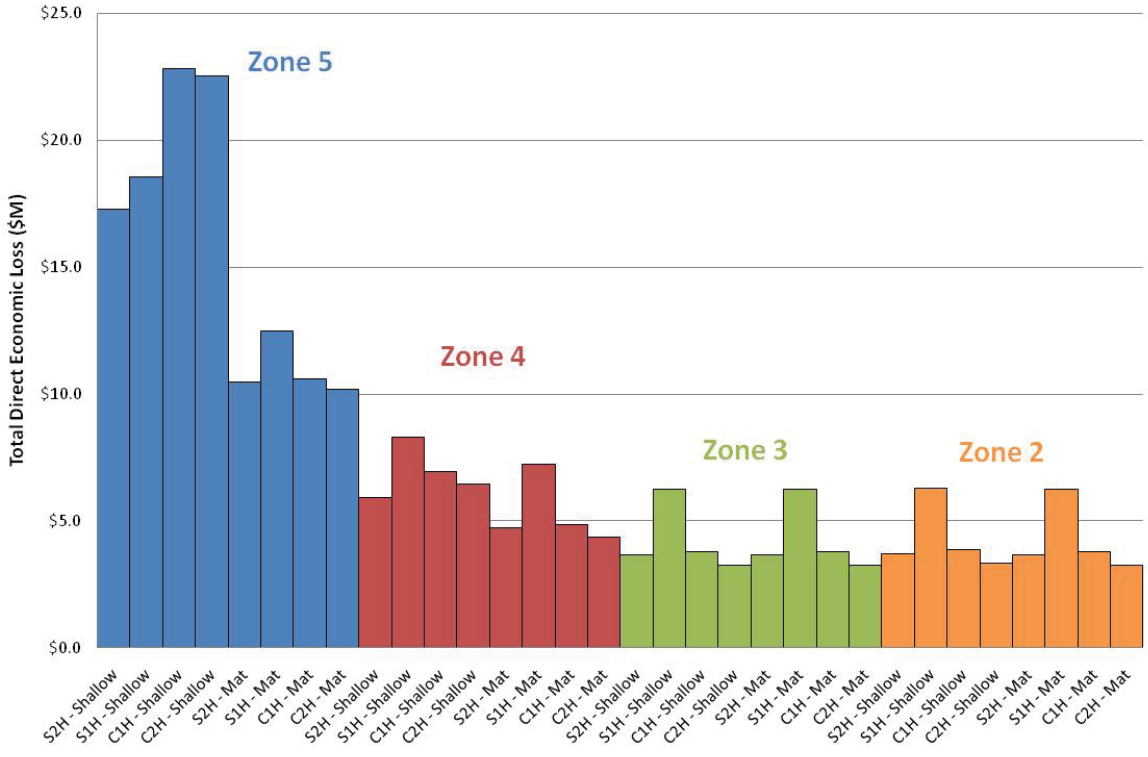


Figure 18: Total Night Casualties for Prototypical Building #3 (Large Multi-Family Residential) due to Shaking and Ground Failure in an IBC Design Level Earthquake

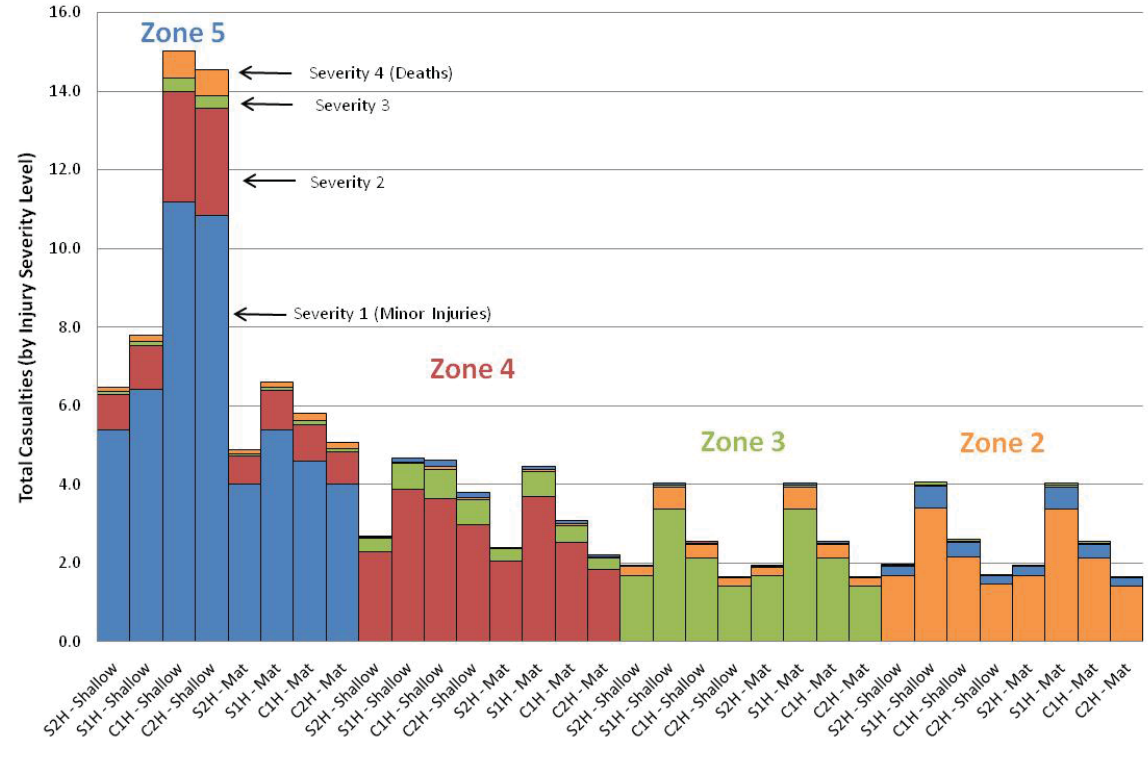


Figure 19: Total Direct Economic Loss for Prototypical Building #4 (Small Offices) due to Shaking and Ground Failure in an IBC Design Level Earthquake

