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A METHODOLOGY FOR ESTIMATING EARTHQUAKE LOSSES FOR BUILDINGS IN URBAN AREAS

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ABSTRACT

The project described in this paper contained two objectives: first, to conduct a survey of the seismic hazards for 4,500 non-residential buildings in Portland, Oregon, and second, to develop an earthquake damage and loss estimation model for buildings to estimate the potential earthquake damage and loss for the surveyed buildings.

To conduct the buildings survey, ATC-21's Rapid Screening Procedure was used. The data contained: map section number, survey sequence number, tax lot parcel number, address, year built, area, use code, number of stories, building name, use, occupancy, estimated average number of people, special occupancy designation by the State Building Code, non-structural falling hazards, building type, and performance modifiers. The performance modifiers were: high rise, poor condition, vertical irregularity, soft story, torsion, plan irregularity, pounding, large heavy cladding, short columns, and post benchmark year. The modeling methodology incorporated ATC-21 data, and the effects of soil conditions utilizing the Earthquake Hazard Maps available from Department of Geology and Mineral Industries of the State of Oregon. These maps show soil susceptibility to amplification, lateral spread, and dynamic slope instability. Also, a procedure for estimating loss of life and serious injuries based on the results of the damage estimation model was developed.

The results are in terms of percent (or dollar) damage to buildings in the survey. The damage for an urban region may be compiled based on type of structure, age of building, number of stories, and a variety of other characteristics.

It is possible to obtain an assessment of damage due to earthquakes of various magnitude in an urban area, based on survey data on buildings and site characteristics. These results can provide guidance to planners, engineers, and insurers.

KEYWORDS

Building response; soil-structure interaction; liquefaction; ground motion; urban hazards; regional seismic hazards; amplification; seismic zonation; loss estimation.

PSHS: PORTLAND SEISMIC HAZARDS SURVEY

Portland State University's Department of Civil Engineering, funded by Metro, conducted a survey of the seismic hazards for 4,500 non-residential buildings in Portland. The area covered was the USGS Portland quadrangle, exclusive of the downtown core (the downtown core was inventoried by the Bureau of Buildings, City of Portland).

About a dozen civil engineering graduate and upper-division students were supervised by 2 faculty members in planning and executing the survey, utilizing ATC-21's Rapid Screening Procedure (RSP). The PSU team then created an inventory of the survey data on the database "ACCESS", wherein one data-line is used for each building. Each data-line contains the map section number, survey sequence number, tax lot parcel (R) number, address, year built, area, use code, number of stories, building name, use, occupancy, estimated average number of people, state special occupancy, non-structural falling hazards, RSP building type, and RSP performance modifiers. A sample of the database is included in Table 1.

The Building Type was recorded, and the Performance Modifiers were identified as either present (Y) or absent (blank).

EARTHQUAKE DAMAGE ESTIMATION METHODOLOGY

A second phase of this study included the development of an earthquake damage and loss estimation model for buildings, to be applied to the Portland Seismic Hazards Survey data, to estimate the potential earthquake damage and loss for Portland, Oregon. In this phase, the following models and procedures were developed:

a. A model to estimate the potential earthquake damage, from ATC-21 data.

b. A model to include the effect of the soil conditions in the damage estimate, utilizing the DOGAMI Earthquake Hazard Maps.

c. A procedure for estimating the Loss of Life and Serious Injuries, based on the results of the damage estimation model.

d. A procedure to apply these models to the Portland Seismic Hazards Survey fieldwork data on file at Metro.

Existing studies and data, shown below, were utilized:

* ATC-13: Earthquake Damage Evaluation Data for California.
* ATC-21: Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook.
* ATC-21-1: ATC-21 Supporting Documentation.
* Oregon DOGAMI Earthquake Hazard Maps for Portland.
* Portland Seismic Hazards Survey.

ATC-13: Earthquake Damage Evaluation Data for California

ATC-13 provides estimates of percent physical damage versus six levels of earthquake intensity (MMI from IV through XII) for 78 existing facility classes in California, including 36 building structure classes. The low and high estimates were defined to be the 90% probability bounds of the Damage Factor (DF) distribution, while the best estimate was defined as the DF most likely to be observed for a given MMI and facility class. Appendix G of ATC-13 summarizes the weighted means of the low, best, and high DF estimates for the 78 facility classes, subjected to each of six levels of input motion.

