UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

REPORT ON RECOMMENDED LIST OF STRUCTURES FOR SEISMIC INSTRUMENTATION IN ALASKA

The U.S. Geological Survey Strong-Motion Instrumentation of Structures Advisory Committee for Alaska

(Report compiled by M. Çelebi)

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OUTLINE

I. INTRODUCTION

"Alaska, including the Aleutians, produces a greater number of earthquakes than the rest of the United States combined," writes Gedney [1]. Furthermore, Gedney cites relevant statistics: during 1979, 476 earthquakes with magnitudes greater than 3.0 occurred in Alaska as compared to 261 earthquakes in all of the other states combined, and that Alaska produces 20 times as much "earthquake energy" as all the states combined.

What better natural laboratory can be found than Alaska?

Alaska's largest city, Anchorage, is at the junction of a subduction zone and a strike-slip zone—Aleutian Trench, which contains the Shumagin and Unalaska Gaps (Subduction Area) and the normal north-south fault that contains the Yakataga Gap. The 1964 earthquake of magnitude 8.4 occurred at the Aleutian Trench.

Downtown Anchorage is founded on glacial debris with depth of 600-800 feet. As happened in the past, a future earthquake of sizeable magnitude is surely to affect the structures in Anchorage and all other towns in its vicinity. Therefore, along with free-field surface arrays that are in operation in all parts of Alaska, it is of utmost engineering importance to instrument some structures in Anchorage and other towns. The purpose of this instrumentation effort would be to obtain data from structures (within this unique geotechnical environment) during strong motion events so that research can be conducted on their performances.

It is important, however, that the instrumentation of structures be implemented under planned and programmed schemes. It is also important that the instrumentation effort be coordinated and maintained properly.

The aim of the USGS–Alaska Instrumentation of Structures Advisory Committee is to follow such a planned program using federal and state resources as available. This effort is also part of a national effort by the USGS to encourage instrumentation of selective structures in potentially seismically active regions requiring earthquake hazard mitigation programs.

The objectives of the advisory committee are to prepare the recommended list of structures to be instrumented within several centers in the State of Alaska and to provide guidance on background information necessary to design and implement instrumentation schemes.

II. THE STATUS OF STRUCTURAL INSTRUMENTATION PROGRAMS OF THE USGS

The main objective of any instrumentation program for structural systems is to improve the understanding of the behavior, and potential for damage, of structures under seismic loading. The acquisition of structural response data during earthquakes is essential to confirm and develop methodologies used for analysis and design of earthquake-resistant structural systems. This objective can best be realized by selectively instrumenting structural systems to acquire strong motion data, and the response of structural systems (buildings, components, lifeline structures, etc.) to the strong ground motion. As a long-term result one may expect design and construction practices to be modified to minimize future earthquake damage [2].

Various codes in effect in the United States, whether nationwide or local, recommend different quantities and schemes of instrumentation. The Uniform Building Code (UBC) [3] recommends for Seismic Zones 3 and 4 a minimum of three accelerographs be placed in every building over six stories in height with an aggregate floor area of 60,000 feet or more and in every building over 10 stories in height regardless of floor area. The City of Los Angeles adopted this recommendation in 1966 but in 1983 revised this recommendation to require a single accelerograph to be placed at the top of the building meeting the above criteria. Previous experiences show that the instrumentation guidelines given by the UBC code, for example, although providing sufficient data for the limited analyses projected at the time, do not provide sufficient data to perform the model verifications and structural analyses now demanded by the profession.

On the other hand, valuable lessons have been derived from the study of the data obtained from a well-instrumented structure, the Imperial County Services Building, during the moderate-sized Imperial Valley earthquake ($M_s = 6.5$) of October 15, 1979 [4].

To reiterate, it is expected that a well-instrumented structure for which a complete set of recordings has been obtained would provide useful information to:

- check the appropriateness of the design dynamic model (both lumped mass and finite element) in the elastic range;
- determine the importance of non-linear behavior on the overall and local response of the structure;
- follow the spreading of the non-linear behavior throughout the structure as the response increases and the effect of the non-linear behavior on frequency and damping;
- correlate the damage with inelastic behavior;
- determine ground motion parameters that correlate well with building response damage; and
- make recommendations to improve seismic codes.

To enhance the effort in instrumentation of structures, the USGS recently established an advisory committee program. The advisory committees are regional committees comprised of professionals from universities, state, federal, and local government agencies, and private companies. The advisory committees are formed in regions of seismic activity and are requested to develop recommended lists of structures for possible instrumentation. The first of these committees was formed in the San Francisco Bay Region [2]. The second committee was formed in San Bernardino County [5]. Other committes including this committee in Alaska followed. Reports of the committees of Charleston, South Carolina and the New Madrid region have recently been issued [6,7].

A general description of the targeted regions for structural instrumentation is shown in the map in Figure 1. Whether committees are formed in these targeted regions and reports were issued by the committees is indicated in Figure 2.

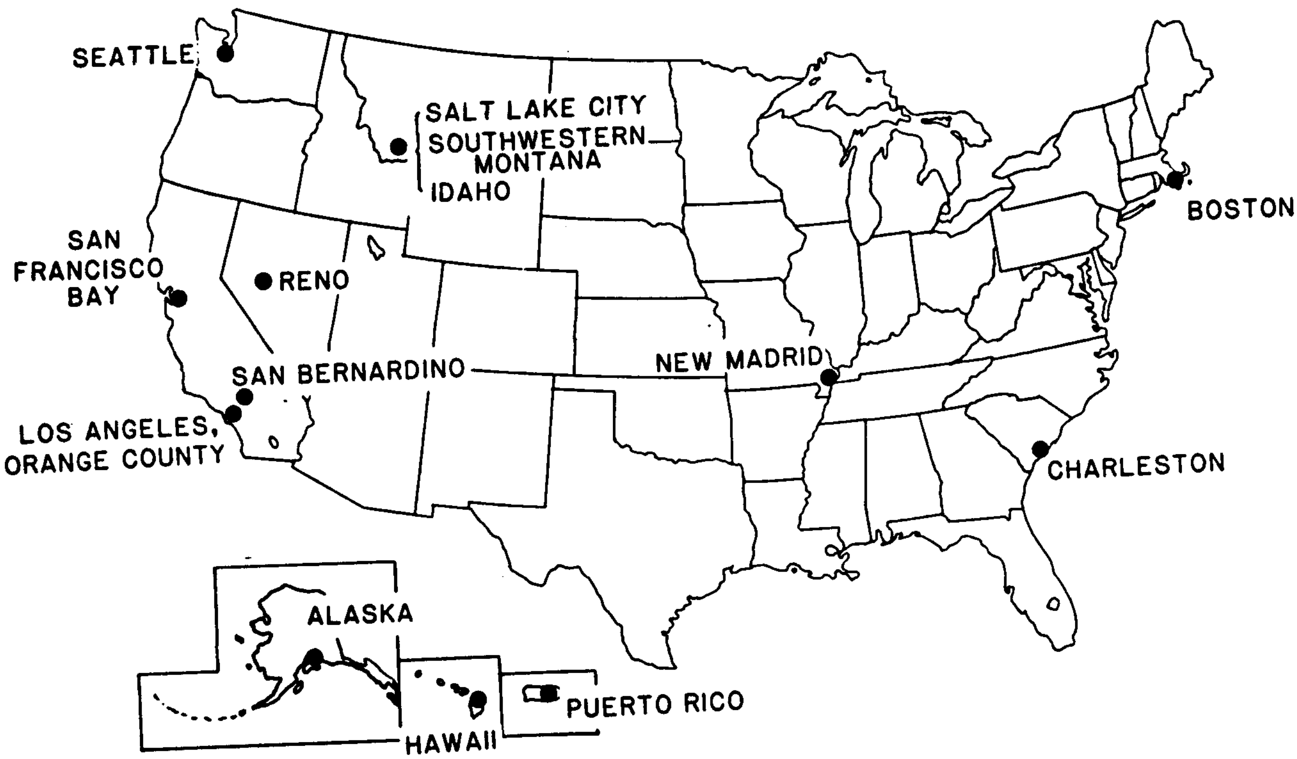

Figure 1. Targeted seismic regions for instrumentation of structures program.

Advisory Committees for Structural Instrumentation

Regions Considered	Committee Formed	Report Completed
San Francisco Area	●	●
San Bernardino	●	●
Los Angeles	●	●
Orange County	●	
Charleston, SC (Southeast)	●	●
Boston, MA (Northeast)	●	
New Madrid	●	●
Seattle, WA (Northwest)	●	
Utah, Idaho, SW Montana (Mountain Region)		
Alaska	●	●
Reno		
Hawaii	●	
Puerto Rico	●	

Figure 2. Current status of Advisory Committees.