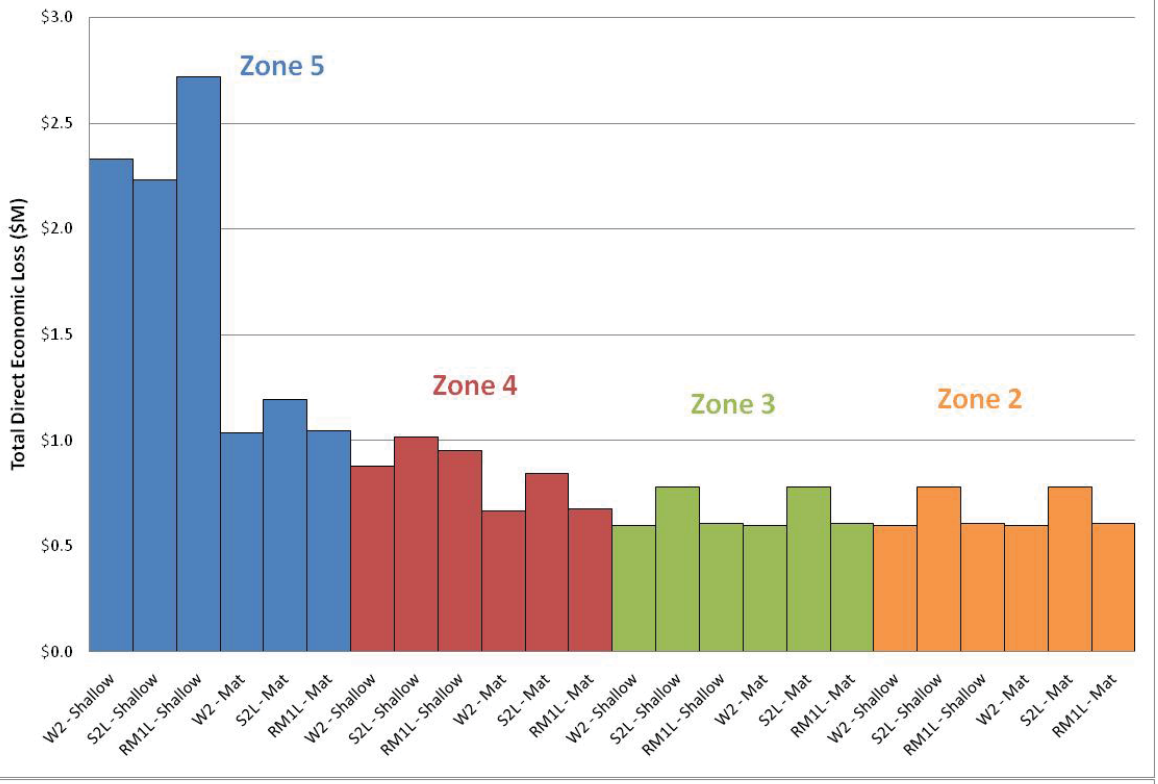


Figure 20: Total Day Casualties for Prototypical Building #4 (Small Offices) due to Shaking and Ground Failure in an IBC Design Level Earthquake

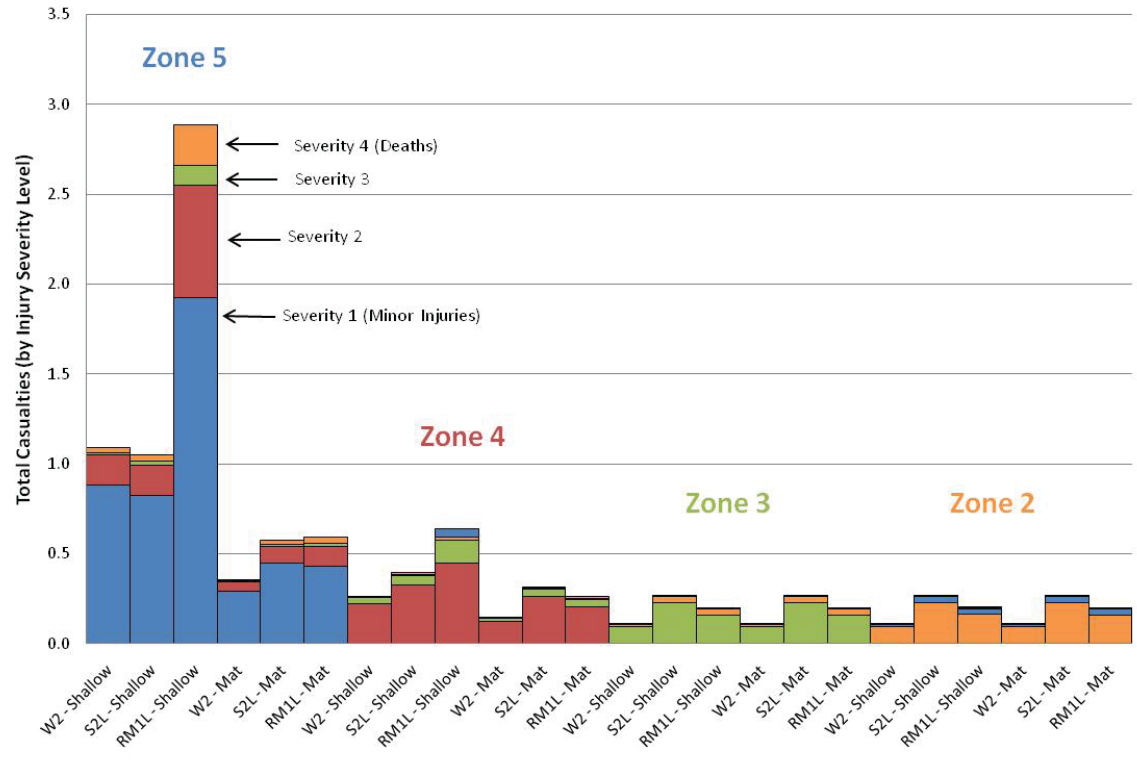


Figure 21: Total Direct Economic Loss for Prototypical Building #5 (Medium Offices) due to Shaking and Ground Failure in an IBC Design Level Earthquake