ATC-21: Rapid Visual Screening of Buildings for Seismic Hazards

ATC-21 presents a field survey methodology, based on visual observations, to identify the primary structural lateral load resisting system and significant seismic-related defects for each building, and a scoring system based on the field survey data, which relates to the probability of each building sustaining major life-threatening structural damage during a major earthquake.

The RSP begins by classifying the primary structural lateral load resisting system into one of 12 Building Types, shown in Table 2. Next, each of 11 Performance Modifiers (Table 3) are identified as present or absent in each building.

The scoring system begins by specifying a range of seismic intensities to which the surveyed buildings could be subjected. In ATC-21, seismic intensity is specified by the maximum Effective Peak Acceleration (EPA) likely to occur during the life of a building. The United States has been divided into 7 "NEHRP Map Areas," corresponding to estimated maximum EPA levels, which are condensed into 3 levels of "Seismicity," as shown in Table 4. A Basic Structural Hazard (BSH) score, ranging from 1 to 8.5, is assigned to each building, depending on the Building Type and the NEHRP Map Area as shown in Table 2. Next, each of the Performance Modifiers present in a building is assigned a Performance Modification Factor (PMF), see Table 5, dependent on the specific Performance Modifier, Building Type, and NEHRP Map Area. Most PMF's are "detractors", indicating a reduction in the seismic performance of a building, and are therefore negative.

Finally, each building is assigned a Structural Score (S), equal to the BSH score plus the sum of all the PMF values for the building, i.e., S = BSH + PMF.

Oregon DOGAMI Earthquake Hazard Maps

The Oregon Department of Geology and Mineral Industries has published an earthquake hazard map series, designated GMS-79, dated 1993. This series consists of 3 maps of the USGS Portland Quadrangle, as follows:

Plate 1: Soil Liquefaction Potential
Plate 2: Ground Motion Amplification
Plate 3: Lateral Spread Displacement & Dynamic Slope Instability

Each map plate is color-coded for gradations of the severity of each of the four types of geologic seismic hazards.

DAMAGE FACTOR MODEL

The objective was to establish a continuous transformation from Structural Score (S) to Damage Factor (DF), for a given building. ATC-21's Structural Score (S) has been developed from the Damage Factor (DF) established from ATC-13. The Structural Score (S) has been defined as the negative of the logarithm (base 10) of the probability of damage (DF) exceeding 60-percent of the building value for a specified NEHRP Effective Peak Acceleration (EPA) loading. Sixty percent damage was selected as the generally accepted threshold of major damage, roughly the point at which many structures are a "total loss," and the approximate lower bound at which there begins to be a significant potential for building collapse and significant life-safety threat.

ATC-21's development of S from DF was accomplished by treating ATC-13's DF as a random variable, and modeling it with a Beta probability distribution. The probability of the DF being greater than 60 percent was calculated from a polynomial approximation. MMI intensities were transformed to EPA values, and factors incorporated to extend the values to non-California buildings. Where several ATC-13 building types correspond to one in ATC-21, the results were averaged. Inconsistencies were smoothed and adjusted on the basis of judgment, and the final Structural Score (S) rounded to the nearest 0.5. The resulting Structural Score (S) was a measurement of the likelihood of major damage for a given building. What did not result from ATC-21 was a continuous, deterministic function, allowing retrieval of the DF from S. The development of the DF model for the present project is described elsewhere (Rad, McCormack, 1996) and due to space limitations it is not presented in this paper. The model describes a correlation between S and DF.

Soil Profile Effects Model

The Basic Structural Hazard Score (BSH) is modified by adding applicable Performance Modification Factors (PMF) to arrive at the final Structural Score (S). The PMF's modify the BSH to reflect deviations from "normal" structural practice or conditions. This provides a significant refinement in the Structural Score (S), since the BSH scores were determined for normal structural practice and conditions. The number and variety of potential PMF's for all building types is very large, many of which cannot be detected from the street on the basis of a rapid visual inspection. Therefore, ATC-21 limited the PMF's to having an especially severe impact on seismic performance, eliminating those that could not be readily observed from the street. The ten Performance Modifiers previously discussed were the result. The PMF values were assigned based on judgment, so that the resulting Structural Score (S) would approximately reflect the building performance. ATC-21 includes a Performance Modifier for Soil Profile, SL. This PMF, ranging from -0.3 to -0.8, reflects ground motion amplification based on the UBC and NEHRP classifications of "standard" soil profiles.