III. SEISMICITY, SEISMIC GAPS AND EARTHQUAKE POTENTIAL IN ALASKA

A detailed review of the subject has been made by Davies [8]. To provide this information to the reader, it is included in Appendix A.

IV. METHODOLOGY FOR RANKING STRUCTURES

The ranking of structures in Alaska was realized by looking into several factors and parameters, grouped under one of the two methods shown below:

$$\text{RANK (A)}_{(\text{structures})} = P_{(\text{data})} \times P_{(\text{use})} \times P_{(\text{care})} \times 100$$

or

$$\text{RANK (B)}_{(\text{structures})} = \left[P_{(\text{data})} + P_{(\text{use})} + P_{(\text{care})} + \right] \frac{100}{3}$$

where $0 \leq P_i \leq 1$ and,

$P_{(\text{data})}$ = probability that instruments will be triggered.

$P_{(\text{use})}$ = probability that the data obtained will be useful.

$P_{(\text{care})}$ = probability that results will be useful (*i.e.*, how interested are we in the particular structure?).

and, therefore,

$$0 \leq \text{RANK} \leq 100 .$$

$P_{(data)}$ Coefficient:

This coefficient is to be determined by the relationship:

$$P_{(data)} = A_b \times S(T)$$

where

A_b = bedrock acceleration expected in 50 years with a 90% confidence level (expressed as velocity-related acceleration coefficient). The values of A_b are to be taken from Figure 3 (adopted from ATC–3–06 , Figure C1–6)[9]. Therefore, we have:

$$0 \leq A_b \leq 0.4$$

and

$S(T)$ = site amplification factor at the period of interest.

For $S(T)$, Figure 4 is adopted from Figure C1–9 of ATC–3–06[9]. Accordingly, the three curves in Figure 4 represent the following soil conditions:

Soil Profile type S_1: Rock of any characteristic, either shale-like or crystalline in nature (such material may be characterized by a shear-wave velocity greater than 2500 feet per second); or stiff soil conditions where the soil depth is less than 200 feet and the soil types overlying rock are stable deposits of sands, gravels, or stiffer clays.

Soil Profile Type S_2: Deep cohesionless or stiff clay soil conditions, including sites where the soil depth exceeds 200 feet and the soil types overlying rock are stable deposits of sands, gravels, or stiff clays.

Soil Profile Type S_3: Soft-to-medium stiff clays and sands, characterized by 30 feet or more of soft- to medium-stiff clay with or without intervening layers of sand or other cohesionless soils.

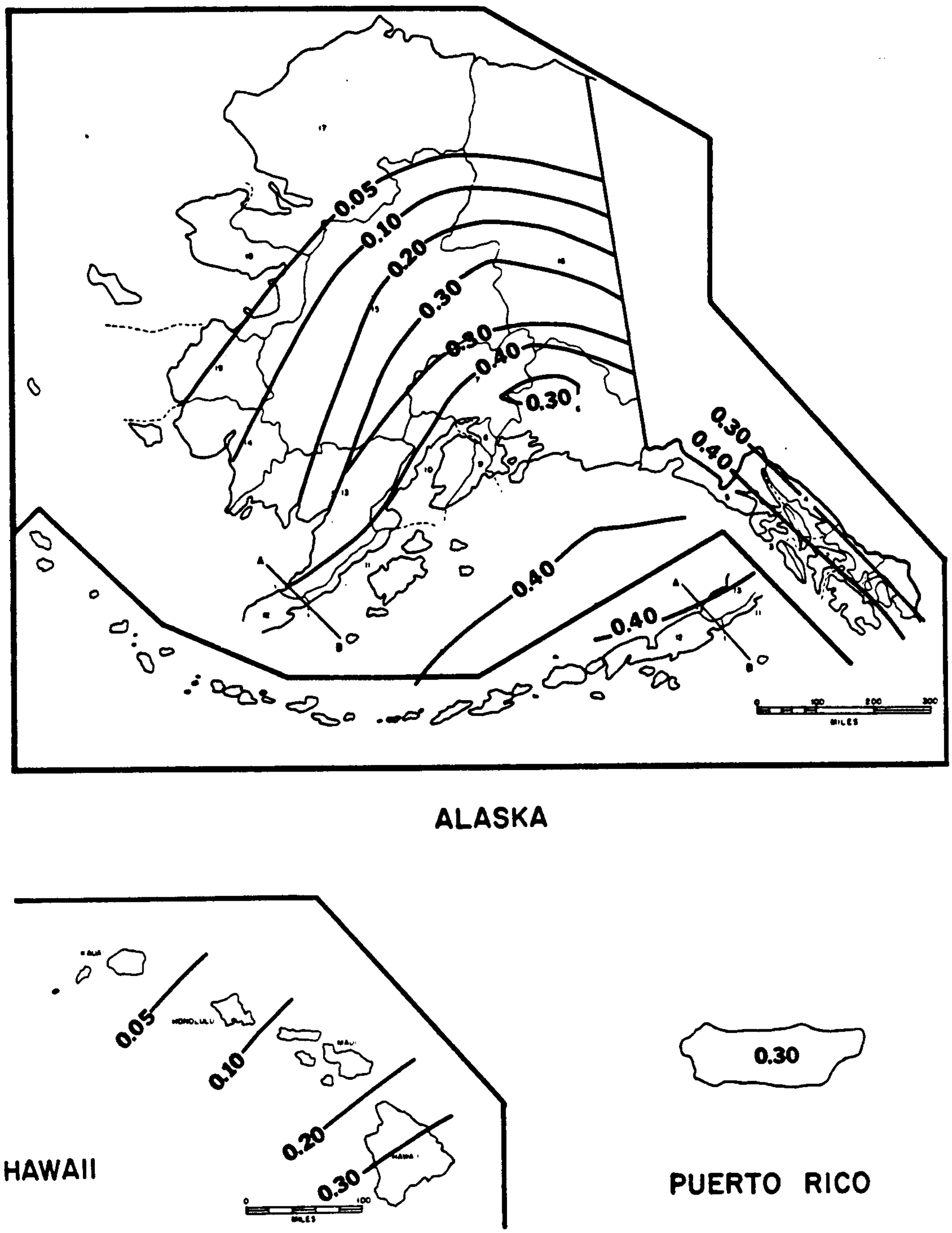

Figure 3. Contour map for effective peak velocity related acceleration coefficient, A_b [adopted from Figure C1–9 (ATC–3–06)].

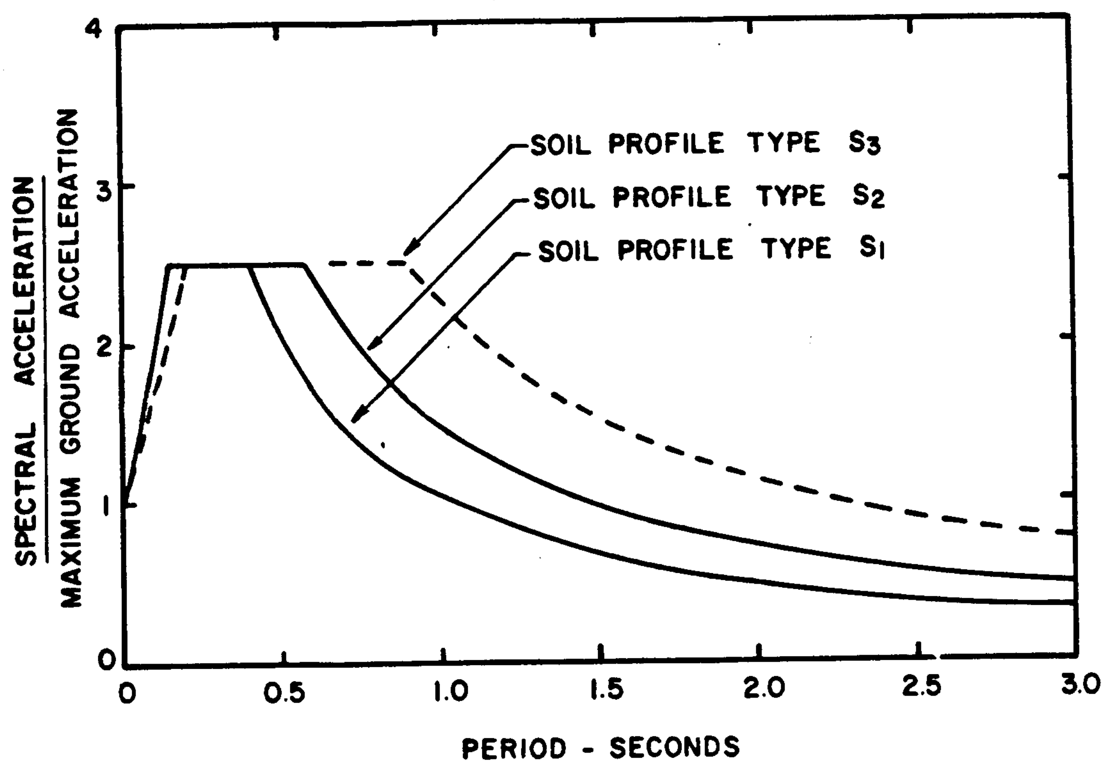

Figure 4. Normalized response spectra recommended for use in building code [adopted from Figure C1–9 (ATC–3–06)].