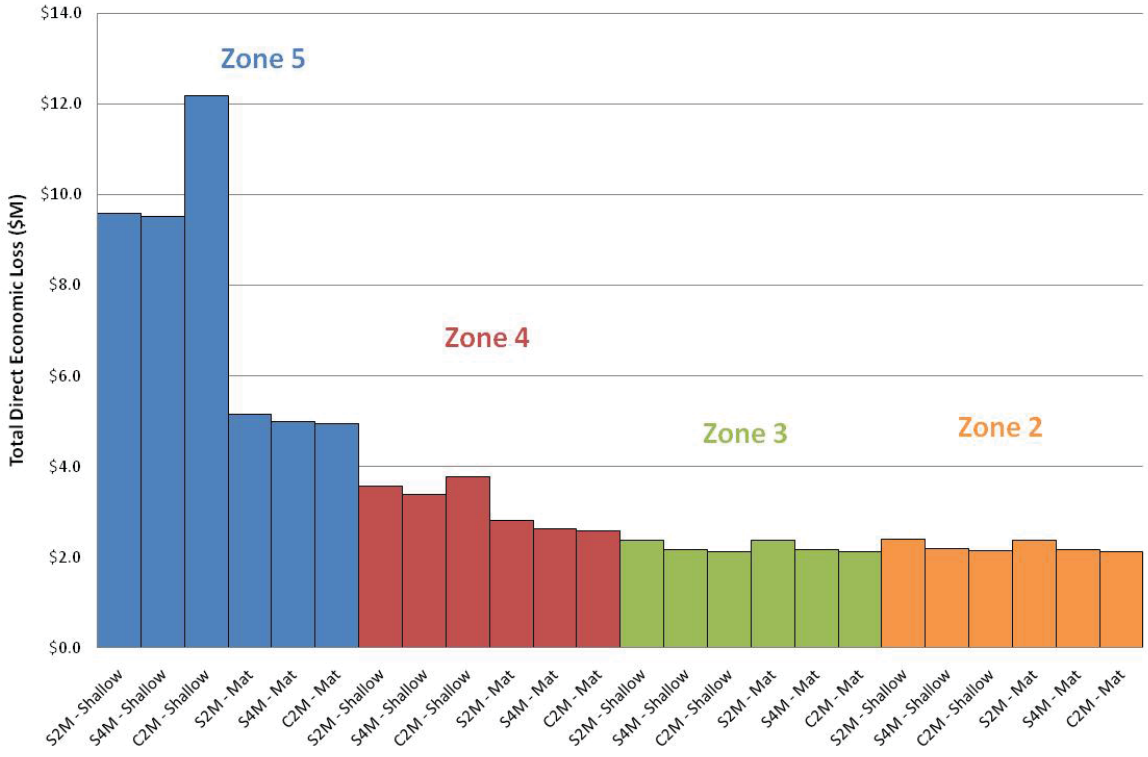


Figure 22: Total Day Casualties for Prototypical Building #5 (Medium Offices) due to Shaking and Ground Failure in an IBC Design Level Earthquake

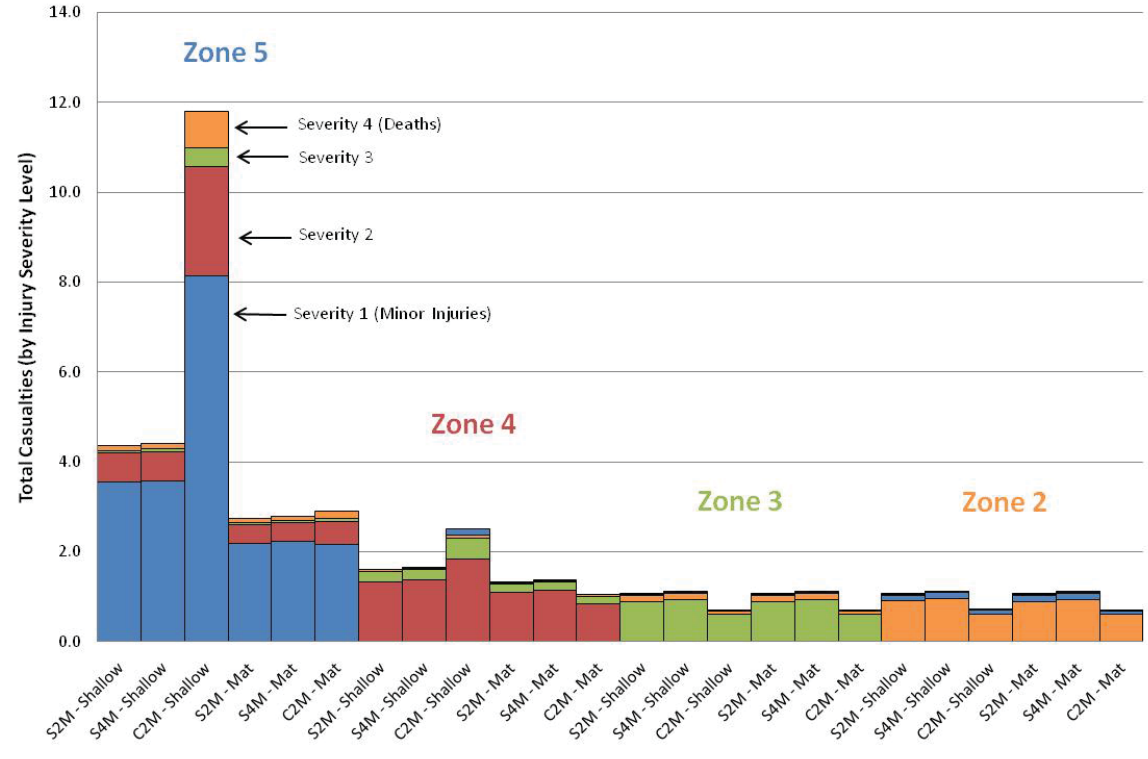


Figure 23: Total Direct Economic Loss for Prototypical Building #6 (Large Offices) due to Shaking and Ground Failure in an IBC Design Level Earthquake