The Oregon DOGAMI Earthquake Hazard Maps provide maps of not only the amplification hazard for Portland, but also liquefaction, lateral spread, and seismic slope stability hazard. In an effort to utilize this additional geologic information for Portland, Soil Modification Factor (SMF) was developed to be used in lieu of the ATC-21 Soil Profile Factor, SL (Rad, McCormack, 1996).

The Soil Modification Factor (SMF) was designed as a Performance Modification Factor to be used in combination with the ATC-21 BSH score and other PMF's. The SMF is based on three modification factors: AF, Amplification Modification Factor; LF, Lateral Spread Modification Factor; and SF, Slope Modification Factor.

Loss of Life and Serious Injury

ATC-13 includes Table 9.3: Injury and Death Rates, which shows the Central Damage Factor (CDF) vs. Fraction Dead (FD), and CDF vs. range for a given "damage state." The Fraction Dead estimates were based on the consensus of the ATC-13 Project Engineering Panel, that can be approximated by the following equation:

$$FD = 5.94 * E\text{-}06 * \exp(.104*DF)$$

Since FD can be defined as the Loss of Life (LL) divided by the total Number of People (NP), the above equation to be transformed into an equation of LL. Furthermore, the serious injury rate is generally four times the death rate. Hence, equations for Loss of Life (LL) and Serious Injuries (SI) can be summarized as follows:

$$LL = NP * 5.94 * E\text{-}06 * \exp(.104*DF), \text{ and } SI = 4 * LL$$

In these equations, NP = the Number of People in the building, and DF = the Damage Factor, expressed as a percentage.

Results

Table 6 shows a spreadsheet of sample results for ten buildings. Columns A through Q describe items such as sections no., address, etc. Columns R through AA show modification factors, and AE through AP relate to GIS computations. The final results are Loss of Life (Col. AY), Serious Injury (Col. AZ), and Dollar Damage (Col. BA).

Conclusions

It is possible to obtain an assessment of damage due to earthquakes of various magnitude in an urban area, based on survey data on buildings and site characteristics. These results can provide guidance to planners, engineers, and insurers.

REFERENCES

ATC-21, Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook (1988). Applied Technology Council.

ATC-13, Earthquake Damage Evaluation Data for California (1985). Applied Technology Council.

ATC-21-1, Rapid Visual Screening of Buildings for Potential Seismic Hazards: Supporting Documentation (1988). Applied Technology Council.

Earthquake Hazard Maps for Portland (1993). Department of Geology and Mineral Industries, Portland, Oregon.