Therefore, as seen in Figure 4,

$$0.5 \leq S(T) \leq 2.5$$

The period, T, of the structure for use in determining $S(T)$ is estimated by using the well-known approximate formula [3]:

$$T = 0.1\ N$$

where

N = number of stories of the structure.

As a result,

$$0 \leq P_{(\text{data})} \leq 1.0$$

<u>$P_{(\text{use})}$ Coefficient:</u>

This coefficient is to be determined by the relationship:

$$P_{(\text{use})} = (U_1 + U_2 + U_3)/3$$

where

U_1 = factor related to quality of documentation of structure.

U_2 = factor related to extent to which structural response is calculable (analytical techniques, regular shape, etc.).

U_3 = factor related to accessibility to structure or chance of obtaining instrumentation permit from the owner.

The factors are to have the values ranging

$$0 \leq U_i \leq 1.0$$

and, therefore,

$$0 \leq P_{(\text{use})} \leq 1.0$$

$P_{(\text{care})}$ Coefficient:

This coefficient is to be determined by the relationship:

$$P_{(\text{care})} = (C_1 + C_2 + C_3 + C_4)/4$$

where

C_1 = structural type factor

C_2 = structural importance factor

C_3 = factor related to materials of construction

C_4 = factor related to significance of soil-structure interaction or having analysis incorporating soil-structure interaction.

In general, these factors will have values ranging

$$0 \leq C_i \leq 1.0$$

.

However, for the C_2 factor, if special circumstances are present, the factor could be taken up to 2.0 (*e.g.,* if the structure is a base-isolated structure).

V. DIFFERENT REGIONS CONSIDERED

During the evaluation of structures, the regions considered in Alaska are:

1. Anchorage
2. Outside Anchorage
   a. Valdez

b. Homer

c. Seward

d. Kenai

e. Soldatna

f. Kodiak

g. Fairbanks

From each of these areas several structures are identified.

VI. RECOMMENDED LIST OF STRUCTURES

The structures identified in Alaska are subjected to the criteria developed in Section IV. Results are provided in Appendix B Table B–1 (Anchorage) and Table B–2 (Outside Anchorage), respectively. In both Tables B1–d and B2–d, the ranking is shown for both methods adopted in Section IV.

For an initial implementation strategy, the top ranking ten structures in Anchorage are provided in Table 1. As seen in Table 1, there was not much difference in the conclusive ranking with either method A or B adopted in Section IV.

TABLE 1
TOP-RANKED STRUCTURES (ANCHORAGE)

	Method (A or B)	
Structure	RANK (A)	RANK(B)
Aleut Office Complex	56.1	82.8
Humana Hospital	53.5	82.1
Sullivan Sports Arena	49.7	79.3
Library	45.7	77.6
6th & G Street Garage	45.4	77.6
Arco Building	34.8	76.5
Federal Building	35.3	70.7
A&S Off-Loading Bridge	36.4	72.0
Historic Arts Building	34.0	69.8
Sohio Building	32.3	71.8

V. CONCLUSIONS

This report represents the efforts of the USGS–Alaska advisory committee for strong-motion instrumentation of structures. The committee worked over a period exceeding two years and compiled the list of structures and developed the criteria for ranking them. The committee does not claim that the list or the areas covered within Alaska is by any means complete. However, the recommendations are a beginning and it is hoped that in the future other structures in the Alaska that were not covered in this report can also be considered as funds become available.

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APPENDIX A

SEISMICITY, SEISMIC GAPS AND EARTHQUAKE POTENTIAL IN ALASKA

The following material is reprinted from:

Davies, J., 1986, Seismicity, seismic gaps and earthquake potential in Alaska, in *PROCEEDING Conference XXXI- Workshop on Evaluation of Regional and Urban Earthquake Hazards and Risk in Alaska,* edited by W. Hays and P. Gori, *U.S. Geol. Surv. Open-File Rep.* **85-79**.

SEISMICITY, SEISMIC GAPS AND EARTHQUAKE POTENTIAL IN ALASKA

By

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EARTHQUAKE OCCURRENCE IN ALASKA

Approximately 11 percent of the world's earthquakes occur in Alaska. Even considering that the land area of Alaska is only about three-tenths of one percent of the surface area of the world, this figure still understates the level of earthquake activity in Alaska during the past 80 years. It is only when the energy released by Alaskan earthquakes in this period is taken into account that a proper perspective is gained.

The ten largest earthquakes in the world since 1904 are listed in Table 1. Of these, three occurred in Alaska: the Good Friday earthquake of 1964 (M_w = 9.2, rank no. 2), the Andreanof-Fox Islands earthquake of 1957 (M_w = 9.1, rank no. 3), and the Rat Islands earthquake of 1965 (M_w = 8.7, rank no. 6). Three out of ten gives the right impression of the ratio of energy released in Alaska compared to the whole world for the period 1904-1984.

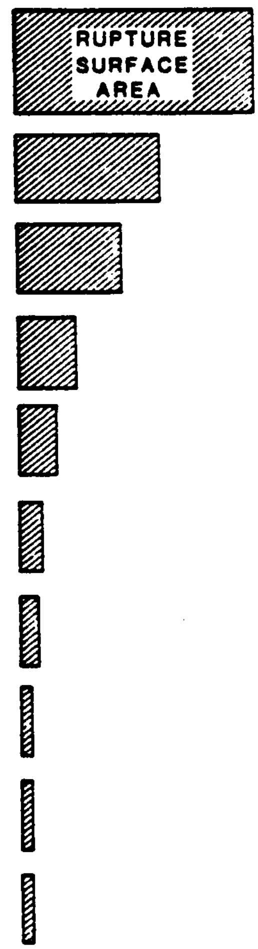
Table 1 is based on one compiled by Hiroo Kanamori which gives the energy released by each earthquake larger than M_w = 8.0 since 1904 for the world. In this list Alaskan earthquakes contribute 30 percent of the total energy. It appears during the past 80 years that Alaska has had a few really large earthquakes and that the rate of occurrence of medium-sized shocks is more normal. If one assumes that Alaska has 30 percent of the energy released by quakes larger than M_w = 8.0, but only 11 percent of that released by smaller quakes, then the energy released by earthquakes in Alaska since 1904 would be about 25 percent of the total for the world.

A Comparison with California

California is regarded by many as the archetype of "earthquake country" (Iacopi, 1971). California is indeed earthquake country, cut by the San

Table 1. The World's Ten Largest Earthquakes 1904 - 1984

No.	Location	Year	M_W	Energy*
1.	CHILE	1960	9.5	2000
2.	ALASKA	1964	9.2	820
3.	ALASKA	1957	9.1	585
4.	KAMCHATKA	1952	9.0	350
5.	ECUADOR	1906	8.8	204
6.	ALASKA	1965	8.7	125
7.	ASSAM	1950	8.6	100
8.	BANDA SEA	1938	8.5	70
9.	CHILE	1922	8.5	69
10.	KURILES	1963	8.5	67



*Energy in dyne-cm x 10^{27}
Source: Based on data from Kanamori[1]

Andreas fault system and many other faults; it has been the site of several historical great earthquakes. Most famous among these was the 1906 M_w = 7.8 earthquake which devastated San Francisco. All of the recent damaging earthquakes in California such as the San Fernando, Coalinga, and Morgan Hill events, were rated about 6.5 on the Richter scale.

One can compare this activity in California to that in Alaska by considering the histogram shown in Figure 1. This histogram shows the number of earthquakes larger than magnitude 5.5 in each of the years from 1976 through 1980 for both Alaska and California. It is easy to see from this comparison that Alaska also deserves to be called earthquake country. In Alaska, however, most of these large earthquakes occur in remote, sparsely populated regions so that many events with magnitudes in the 5 to 7 range cause little if any damage and go almost unnoticed.

MAJOR EARTHQUAKE ZONES IN ALASKA

The Alaska-Aleutian Subduction Zone

The vast majority of the large earthquakes in Alaska occur along the Aleutian Islands, the Alaska Peninsula, and the Kenai Peninsula. Almost three-quarters of the events shown on the map in Figure 2 fall in this region. Plotted on this map are the epicenters of all of the earthquakes larger than M_w = 7.2 for the period from 1897 through 1980, a total of 35 events (in fact, no events of $M_w \geq 7.2$ have occurred in Alaska since 1980). All three of the great Alaskan earthquakes listed in Table 1 occurred in this region.