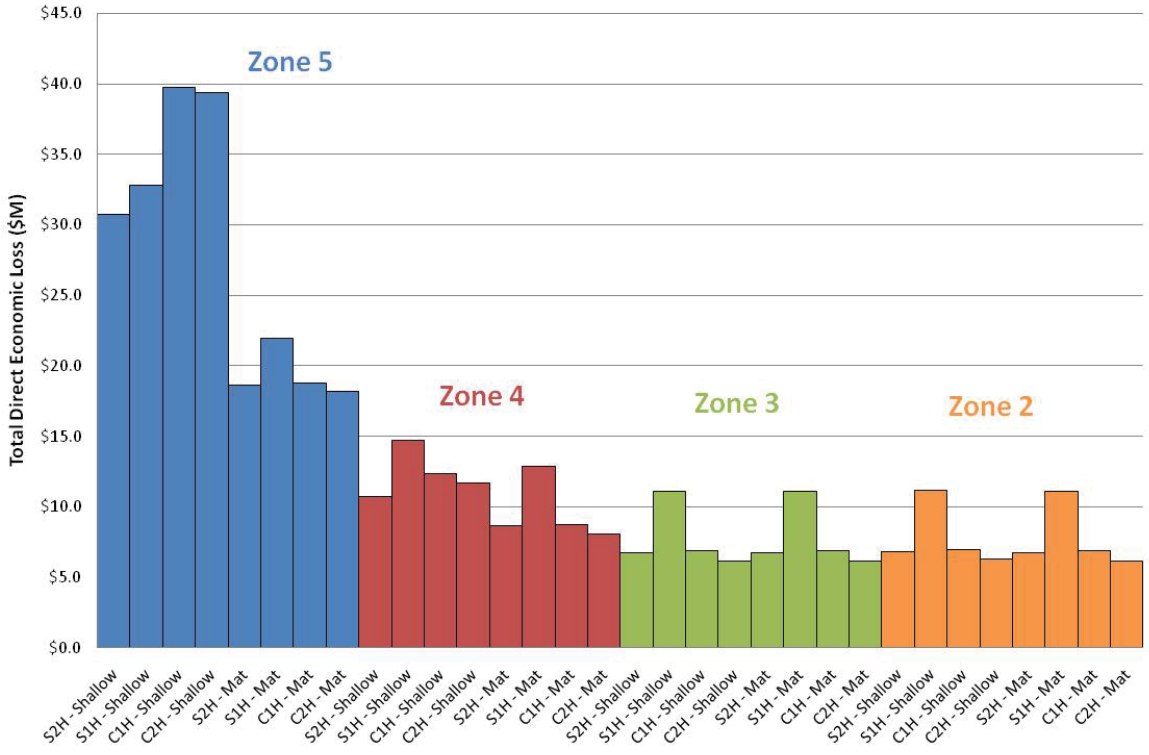


Figure 24: Total Day Casualties for Prototypical Building #6 (Large Offices) due to Shaking and Ground Failure in an IBC Design Level Earthquake

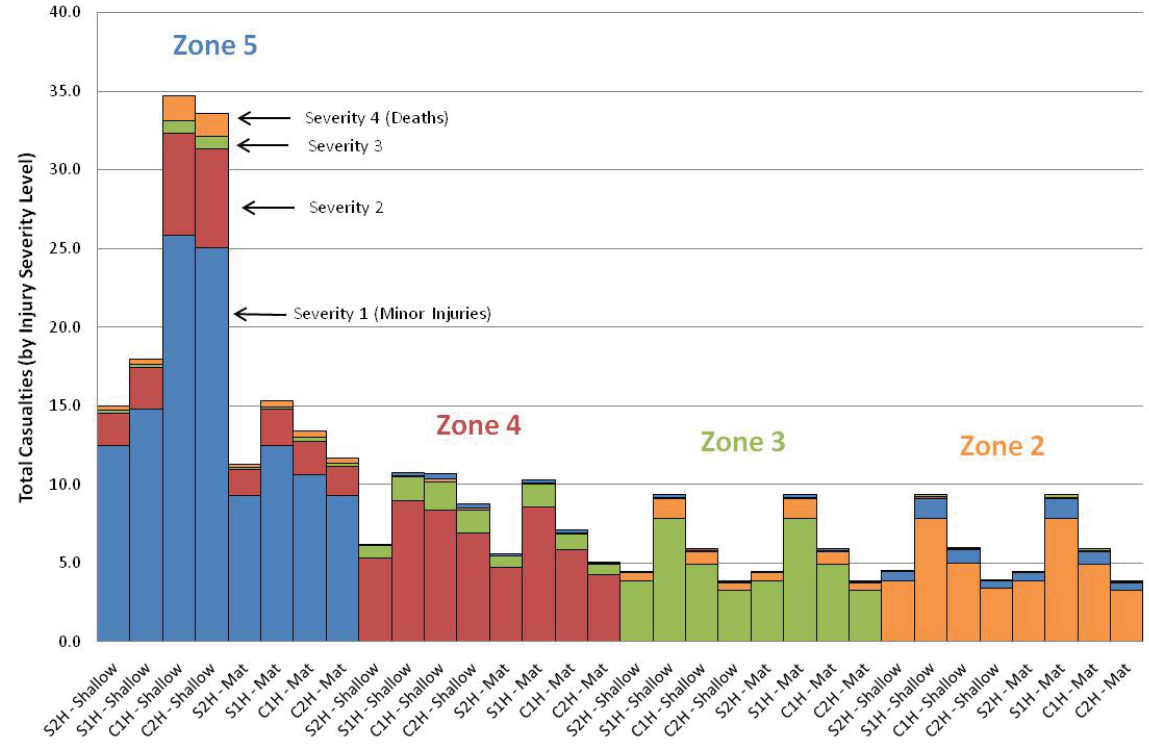


Figure 25: Total Direct Economic Loss for Prototypical Building #7 (Medium Hotel) due to Shaking and Ground Failure in an IBC Design Level Earthquake