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TABLE 1. A SAMPLE FROM THE PORTLAND SEISMIC HAZARDS SURVEY

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16. 25									
Section	Seque		Year	Area	Use	No S	Building Name	Use	Occupancy	No Peopl	State Occ	NSFH	Str Ty	Mixed	HR	PC	VI	SS	T	PI	P	LH	SC	PB
1N1E25	01	R14	1914	11870	KE	1	[redacted]	[redacted]	Commercial	0-10		Y	C2						Y					
1N1E25	02	R14	1984	1500	KB	1	[redacted]	[redacted] Store	Commercial	11-30			RM						Y					
1N1E25	03	R14	1900	8103	UG	2	[redacted]	Church	Pub. Assem.	100-500	Special		W											
1N1E25	04	R14	1909	3643	KC	1	[redacted]	Commercial	Commercial	30-100		Y	C3/S5						Y					
1N1E25	05	R14	1906	4000	K	1	[redacted]	Commercial	Commercial	11-30		Y	C3/S5						Y					
1N1E25	06	R14	1927	13268	FA	2	[redacted]	Residential	Residential	30-100			URM	W						Y				
1N1E25	07	R14	1914	3208	KC	1	[redacted]	[redacted]	Commercial	0-10		Y	W						Y					
1N1E25	08	R14	1914	1334	KD	1		Vacant	Commercial	0-10		Y	W						Y					
1N1E25	09	R14	1981	6988	ME	2	[redacted]	Multi use	Commercial	11-30			RM						Y	Y				Y
1N1E25	10	R14	1982	7938	LD	2	[redacted]	Office, Whershous	Industrial	11-30			RM							Y				Y
1N1E25	11	R14	1947	7418	PC	1	[redacted]	Office, [redacted]	Office	30-100			W							Y				
1N1E25	12	R14	1948	10286	KE	1	[redacted]	Gym	Commercial	30-100		Y	W						Y					
1N1E25	13	R14	1908	1624	L	2	[redacted]	[redacted]	Office	0-10			W											
1N1E25	14	R22	1918	2006	LB	2		Vacant	Commercial	0-10		Y	W											
1N1E25	15	R22	1924	1904	L	2	[redacted]	Commercial	Residential	0-10			W											
1N1E25	16	R22	1925	9000	KE	1		Shops	Commercial	30-100			C2			Y			Y					
1N1E25	17	R22	1957	3600	Z	1	[redacted]	[redacted]	Commercial	11-30			S3	W					Y					
1N1E25	18	R22	1946	3600	KD	1	[redacted]	HomeFurnishings	Commercial	11-30			C2						Y					
1N1E25	19	R22	1982	3960	KD	1	[redacted]	[redacted]	Commercial	11-30			RM						Y					Y
1N1E25	20	R22	1923	884	K	1	[redacted]	[redacted]	Commercial	11-30		Y	RM						Y					
1N1E25	21	R10	1980	6392	KE	1	[redacted]	[redacted]	Commercial	0-10			RM							Y				Y
1N1E25	22	R10	1921	2467	K	2		Vacant	Commercial	0-10			W				Y							
1N1E25	23	R10	1910	2651	K	1	[redacted]	Office	Office	0-10			RM	W					Y					
1N1E25	24	R10	1956	8600	L	2	[redacted]	Office	Office	30-100			RM	W					Y	Y				
1N1E25	25	R10	1910	1656	KA	2	[redacted]	Commercial	Commercial	0-10		Y	W							Y				
1N1E25	26	R10	1987	1800	ZA	1	[redacted]	Car Repair	Commercial	11-30			W						Y					Y
1N1E25	27	R10	1979	10000	MH	1		Warehouse	Industrial	0-10			PC1											Y
1N1E25	28	R10	0	9000	MH	1	[redacted]	[redacted], Warehouse	Industrial	30-100		Y	C2	W										
1N1E25	29	R10	1910	4100	MH	1	[redacted]	[redacted]ustrial	Industrial	11-30	Hazardous		W						Y	Y				
1N1E25	30	R73	1918	25665	KD	3	[redacted]	[redacted]rating	Commercial	30-100		Y	S1						Y					
1N1E25	31	R73	1910	9676	KD	1	[redacted]	[redacted] Store	Commercial	30-100		Y	S1						Y					
1N1E25	32	R94	1986	5000	PC	1	[redacted]	[redacted] Offices	Commercial	11-30			W						Y	Y				Y
1N1E25	33	R94	1983	3192	UA	1	[redacted]	[redacted]ood	Commercial	30-100			W						Y					Y
1N1E25	34	R94	1971	32007	G	1	[redacted]	[redacted]ent	Industrial	100-500	Hazardous		RM	W			Y		Y	Y				
1N1E25	35	R35	1923	888	LA	1	[redacted]	[redacted]ment	Office	0-10			W											
1N1E25	36	R35	1927	1269	LA	1		[redacted] Office	Office	11-30			W							Y				
1N1E25	37	R35	1910	1684	K	2	[redacted]		Commercial	11-30			W											
1N1E25	38	R35	1945	3326	MH	1	[redacted]		Commercial	11-30			C2						Y					
1N1E25	39	R35	1943	4752	MH	1	[redacted]	[redacted]	Commercial	11-30			RM	W						Y				
1N1E25	40	R35	1935	1360	KD	1	[redacted]	[redacted]	Commercial	11-30			W						Y					
1N1E25	41	R35	1910	1855	LA	2	[redacted]	[redacted]	Commercial	0-10		Y	W											
1N1E25	42	R35	1912	1516	KA	2	[redacted]	[redacted]	Commercial	0-10		Y	W											
1N1E25	43	R35	1912	1560	K	2			Commercial	0-10			S4	W					Y	Y	Y			

Explanation of table columns:

1. Section number on the city map
2. Sequence number; specifies the sequence for field inspection
3. Tax code number and address of the building (omitted here)
4. Year built (from tax assessor's data)
5. Area in square feet
6. Use; based on the tax assessor's use code
7. Number of stories
8. Building name
9. Use; identifies the type of business
10. Occupancy; residential, commercial, ... etc.
11. No. of people, ranges specified: 0-10, 11-30, 30-100, 100-500, 500-5000, 5000+
12. State occupancy, if applicable: essential, hazardous, major, special
13. Non-structural falling hazard
14. Structure type, as defined in Table 2
15. Mixed construction