The belt of earthquakes and volcanoes stretching from the western Aleutians to the Kenai Peninsula is known as the Alaska-Aleutian subduction zone. The great earthquakes here result from episodic slipping along the shallow contact zone between the Pacific and North American plates or the Pacific plate is thrust beneath the Alaskan portion of the North American plate. These earthquakes typically cause very strong shaking which lasts several minutes; significant, permanent uplift or subsidence over very large area; very large seismic sea waves or tsunamis which cause damage at great distances across the Pacific; extremely high wave run-up of a few to more than 30 m locally; and

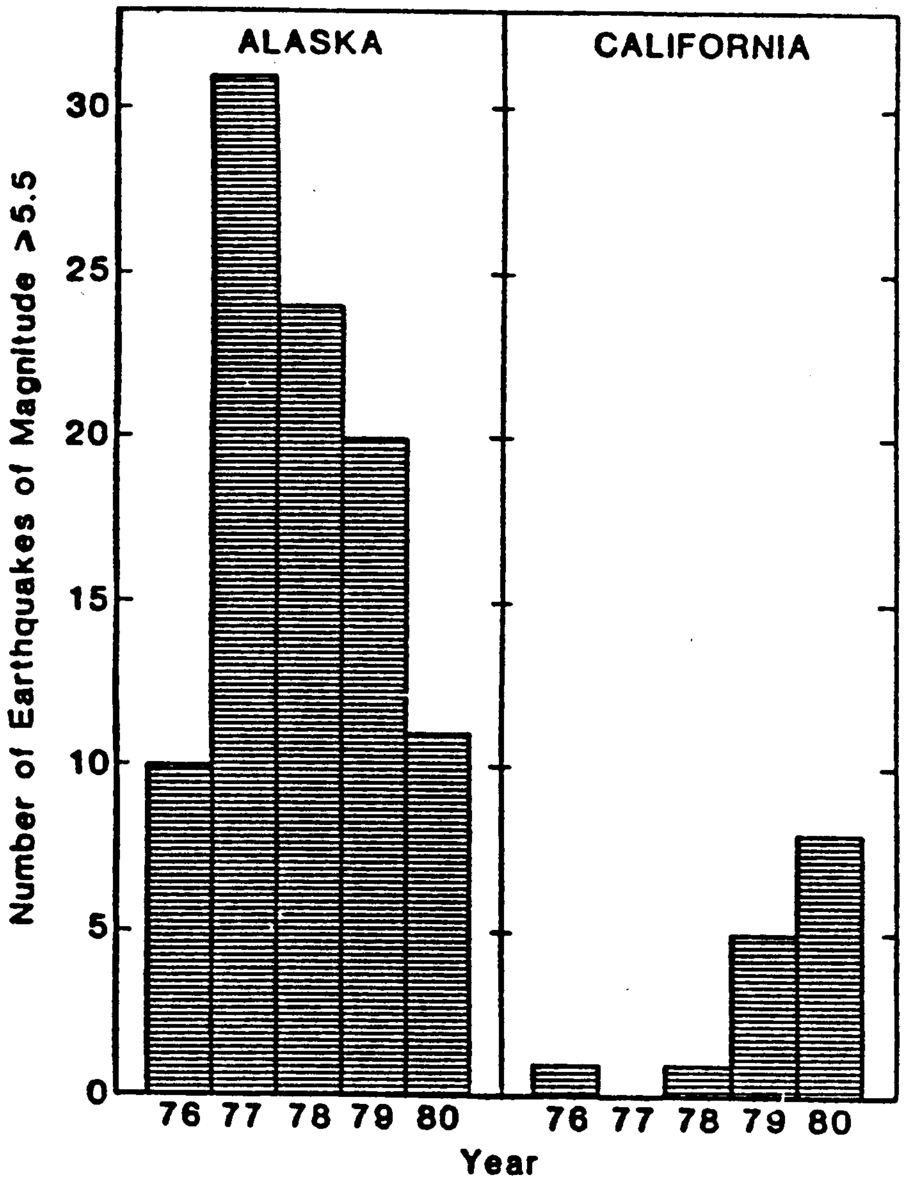


Figure 1.--International Seismological Center reports for earthquakes of magnitude $\geq$ 5.5 during the 5-year period from 1976 to 1980.

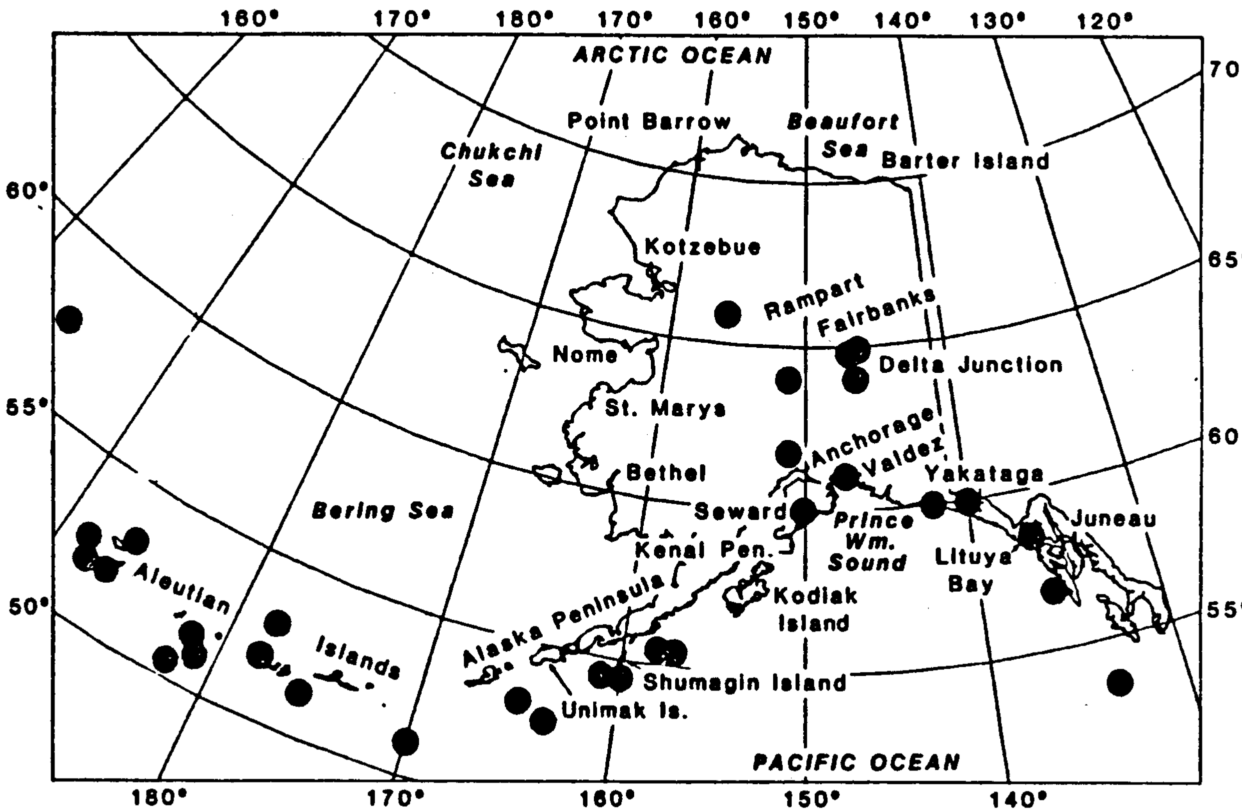


Figure 2.--The dots show the epicenter locations of all shallow (depth less than 70 km) earthquakes in Alaska of magnitude 7.2 or more from 1897 through 1980. The map shows 31 events, but two dots in the Yakutat - Yakataga area actually represent two events each, and two in the westernmost Aleutians are off the map. The 83-year record thus indicates that Alaska has 35 earthquakes of at least magnitude 7.2, or one every 2.3 years.

many landslides, snow avalanches, and submarine slumps at distances out to 100 km from the epicenter.

The 1946 Scotch Cap earthquake generated an extremely large tsunami which completely destroyed the reinforced concrete lighthouse at Scotch Cap on Unimak Island in the Aleutians and caused significant damage in the Hawaiian Islands. The 1964 great Alaska earthquake caused permanent uplift or subsidence of tens of thousands of square kilometers from Prince William Sound to Kodiak Island. The tsunami did terrible damage at Kodiak, Seward, Chenega, and other coastal villages of Alaska and at places as distant as Newport, Oregon, and Crescent City, California. A secondary submarine slump near Shoup Bay in Valdez Arm created a seiche wave which broke off trees more than 35 m above Shoup Bay and which sloshed a wall of water about 7 m high through the town of Valdez. The long duration of the strong shaking in Anchorage, more than 60 km from the nearest point on the rupture surface, caused a dozen damaging landslides along the bluffs of Knik Arm and Ship Creek.