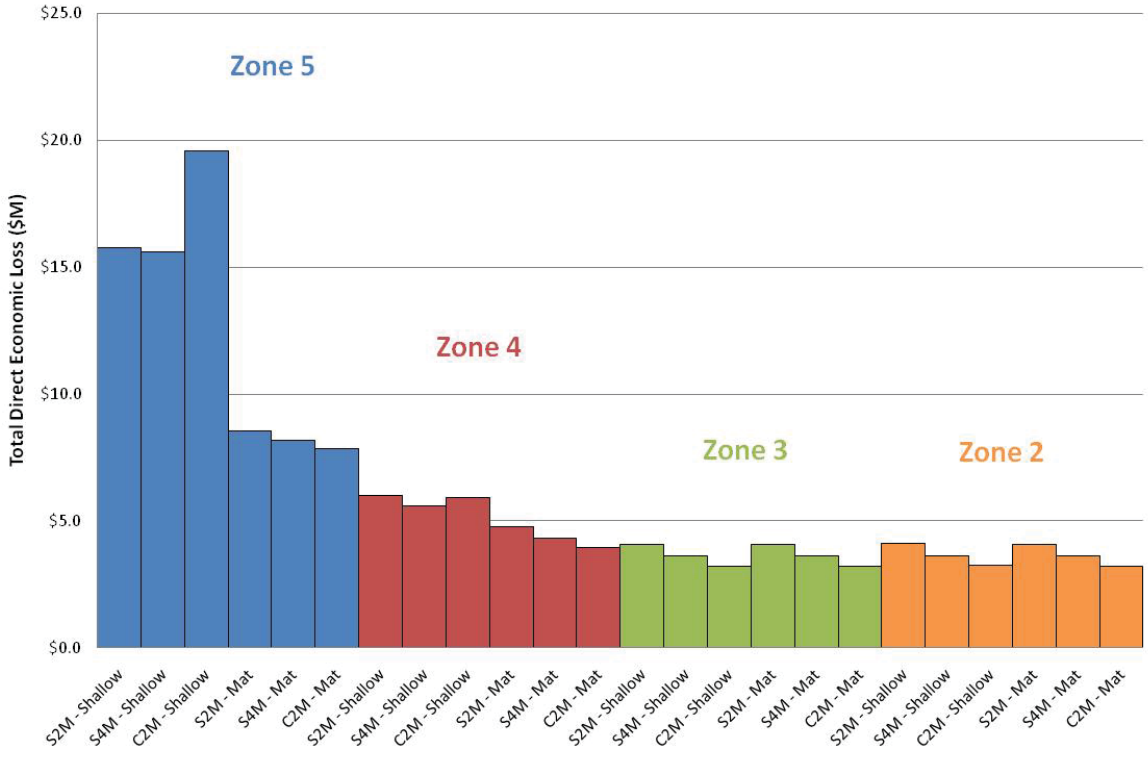
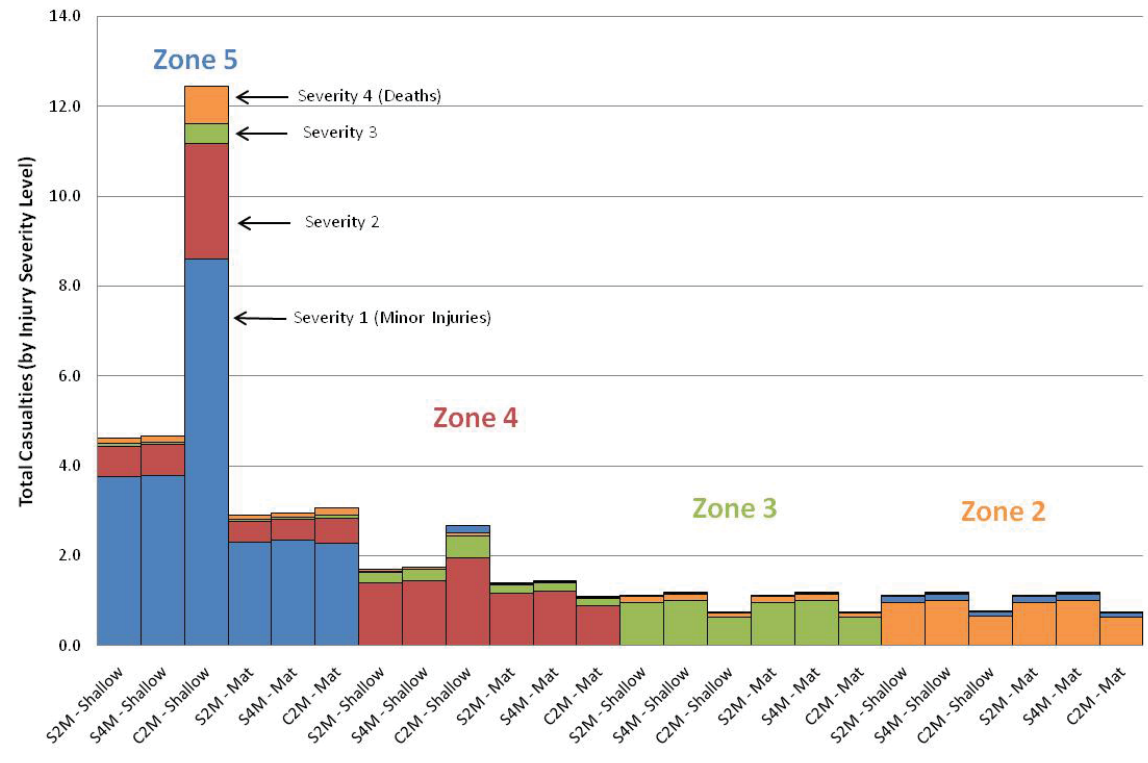


Figure 26: Total Night Casualties for Prototypical Building #7 (Medium Hotel) due to Shaking and Ground Failure in an IBC Design Level Earthquake



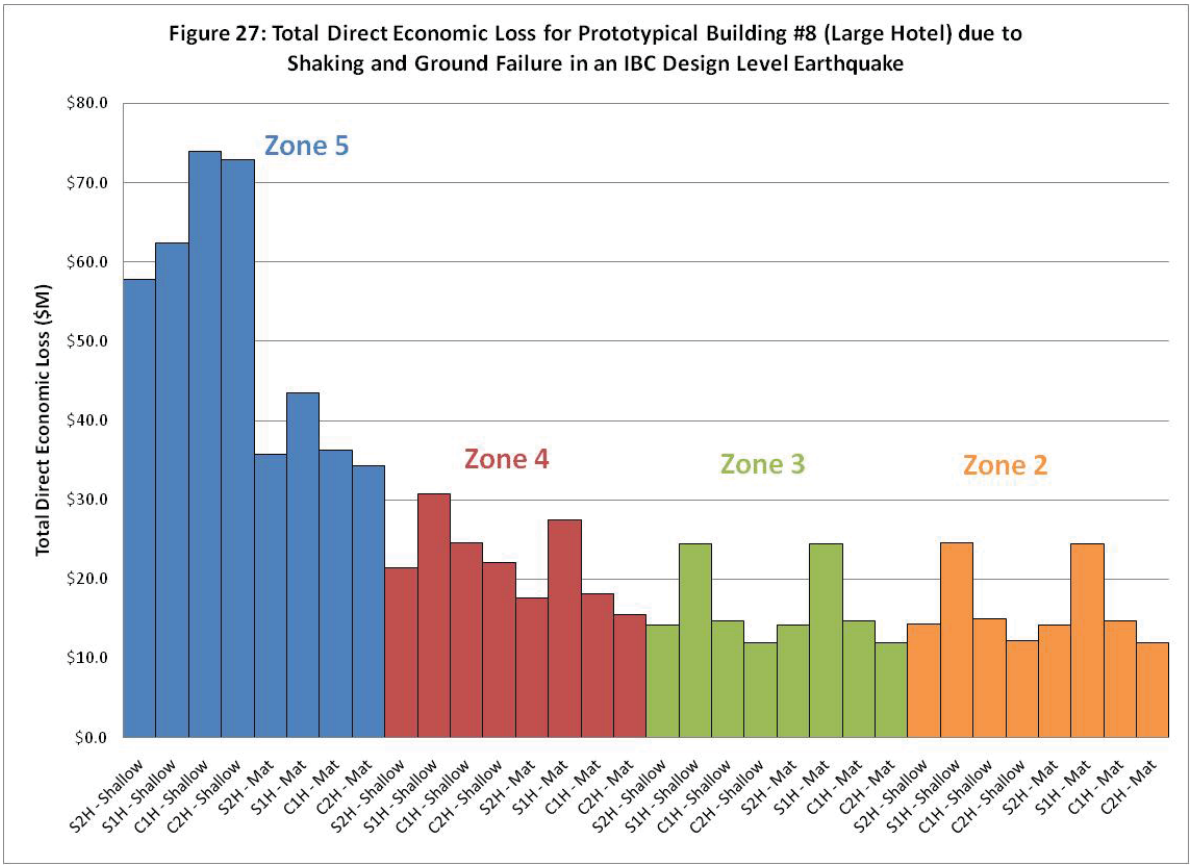


Figure 27: Total Direct Economic Loss for Prototypical Building #8 (Large Hotel) due to Shaking and Ground Failure in an IBC Design Level Earthquake