16-25 are the Performance Modifiers described in Table 3: HR, PC, VI, SS, T, PI, P, LH, SC, PB

TABLE 2. ATC-21 BUILDING TYPES & BASIC STRUCTURAL HAZARD SCORES (for low, moderate, and high seismicity)

BUILDING TYPE		LOW	MODERATE	HIGH
W	Wood frame	8.5	6.0	4.5
S1	Steel moment resisting frame	3.5	4.0	4.5
S2	Braced steel frame	2.5	3.0	3.0
S3	Light metal	6.5	6.0	5.5
S4	Steel frame with concrete shear walls	4.5	4.0	3.5
C1	Reinforced concrete moment resisting frame	4.0	3.0	2.0
C2	Reinforced concrete shear walls, no MRF	4.0	3.5	3.0
C3/S5	Concrete or steel frame buildings with URM infill walls	3.0	2.0	1.5
PC1	Tilt-up concrete buildings	3.5	3.5	2.0
PC2	Precast concrete frame	2.5	2.0	1.5
RM	Reinforced masonry	4.0	3.5	3.0
URM	Unreinforced masonry	2.5	2.0	1.0

TABLE 3.
ATC-21 PERFORMANCE MODIFIERS

HR	High Rise
PC	Poor condition
VI	Vertical irregularity
SS	Soft story
T	Torsion
PI	Plan irregularity
P	Pounding
LH	Large heavy cladding
SC	Short columns
PB	Post benchmark year
SI	Soil profile

TABLE 4. ATC-21 SEISMICITY

NEHRP Map Area	Seismicity	EPA	» MMI
1, 2	Low	.05, .05	VI
3, 4	Moderate	.10, .15	VII, VIII
5, 6, 7	High	.20, .30, .40	IX

TABLE 5. PERFORMANCE MODIFICATION FACTORS

BUILDING TYPE	HR	PC	VI	SS	T	PI	P	LH	SC	PB
W	n/a	-0.5	-0.5	-1.0	-1.0	-1.0	n/a	n/a	n/a	+2.0
S1	-1.0	-0.5	-0.5	-2.0	-2.0	-0.5	-0.5	-2.0	n/a	+2.0
S2	-0.5	-0.5	-0.5	-2.0	-1.0	-0.5	-0.5	n/a	n/a	+2.0
S3	n/a	-0.5	-0.5	-1.0	-1.0	-0.5	n/a	n/a	n/a	+2.0
S4	-1.0	-0.5	-1.0	-2.0	-1.0	-0.5	-0.5	n/a	n/a	+2.0
C1	-0.5	-0.5	-1.0	-2.0	-1.0	-0.5	-0.5	-1.0	-1.0	+2.0
C2	-1.0	-0.5	-0.5	-2.0	-1.0	-0.5	n/a	n/a	-1.0	+2.0
C3/S5	-1.0	-0.5	-1.0	-1.0	-1.0	-0.5	n/a	n/a	-1.0	n/a
PC1	n/a	-0.5	-1.0	-1.0	-1.0	-1.0	n/a	n/a	n/a	+2.0
PC2	0	-0.5	-1.0	-1.0	-1.0	-1.0	-0.5	-1.0	-1.0	+2.0
RM	-0.5	-0.5	-0.5	-2.0	-1.0	-1.0	n/a	n/a	n/a	+2.0
URM	-0.5	-0.5	-1.0	-1.0	-1.0	-1.0	n/a	n/a	n/a	n/a

TABLE 6. A SAMPLE COMPUTATION SPREADSHEET FROM THE DAMAGE ESTIMATION METHODOLOGY

	A	B	C	D	E	F	G	H
1	Tom M.	21-Mar-95	sectmp3f.wkz					
2	section	sequence	RNO	Address	yrbuilt	area	usecod	no
3	1N1E16	88.00	[redacted]	[redacted]	1965.00	3882.00	U	1.00
4	1N1E16	1.00	[redacted]	[redacted]	1958.00	1176.00	Z	1.00
5	1N1E16	2.00	[redacted]	[redacted]	1913.00	3840.00	J	2.00
6	1N1E16	3.00	[redacted]	[redacted]	1977.00	3904.00	P	1.00
7	1N1E16	4.00	[redacted]	[redacted]	1953.00	1920.00	K	1.00
8	1N1E16	5.00	[redacted]	[redacted]	1927.00	5482.00	K	1.00
9	1N1E16	6.00	[redacted]	[redacted]	1926.00	1324.00	K	1.00
10	1N1E16	7.00	[redacted]	[redacted]	1920.00	1396.00	K	1.00