Queen Charlotte-Fairweather Transform Fault Zone

Five epicenters are shown in Figure 2 along the panhandle region in southeastern Alaska. These events occurred along the Fairweather fault which is part of a transform fault system along which the Pacific plate is sliding to the northwest (horizontally) by southeast Alaska. This region is known as the Queen Charlotte-Fairweather transform fault zone. Great earthquakes with Richter magnitudes up to the mid-8s can occur here, but the extremely large events in the high 8s and low 9s typical of the subduction zone to the west are not expected. Earthquakes in the transform zone occur on strike-slip faults which cut the surface of the earth in long straight lines. Offsets along these surface breaks can be on the order of meters, causing very intense shaking near the fault.

The 1958 Lituya Bay earthquake (M = 7.9) had a horizontal displacement across the Fairweather fault of about 15 m. The violent shaking from this quake dislodged a giant rockslide in Lituya Bay, causing a seiche wave which washed trees and soil from the bedrock of the opposite shore to an elevation more than 500 m(!) above sea level.

Interior, Northern, and Western Alaska

In the interior of Alaska there are five epicenters shown on the map of Figure 2. The largest of these quakes, the 1904 Rampart earthquake, is sometimes listed as having a magnitude of 8, though 7.3 is probably more correct. A sixth event south of the Alaska Range and about 50 km north of Anchorage occurred in 1943, had a Richter magnitude of 7.4 (M_s) and probably should be classed with these other mainland Alaskan events. All of these earthquakes occurred on faults which did not break the surface of the earth in a clear escarpment. Typically, these events have durations of strong shaking which last somewhat less than a minute. Rock fall and liquefaction of the soil can occur 30 to 50 km away from the epicenter. The 1937 Salcha earthquake left a number of fissures in the soil and caused a rockfall which closed the Richardson Highway. The 1958 Huslia earthquake caused widespread cracking and fissuring of the soil. A significant amount of liquefaction was indicated by the numerous sand flows and sinkholes seen after the quake.

There have been no events larger than M = 7.0 in western and northern Alaska including the offshore regions of the Bering, Chukchi, and Beaufort seas (excluding the Aleutian zone, of course). If one lowers the magnitude threshold a little and considers all events larger than M = 6.0, we begin to see a trend of epicenters defining a broad belt from the Fairbanks-Delta Junction area in interior Alaska through the Kotzebue-Nome area in western Alaska, and on across the Chukchi Sea into Siberia. If one lowers the threshold still further and considers all events larger than M = 4.5, then a second trend emerges. This is a broad belt of epicenters trending north-northeast, which again originates in the Fairbanks-Delta Junction area and goes through the Barter Island area of north-eastern Alaska. The two regions of lowest historical seismic activity in Alaska are the Kuskokwim and Yukon deltas region around St. Marys and Bethel and the western half of the north slope region centered around Point Barrow, with the latter being somewhat less active than the former.

Alaskan Earthquake Statistics

We can get a reasonably quantitative sense of the relative hazards between these broad zones of Alaska by examining the historical record for earthquakes of magnitude greater than or equal to seven as compiled in Table 2. The events listed in that table have been assigned to three zones: (1) the subduction zone; (2) the transform zone; and (3) the mainland Alaska zone. Recall that no large earthquakes ($M \geq 7.0$) have occurred in Alaska outside of these three zones. That is not to say that it is impossible for a magnitude seven event to occur near Bethel or Barrow, e.g., just that the probability is considerably lower there relative to the three zones which have been active over the past 90 years.

For each of these active zones the number of independent events larger than or equal to magnitude seven and the time intervals between them are summarized statistically in Table 3. In the subduction zone, e.g., there have been 37 events of $M \geq 7.0$ during the past 90 years. Excluded from this tabulation are events that appear to be foreshocks or aftershocks of some other event. The mean repeat time, or average interval time for independent earthquakes of $M \geq 7.0$ in the subduction zone was 2.3 years, and it has been 5.0 years since the last such earthquake. The "time for 95% of cases" is the mean repeat time plus 1.645 times one standard deviation of the individual repeat times about their mean. This statistic assumes a Gaussian distribution of the repeat times which is clearly not true for the $M \geq 7.0$ case, but which may be true for the $M \geq 7.8$ case. It is simply meant to be a measure of how "overdue" a particular zone may be. If the time interval since the last event in a particular zone is longer than "95%" of all previously observed time intervals between events, then one might say that zone is overdue for an earthquake of the class in question. In the example of the subduction zone the time for 95% of previous intervals is 6.1 years, so the fact that it has been 5.0 years since the last event means that we are approaching being overdue for an earthquake of $M \geq 7.0$ there. However, for earthquakes of $M \geq 7.8$ it has been 20.9 years since the last event and the 95% time is 19.3 years, so in this case we are now overdue.

Table 2

MAJOR SHALLOW ALASKAN EARTHQUAKES: 1897 -1980

(After Abe and Noguchi, 1981 and 1983)*

#	YEAR	MO	DY	TIME	LAT.	LONG.	M_s	LOCATION	ZONE*
1	1898	6	29	1836	52.	+172.	7.6	Near Is.	S+
2	1898	10	11	1637	50.	180.	6.9	Rat/Andreanof Is.	S-
3	1899	4	16	1342	58.	-138.	6.9	S.E. Alaska	T-
4	1899	7	14	1332	(60.)*	(-150.)*	7.2	(Kenai Penin.)*	S+
5	1899	9	4	0022	60.	-142.	7.9	Gulf of Alaska	T+
6	1899	9	4	0440	60.	-142.	6.9	Gulf of Alaska	T-
7	1899	9	10	1704	60.	-140.	7.4	S.E. Alaska	T+
8	1899	9	10	2141	60.	-140.	8.0	S.E. Alaska	T+
9	1899	9	17	1250	59.	-136.	6.9	S.E. Alaska	T-
10	1899	9	23	1104	60.	-143.	6.9	Gulf of Alaska	T-
11	1899	9	23	1250	60.	-143.	7.0	Gulf of Alaska	T+
12	1900	10	9	1228	(60.)*	(-142.)*	7.7	(Kodiak)*	S+*
13	1901	1	18	0439	60.	-135.	7.1	S.E. Alaska	T+
14	1901	12	31	0902	52.	-177.	7.1	Andreanof Is.	S+
15	1902	1	1	0520	55.	-165.	7.0	Unimak Is.	S+
16	1903	1	17	1605	50.	-170.	7.0	(Fox Is.)	S+
17	1903	2	5	1826	52.	+175.	6.8	Near/Rat Is.	S-
18	1903	6	2	1317	57.	-156.	6.9	Alaska Penin.	S-
19	1904	8	27	2156	64.	-151.	7.3	Central Alaska	M+
20	1905	2	14	0846	53.	-178.	7.3	Andreanof Is.	S+
21	1905	3	22	0338	50.	180.	7.0	Rat/Andreanof Is.	S+
22	1905	9	15	0602	55.	+165.	7.4	Komandorsky	O+
23	1905	12	10	1236	50.	180.	6.9	Rat/Andreanof Is.	S-
24	1906	8	17	0010	51.	+179.	7.8	Rat Is.	S+
25	1906	12	23	1722	53.	-165.	7.3	(Unimak Is.)	S+
26	1907	9	2	1601	52.	+173.	7.4	Near Is.	S+
27	1908	5	15	0831	59.	-141.	7.0	S.E. Alaska	T+
28	1909	4	10	1936	52.	+175.	7.0	Near/Rat Is.	S+
29	1910	9	9	0113	51.5	-176.	7.0	Andreanof Is.	S+
30	1910	11	6	2029	53.	-135.	6.8	Queen Charlotte Is.	O-
31	1911	9	17	0326	51.	180.	7.1	Rat/Andreanof Is.	S+
32	1911	11	13	1613	52.	+173.	6.9	Near Is.	S-
33	1912	6	10	1606	59.	-153.	6.9	Kodiak Is.	S-
34	1912	7	7	0757	64.	-147.	7.2	Central Alaska	M+
35	1915	7	31	0131	54.	+162.	7.6	Kamchatka	O+
36	1917	1	30	0245	56.5	+163.	7.8	Kamchatka	O+
37	1917	5	31	0847	54.5	-160.	7.9	Alaska Penin.	S+
38	1923	5	4	1626	55.5	-156.5	7.1	Alaska Penin.	S+
39	1925	8	19	1207	55.25	+168.	7.0	Unimak Is.	S+
40	1926	10	13	1908	52.	-176.	7.0	Andreanof Is.	S+