Figure 28: Total Day Casualties for Prototypical Building #8 (Large Hotel) due to Shaking and Ground Failure in an IBC Design Level Earthquake

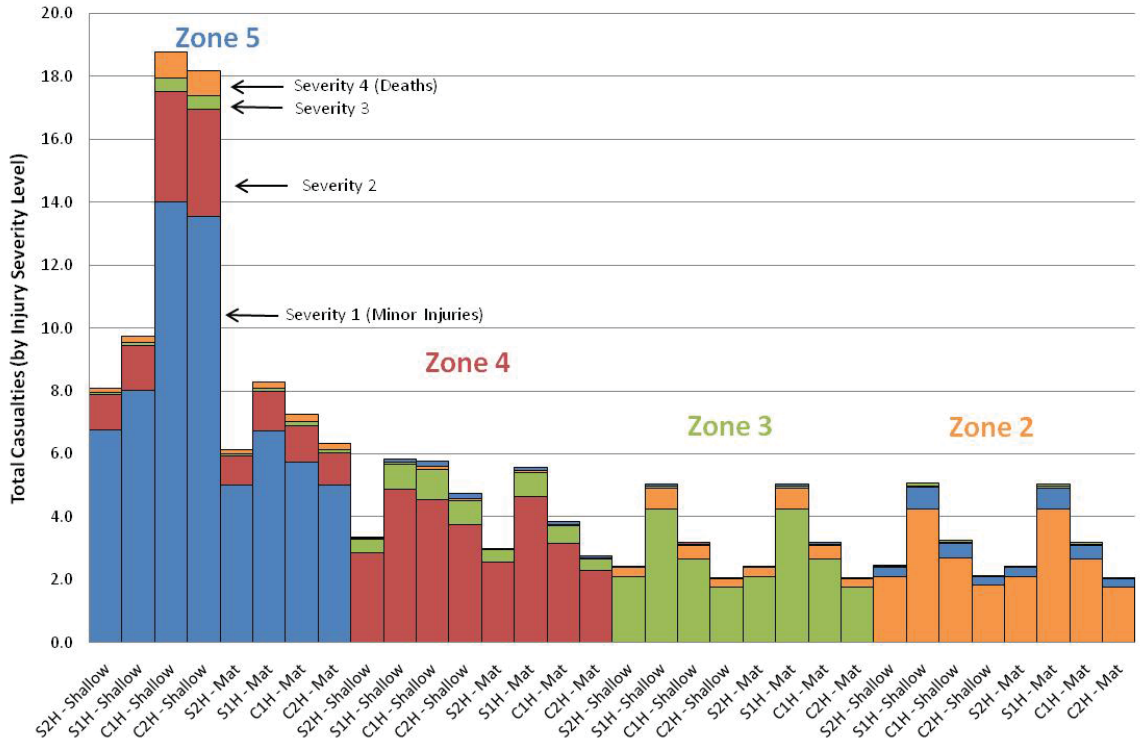
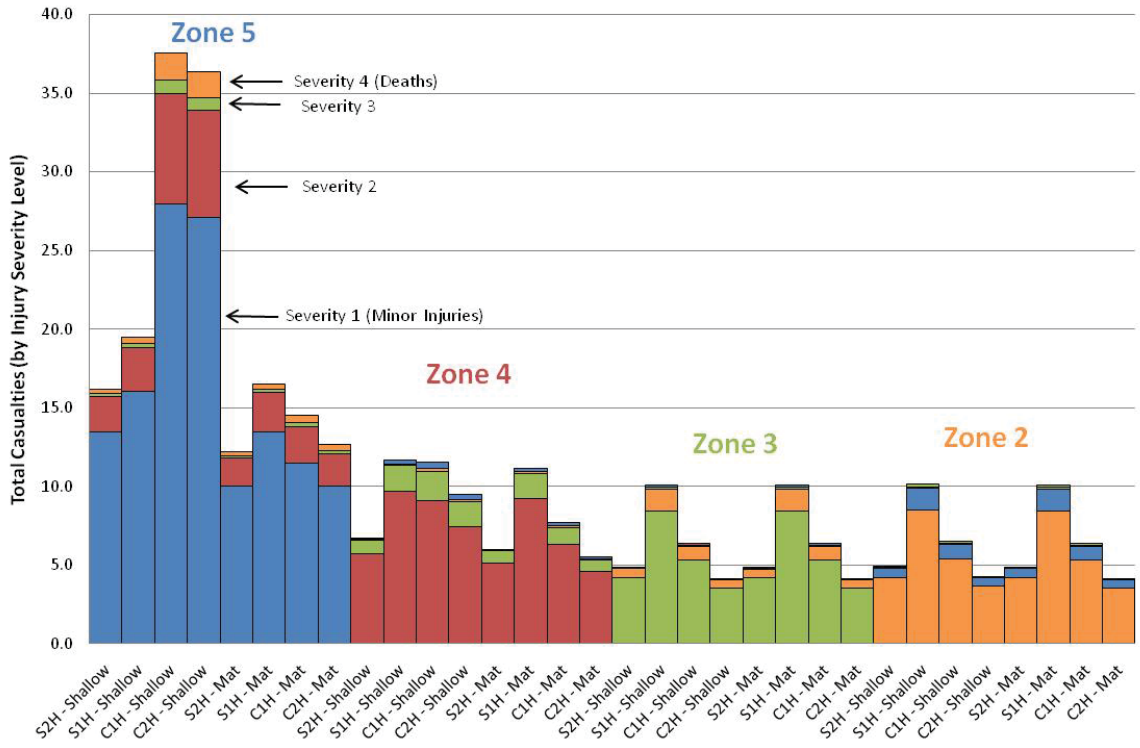


Figure 29: Total Night Casualties for Prototypical Building #8 (Large Hotel) due to Shaking and Ground Failure in an IBC Design Level Earthquake