	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1														
2	buildname	use	occupancy	nopeople	state	nsfh	strtyp	mixed	hr	pc	vl	ss	t	pl
3	[redacted]	[redacted]	Office	11-30		Y	W							Y
4	[redacted]	[redacted]	Commercia	0-10			RM						Y	Y
5	[redacted]	[redacted]	Commercia	11-30		Y	C2			Y				
6	[redacted]	[redacted]	Office	11-30		Y	W							Y
7	[redacted]	[redacted]	Commercia	0-10			RM			Y			Y	
8	[redacted]	[redacted]	Commercia	11-30		Y	C2						Y	
9	[redacted]	[redacted]	Commercia	0-10		Y	W						Y	Y
10	[redacted]	[redacted]	Commercia	0-10		Y	W			Y				

	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK
1															
2	p	rt	lh	sc	pb	confiden	commer	bs	hr2	pc2	vl2	ss2	t2	pl2	p2
3					Y			6.00	0.00	0.00	0.00	0.00	0.00	-1.00	0.00
4								3.50	0.00	0.00	0.00	0.00	-1.00	-1.00	0.00
5								3.50	0.00	-0.50	0.00	0.00	0.00	0.00	0.00
6					Y			6.00	0.00	0.00	0.00	0.00	0.00	-1.00	0.00
7								3.50	0.00	-0.50	0.00	0.00	-1.00	0.00	0.00
8								3.50	0.00	0.00	0.00	0.00	-1.00	0.00	0.00
9								6.00	0.00	0.00	0.00	0.00	-1.00	-1.00	0.00
10								6.00	0.00	-0.50	0.00	0.00	0.00	0.00	0.00

	AL	AM	AN	AO	AP	AQ	AR	AS	AT	AU	AV	AW
1												
2	lh2	sc2	pb2	constan	damage	finalscore	strscore	bldvalu		smf	ls	af
3	0.00	0.00	2.00	24.00	3.53	6.80	7.00	179100.00	0.00	0.20	0.00	0.20
4	0.00	0.00	0.00	30.00	27.27	1.10	1.50	38800.00	0.00	0.40	0.00	0.40
5	0.00	0.00	0.00	32.00	11.43	2.80	3.00	37000.00	0.00	0.20	0.00	0.20
6	0.00	0.00	2.00	24.00	3.53	6.80	7.00	129400.00	0.00	0.20	0.00	0.20
7	0.00	0.00	0.00	30.00	16.67	1.80	2.00	19800.00	0.00	0.20	0.00	0.20
8	0.00	0.00	0.00	32.00	13.91	2.30	2.50	93900.00	0.00	0.20	0.00	0.20
9	0.00	0.00	0.00	24.00	6.32	3.80	4.00	25800.00	0.00	0.20	0.00	0.20
10	0.00	0.00	0.00	24.00	4.53	5.30	5.50	26000.00	0.00	0.20	0.00	0.20

	AX	AY	AZ	BA	BB	BC	BD	BE	BF
1									
2	sf	ll	sl	$damage		grid-co	grid-co	bldarea(ass	midpoint
3	0.00	0.00017150	0.00068600	6322.23	0.00	0.00	2.00	3882.00	20
4	0.00	0.00050635	0.00202540	10580.76	0.00	0.00	3.00	1176.00	5
5	0.00	0.00039001	0.00156004	4229.10	0.00	0.00	2.00	3840.00	20
6	0.00	0.00017150	0.00068600	4567.82	0.00	0.00	2.00	3904.00	20
7	0.00	0.00016815	0.00067260	3300.66	0.00	0.00	2.00	1920.00	5
8	0.00	0.00050476	0.00201904	13061.49	0.00	0.00	2.00	5482.00	20
9	0.00	0.00005731	0.00022924	1630.56	0.00	0.00	2.00	1324.00	5
10	0.00	0.00004757	0.00019028	1177.80	0.00	0.00	2.00	1396.00	5