#	YEAR	MO	DY	TIME	LAT.	LONG.	M_s	LOCATION	ZONE*
41	1927	10	24	1559	57.5	-137.	7.1	S.E. Alaska	T+
42	1928	6	21	1627	60.	-146.5	6.8	Gulf of Alaska	S-
43	1929	3	7	0134	51.	-170.	7.5	Fox Is.	S+
44	1929	7	5	1419	51.	-178.	7.0	Andreanof Is.	S+
45	1929	7	7	2123	52.	-178.	7.3	Andreanof Is.	S+
46	1929	12	17	1058	52.5	+171.5	7.8	Near Is.	S+
47	1933	4	27	0236	61.25	-150.75	6.9	S. Central Alaska	M-
48	1935	2	22	1705	52.25	+175.	7.1	Near/Rat Is.	S+
49	1936	11	13	1231	55.5	+163.	7.1	Kamchatka	O+
50	1937	7	22	1709	64.75	-146.75	7.3	Central Alaska	M+
51	1938	11	10	2018	55.5	-158.	8.3	Alaska Penin.	S+
52	1938	11	17	0354	55.5	-158.5	7.3	Alaska Penin.	S+
53	1940	4	16	0607	52.	+173.5	6.8	Near Is.	S-
54	1940	4	16	0643	52.	+173.5	7.1	Near Is.	S+
55	1940	8	22	0327	53.	-165.5	7.0	Unimak Is.	S+
56	1943	11	3	1432	61.75	-151.	7.4	S. Central Alaska	M+
57	1944	12	12	0417	51.5	+179.5	6.9	Rat Is.	S-
58	1945	4	15	0235	57.	+164.	7.2	Komandorsky	O+
59	1946	1	12	2025	59.25	-147.25	6.7	Gulf of Alaska	S-
60	1946	4	1	1228	52.75	-163.5	7.3	Unimak Is.	S+
61	1946	11	1	1114	51.5	-174.5	7.0	Andreanof Is.	S+
62	1947	10	16	0209	64.5	-147.5	7.2	Central Alaska	M+
63	1948	5	14	2231	54.5	-161.	7.5	Alaska Penin.	S+
64	1949	8	22	0401	53.75	-133.25	8.1	Queen Charlotte Is.	O+
65	1949	9	27	1530	59.75	-149.	6.7	Kenai Penin.	S-
66	1951	2	13	2212	56.	-156.	7.1	Alaska Penin.	S+
67	1953	1	5	0748	54.	+170.5	7.1	Near Is.	S+
68	1957	3	9	1422	51.3	-175.8	(8.1)	Andreanof Is.	S+
69	1957	3	9	2039	52.25	-169.5	7.1	Fox Is.	S+
70	1957	3	11	0958	52.25	-169.25	7.0	Fox Is.	S+
71	1957	3	11	1455	51.5	-178.5	6.9	Andreanof Is.	S-
72	1957	3	12	1144	51.5	-177.	7.0	Andreanof Is.	S+
73	1957	3	14	1447	51.	-177.	7.1	Andreanof Is.	S+
74	1957	3	16	0234	51.5	-178.75	7.0	Andreanof Is.	S+
75	1957	3	22	1421	53.75	-165.75	7.0	Unimak Is.	S+
76	1957	4	10	1129	56.	-154.	6.9	Kodiak Is.	S-
77	1957	4	19	2219	52.25	-166.	6.5	Unimak Is.	S-
78	1958	4	7	1530	65.5	-155.5	7.3	Central Alaska	M+
79	1958	7	10	0615	58.3	-136.5	7.9	S.E. Alaska	T+
80	1960	11	13	0920	51.4	-168.9	6.7	Fox Is.	S-
81	1964	2	6	1307	55.7	-155.9	7.0	Alaska Penin.	S+
82	1964	3	28	0336	61.1	-147.5	(8.4)*	Gulf of Alaska	S+
83	1965	2	4	0501	51.3	+178.6	(8.2)*	Rat Is.	S+
84	1965	2	4	0840	51.4	+179.6	7.0	Rat Is.	S+
85	1965	3	30	0227	50.3	+177.9	7.4	Rat Is.	S+
86	1965	7	2	2058	53.0	-167.6	6.5	Fox/Unimak Is.	S-
87	1965	7	29	0829	51.1	-171.3	6.7	Fox Is.	S-
88	1965	9	4	1432	58.3	-152.5	6.8	Kodiak Is.	S-

#	YEAR	MO	DY	TIME	LAT.	LONG.	M_s	LOCATION	ZONE*
89	1966	7	4	1833	52.0	+179.9	6.8	Rat Is.	S-
90	1966	8	7	0213	50.6	-171.2	6.4	Fox Is.	S-
91	1969	11	22	2309	57.7	+163.6	7.1	Kamchatka	O+
92	1971	12	15	0829	56.0	+163.2	7.5	Kamchatka	O
93	1972	7	30	2145	56.8	-135.9	7.4	S.E. Alaska	T+
94	1975	2	2	0843	53.1	+173.6	7.4	Near Is.	S+
95	1979	2	28	2127	60.6	-141.6	7.0	S.E. Alaska	T+

*Explanation:

(1) Data for 1897-1912 from Abe, K. and S. Noguchi, 1983(a).

(2) Data for 1913-1917 from Abe, K. and S. Noguchi, 1983(b).

(3) Data for 1918-1980 from Abe, K., 1981.

(4) The following notes apply to the respective earthquake number:
4 - location very uncertain, felt reports suggest a more westerly epicenter, perhaps near the Shumagin Islands
12 - location very uncertain, felt reports suggest a more westerly epicenter, perhaps near Kodiak Island
68 - moment magnitude 8.7
82 - moment magnitude 9.2
83 - moment magnitude 8.7

(5) Earthquake zones were defined as follows:

S = Alaska-Aleutian subduction zone
T = S.E. Alaska transform zone
M = Mainland Alaska
O = Outside of Alaska (Kamchatka, Komandorsky, Queen Charlotte)
+ = M_s greater than or equal to 7.0
- = M_s less than 7.0

Table 3
Alaskan Earthquake Statistics
Independent Events, M ≥ 7.0, January 1897 - January 1986

Region	Major (M_s > 7.0)	Great (M_s > 7.8)
Alaska-Aleutian Subduction Zone		
Number in 90 years	37	7
Mean repeat time (years)	2.3	9.7
Time since last event (years)	5.0	20.9
Time for 95% of cases (years)	6.1	19.3
Date of the last event	1-30-81	2-4-65
S.E. Alaska Transform Zone		
Number in 90 years	8	3
Mean repeat time (years)	11.4	29.4
Time since last event (years)	6.9	27.5
Time for 95% of cases (years)	29.3	97.8
Date of the last event	2-28-79	7-10-58
Mainland Alaska Seismic Zone		
Number in 90 years	6	0
Mean repeat time (years)	10.7	?
Time since last event (years)	27.8	?
Time for 95% of cases (years)	24.5	?
Date of last event	4-7-58	?
All of Alaska		
Number in 90 years	51	10
Mean repeat time (years)	1.7	7.3
Time since last event (years)	5.0	21.0
Time for 95% of cases (years)	4.5	17.3
Date of last event	1-30-81	2-4-65

NOTES

1) The data base for these calculations is the catalog of large, shallow earthquakes in Alaska based on the papers of Abe and Noguchi given in Table 2 augmented by data for the period Jan. 1981 - Jan. 1986 from the National Earthquake Information Service (NEIS).
2) The mean repeat time for the M_s > 7.0 and M_s > 7.8 events is the average of the observed interevent times.
3) The "time for 95% of cases" is the mean interevent time plus 1.645 times one standard deviation of the individual interevent times about their mean.

In the transform zone neither class of earthquake is close to being overdue, so while an event of $M \geq 7.0$ could occur tomorrow, we would not be surprised if it did not occur for another 30 years.

In the mainland Alaska seismic zone there have been no events of $M \geq 7.8$ during the past 90 years. This does not mean that such events are impossible, simply that they are less frequent than in the subduction zone. The mean repeat time for great earthquakes in this zone is probably on the order of a few hundred years, so it's not surprising that we have not recorded one given our short history here.

For major ($7.0 \geq M \geq 7.8$) earthquakes in the mainland zone the time since the last event is 27.8 years, and the time for 95% of the cases is 24.5 years, thus we are overdue here too.

It should be noted that these statistics apply to very large zones and that the mean recurrence times for a specific locality within one of these zones is much longer than the mean repeat time for the whole zone.