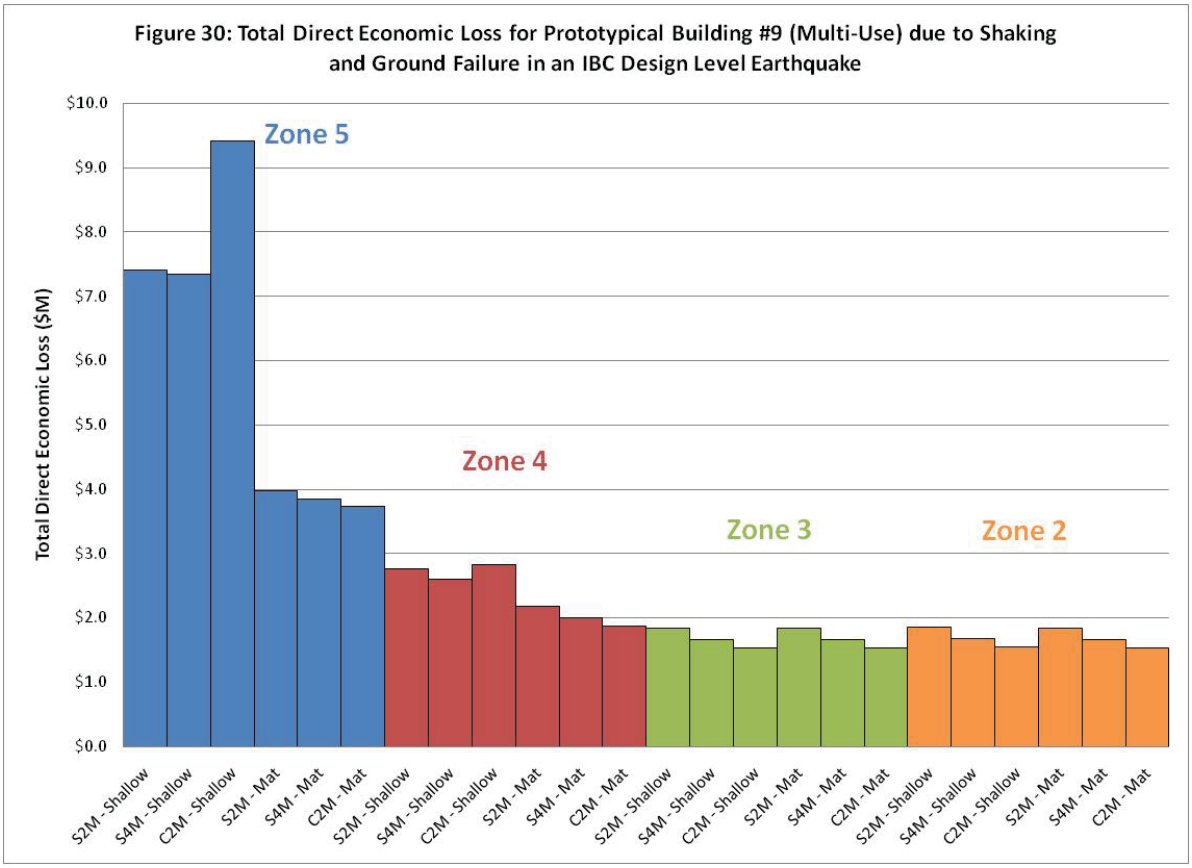


Figure 30: Total Direct Economic Loss for Prototypical Building #9 (Multi-Use) due to Shaking and Ground Failure in an IBC Design Level Earthquake
Total Direct Economic Loss ($M)
$10.0
$9.0
$8.0
$7.0
$6.0
$5.0
$4.0
$3.0
$2.0
$1.0
$0.0
Zone 5
Zone 4
Zone 3
Zone 2
S2M - Shallow
S4M - Shallow
C2M - Shallow
S2M - Mat
S4M - Mat
C2M - Mat
S2M - Shallow
S4M - Shallow
C2M - Shallow
S2M - Mat
S4M - Mat
C2M - Mat
S2M - Shallow
S4M - Shallow
C2M - Shallow
S2M - Mat
S4M - Mat
C2M - Mat
S2M - Shallow
S4M - Shallow
C2M - Shallow
S2M - Mat
S4M - Mat
C2M - Mat

Figure 31: Total Day Casualties for Prototypical Building #9 (Multi-Use) due to Shaking and Ground Failure in an IBC Design Level Earthquake

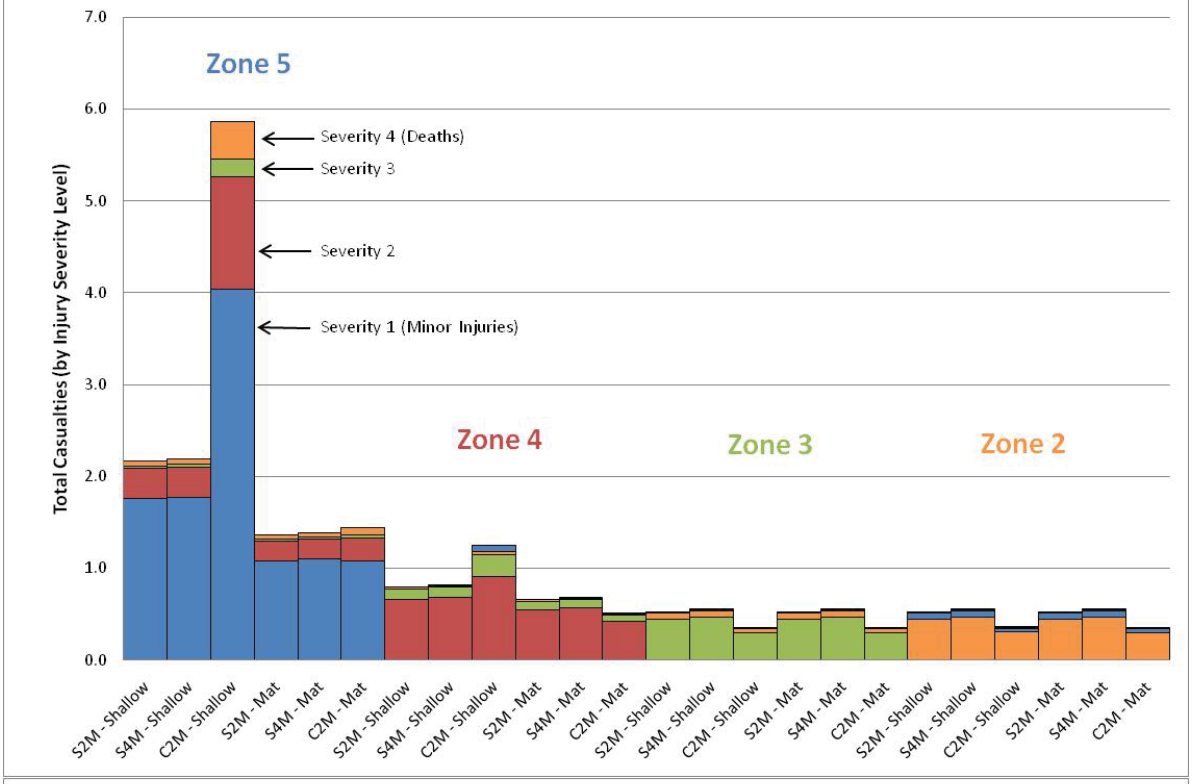


Figure 32: Total Night Casualties for Prototypical Building #9 (Multi-Use) due to Shaking and Ground Failure in an IBC Design Level Earthquake