CAUSE OF EARTHQUAKES IN ALASKA AND LIKELIHOOD OF FUTURE SHOCKS

The direct cause of the very large earthquakes in southeastern Alaska and the Alaska Peninsula-Aleutian zone is the relative motion of the Pacific and North American (Alaska) plates (Fig. 3). The Pacific plate is continuously created by the upwelling of molten rock at the Juan de Fuca and East Pacific spreading centers. The Juan de Fuca spreading center lies offshore of British Columbia, Washington, and Oregon and forms the Juan de Fuca plate on one limb and the northernmost part of the Pacific plate on the other. The East Pacific spreading center begins in the Gulf of California and extends south and then southwesterly from Central America. This spreading center forms the Cocos and Nazca plates on one limb and the central part of the Pacific plate on the other. From the Juan de Fuca and East Pacific spreading centers the Pacific plate moves northwesterly relative to North America along the San Andreas and Queen Charlotte-Fairweather transform fault systems. Along these transform faults the plates slide past one another edge-to-edge. When the Pacific plate arrives at the Gulf of Alaska it can no longer move sideways by the North

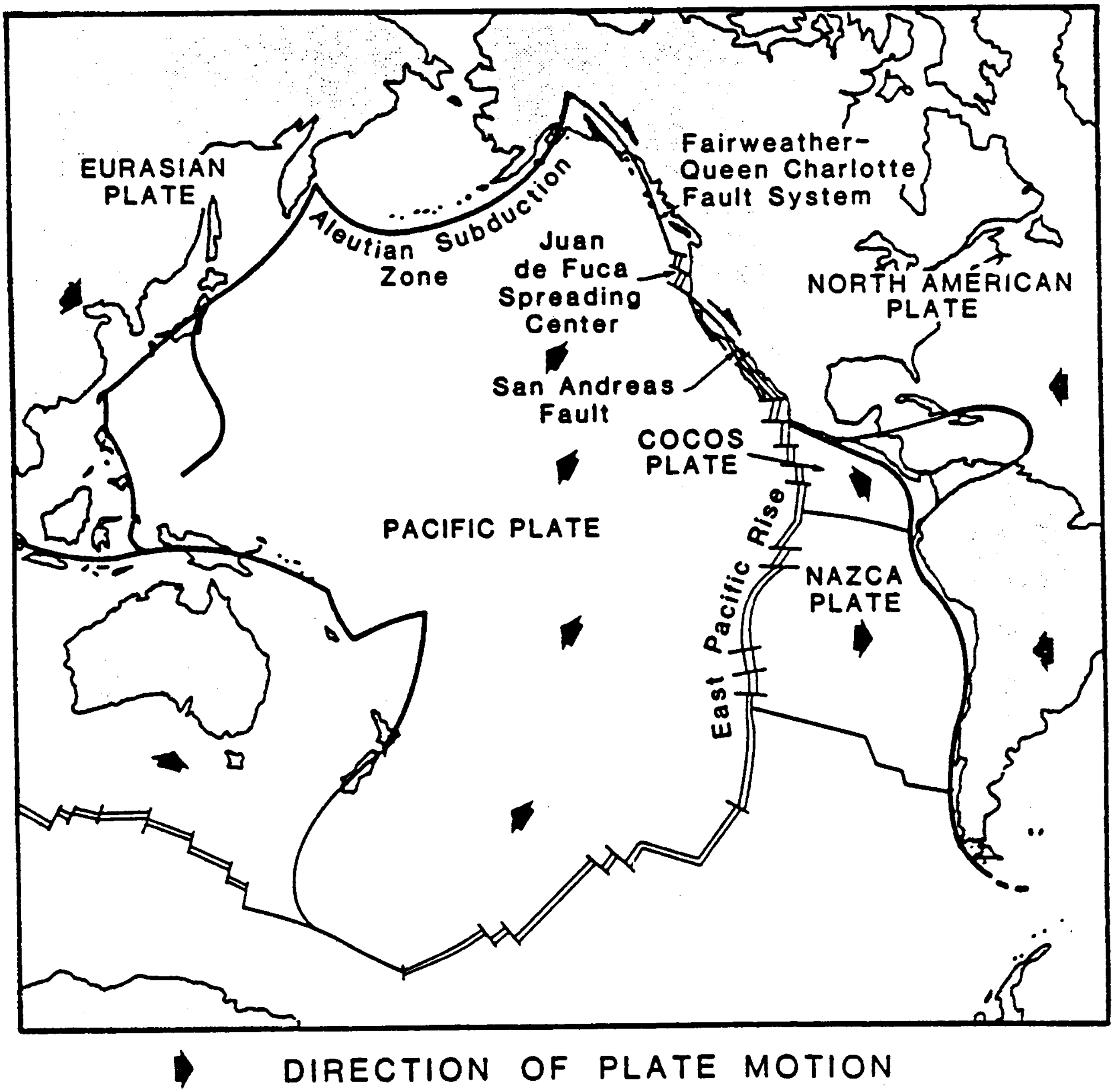


Figure 3.--Some of the plate tectonics features which give rise to the Pacific Ring of Fire. Most earthquakes and volcanoes occur around the margins of the pacific Basin, particularly in the subduction zones and along faults exhibiting strike-slip (lateral) displacement.

American plate; here it begins subducting beneath Alaska. The Pacific plate is consumed beneath the North American and Eurasian plates along the Aleutian, Kurile, and Japanese islands.

The conveyor-belt-like motion of the Pacific plate from spreading center to subduction zone is thought to be driven by buoyancy forces. There may be a small amount of push as it "falls off" the topographic high at the spreading center and there is probably a much stronger pull as the cooler portion of the plate, far away from its origin at the spreading center, sinks under gravitational forces into the less-dense mantle. It is this relentless motion of the Pacific plate as it slides by southeastern Alaska and is thrust beneath the Gulf of Alaska and the Aleutian Islands that causes most of the earthquakes in Alaska.

Over the past 5 million years, about 290 km of Pacific plate has been thrust to the northwest underneath southern Alaska in the vicinity of Anchorage - an average rate of about 5.8 cm year. Since the slip during the 1964 Good Friday earthquake is calculated to have been about 10 m, it would take about 172 years to build up enough strain for a repeat of that devastating event. Note that this is an average number and that it is assumed that no ##?aseismic slip takes place; that is, that all of the 5.8 cm per year of relative motion between the Pacific and North American plates is taken up in strain that is entirely released in the form of great earthquakes. Extreme estimates of the repeat times for great earthquakes in southern Alaska range from 30 years to 1800 years.

Seismic Gaps

The deterministic notion of repeat times of large earthquakes described above leads to the idea of a seismic gap. If it takes a certain amount of time for strain to build up in a region following a large earthquake, then it follows that immediately after such an event the probability for another of similar magnitude is quite low. Conversely, if much time has elapsed since the last large event in an area where large earthquakes are known to occur, then the probability for a large shock in the near future is relatively high. Such an area is called a seismic gap (with a high seismic potential).

In southern Alaska there are two regions that have been identified as seismic gaps: one near Yakataga and the other near the Shumagin Islands and Cold Bay on the Alaska Peninsula. In each of these areas it has been at least 80 years since the last great earthquake ($M_w \geq 7.8$) occurred. In both areas, 80 years is approximately the estimated repeat time for an earthquake of about M_w = 8.0. Hence, both areas are "due" for a large earthquake (i.e., have a high seismic potential), so we wouldn't be surprised if one were to occur there tomorrow. On the other hand, we wouldn't be surprised if one did not occur there during the next 10 years. The quality of the data presently available to us restricts us to the following statement: There is a 30 to 90 percent chance of an earthquake of $M_w \geq 8.0$ occurring in the Yakataga and Shumagin gaps in the next two decades (Nishenko and Jacob, 1985). The range in probabilities arises out of different assumptions about how to do the statistics.

Faults Away from Plate Boundaries

We understand the probabilities for large shocks in the seismic gaps quite well by comparison to how well we understand that likelihood for large earthquakes on most faults that do not lie near plate boundaries. In most cases we have no direct information about the repeat time for large events on a given fault: all we know, for example, is that a certain fault may have been offset in the last 10,000 years - we may not even know if this offset was sudden, in one or more large events, or gradual, in some form of continuous creep.

One particularly important example of this situation is the Border Ranges fault which follows an arcuate path along the northern front of the Chugach and Kenai mountains from north of Cordova to the southwestern tip of Kodiak Island, a distance of over 1000 km. This great fault is thought to be the suture zone (or zone of collision) between parts of southern most Alaska which were rafted together about 40 million years ago. It is possible that portions of this suture zone are active today. There is some evidence, for example, that the portion near Eagle River has moved in the last 4,000 years. There is no large earthquake known to be associated with the Border Ranges fault. This leaves us with the uncomfortable and unsatisfactory conclusion that there is a possibility that there is a high probability for a large earthquake on this major fault system which runs right through Anchorage. Clearly more work is urgently needed to resolve this situation. In the meantime most, but not all, assessments of seismic hazard in the Anchorage area assume the fault to be active.