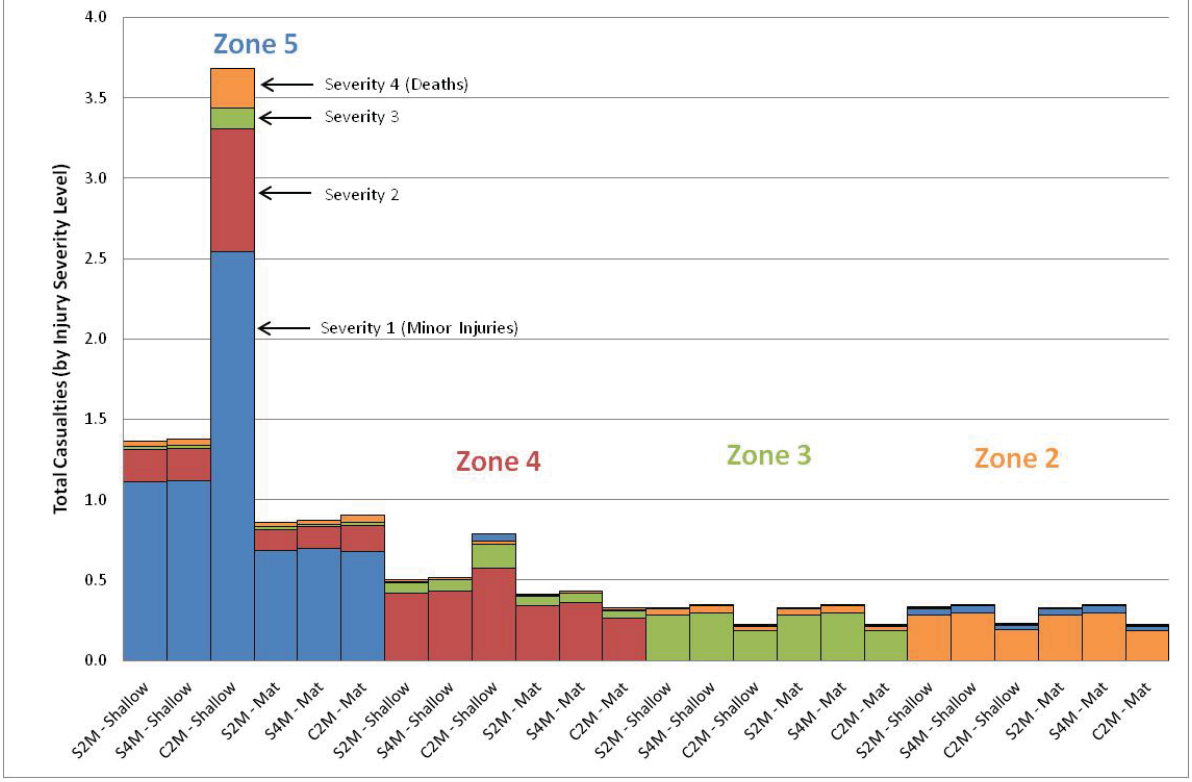


Figure 33: Total Direct Economic Loss for Prototypical Building #10 (Parking Structure) due to Shaking and Ground Failure in an IBC Design Level Earthquake

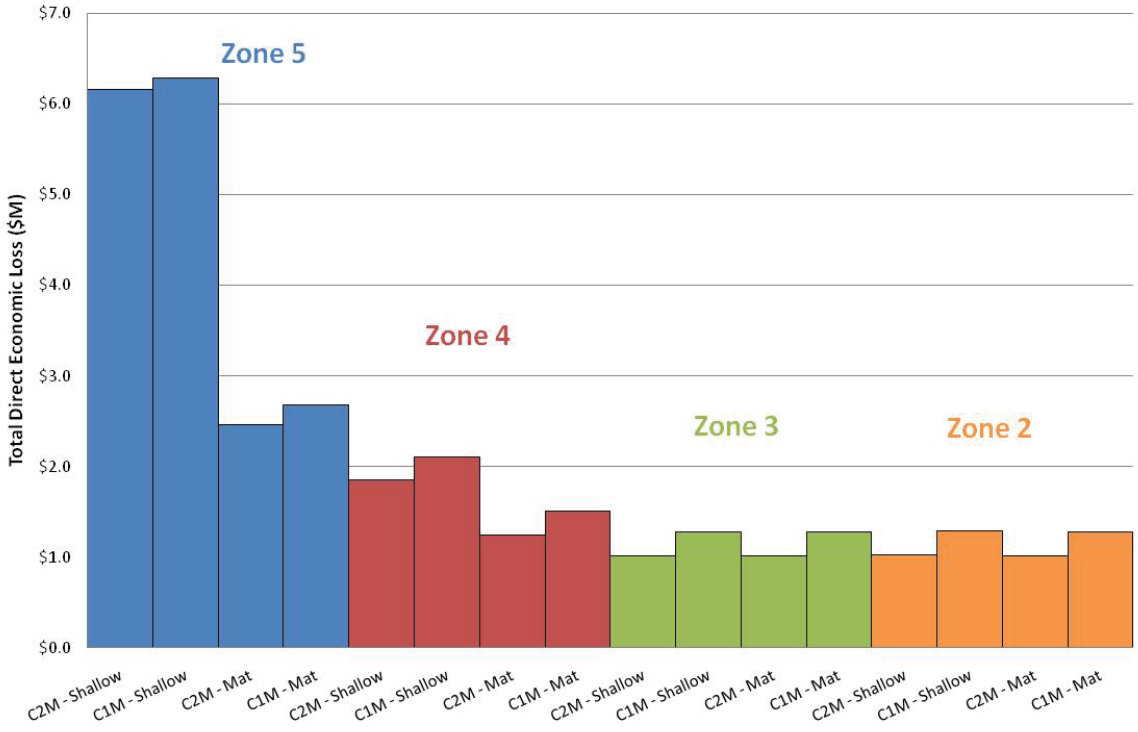


Figure 34: Total Day Casualties for Prototypical Building #10 (Parking Structure) due to Shaking and Ground Failure in an IBC Design Level Earthquake