Again, this is only one example. There are many other major faults in southcentral, western, and northern Alaska which may or may not generate future large earthquakes: The Castle Mountain, Denali, Iditarod, Kaltag, and Tintina faults, to name just a few. Further, there are seismically active zones such as the Badger Road area near Fairbanks that has had thousands of earthquakes, including four events of magnitude 5.5 to 6.0 on one day - June 21, 1967. In this area we have earthquakes but no known fault. This makes it difficult to assess the likelihood of future, possibly larger events. We know these larger events can occur in the Interior: there were events of $M_s = 7.3$ in 1904 south of Rampart, near Salcha in 1937, and near Huslia in 1958. None of these earthquakes clearly occurred on a mapped fault. So, for the time being, we must lump all of these events into one large seismogenic zone and treat their occurrence statistically. This has the result that we "smear out" the probability of occurrence of future larger events over a very big area, with the consequence that some areas are underrated as to their seismic hazard and others are overrated. For the present, this is the best that can be done.

RISK REDUCTION

What can we do to improve this situation in the future, and what can we do to mitigate the effects of the inevitable future large earthquakes? The essential new information will come only from a long-term commitment to a program of seismic monitoring and geological mapping designed to identify and evaluate potential seismic sources in Alaska. As this new information becomes available, it must be incorporated into building codes and zoning requirements so that it is used to assure the cost-effective and safe development of the state.

That a long-term commitment to seismic risk reduction is cost effective was clearly demonstrated by a three-year study carried out by the California Division of Mines and Geology (CDMG). The results of this study are summarized in Figure 4. The histogram shown in this figure indicates three dollar values associated with each of a number of geologic hazards. The first value given is the expected cost to society if we proceed with the status quo. In case of seismic shaking, for example, this would be the expected loss in California due to collapse or major damage to structures if no new hazard mitigation programs were carried out between now and the year 2000. The second value given in each case is the expected reduction possible if state-of-the-art loss-reduction measures were in place from 1970 to 2000. The last value is the expected cost of implementing the best possible programs to reduce losses from the hazard. Again in the case of seismic shaking, this program would include measures such as identifying areas most likely to experience strong seismic shaking or ground failure as a result of large earthquakes in the next 20 years, so that efforts may be concentrated in these areas. Further measures would include the strengthening of some buildings and the removal of other (unreinforced masonry, for example), changes in occupancy, new building code requirements, and new zoning.

Summarizing the earthquake shaking case, we see that for the period from 1970 to 2000 the expected loss in California under current practices would be $21 billion, the possible reduction in these losses given state-of-the-art loss-reduction measures would be about $10.5 billion, and the cost to implement these measures would be about $2 billion. This gives a benefit/cost ratio which is better than 5:1, a pretty good return on investment by any standards! Some of the other major geologic problems yield even higher benefit/cost ratios. Loss of mineral resources to urbanization and landsliding, are both $10 billion-plus problems which have benefit/cost ratios in excess of 9:1. Clearly a little foresight would make good economic sense.

These numbers, of course, apply only to California, where there is a very large population exposed to these hazards. A similar study is needed in Alaska to identify the problem areas where similar benefit/cost ratios might apply to our geologic problem. It is very likely that given properly scaled loss-reduction programs, similar benefit/cost ratios could be achieved for

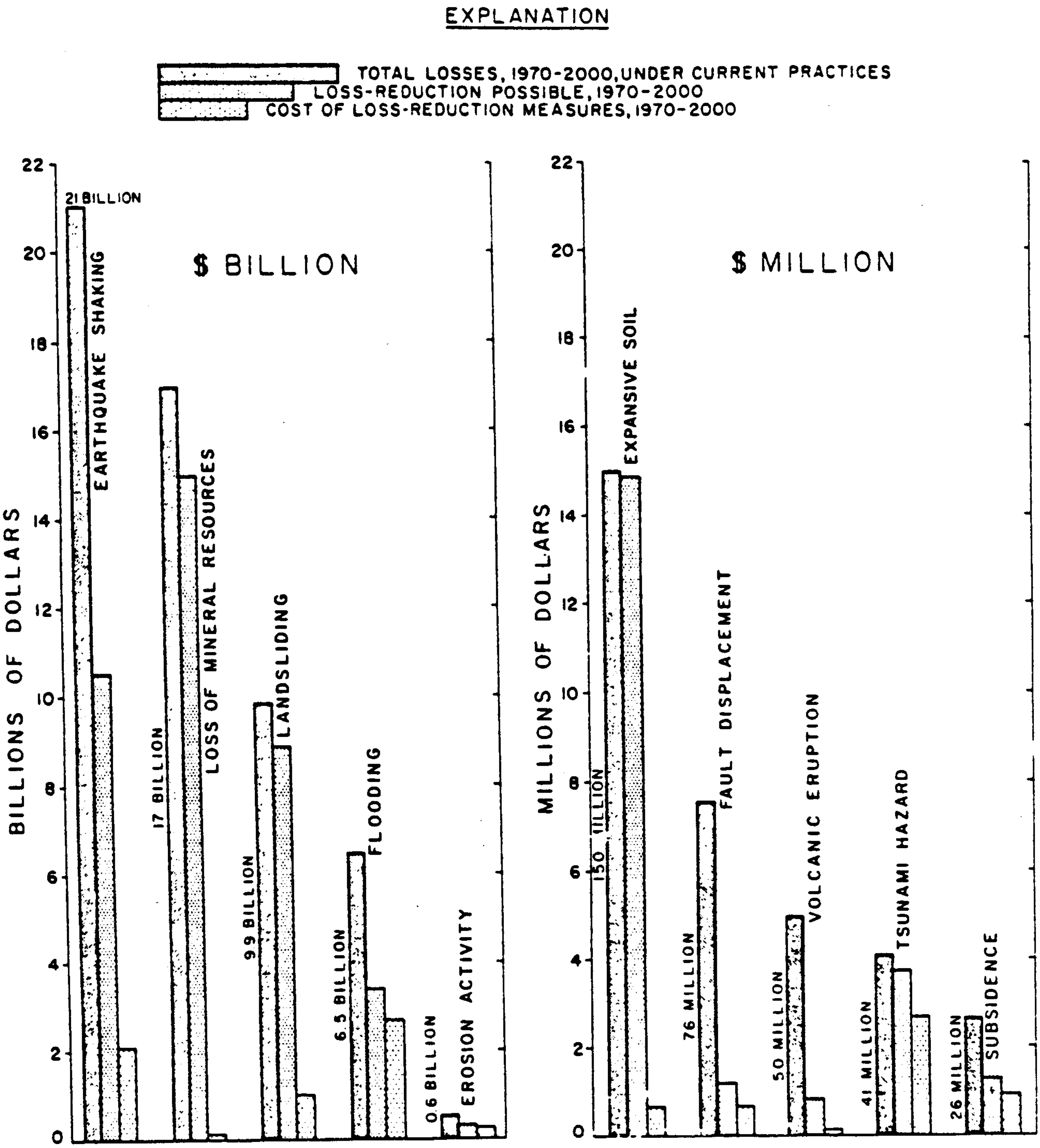


Figure 4.--Estimated losses from geologic problems in California, 1970-2000, and possible loss-reduction if state-of-the-art practices were used.

earthquake losses, loss of mineral resources, and frozen ground losses, to name just a few.

CONCLUSIONS

We have a rapidly developing urban and transportation infrastructure in Alaska which is vulnerable to an extremely high level of earthquake hazard. This hazard, while qualitatively well understood, cannot be adequately quantified for risk assessment purposes at the present level of knowledge. What is required is a two-fold commitment to improving our knowledge of the hazard and to carrying out appropriate loss-reduction measures. There is every reason to believe that substantial benefit/cost ratios can be achieved in Alaska with a well-planned program to reduce losses from earthquakes. Further, there are many other geologic problems in Alaska that likely will admit to similar loss-reduction efforts.

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APPENDIX B

LIST OF STRUCTURES IN ALASKA

In this appendix the following tables are provided:

TABLE B-1 Structures in Anchorage

TABLE B-2 Structures Outside of Anchorage

TABLE B1-a

STRUCTURES IN ANCHORAGE
P(DATA) COEFFICIENT

NO	STRUCTURE	PERIOD	SITE	Ab	S(T)	P(DATA)
1	Sheffield Hotel	1.2	3	.36	1.68	.6048
2	Carr Gott Building	.6	3	.36	2	.72
3	Captain Cook Hotel	1.9	3	.36	1.2	.432
4	C Street Overpass	1	3	.36	1.9	.684
5	Native Hospital	.5	3	.36	2	.72
6	Humana Hospital	.7	2	.36	1.82	.6552
7	Control Tower (airport)	1	2	.36	1.5	.54
8	Providence Building	.5	1	.36		0
9	Alaska USA Fed. Credit Union	1.4	2	.36	1.2	.432
10	Anglo Energy Building	.8	2	.36	1.7	.612
11	Offshore drilling platforms	5	3	.36	.45	.162
12	Ekluna Tunnel	-	1	.36	1	.36
13	Eklutna Pipline	-	1	.36	1	.36
14	Denali Towers	1.7	2	.36	1.03	.3708
15	Aleut Office Complex	.3	2	.36	2.5	.9
16	Elemendorf Hospital	.5	1	.36	1.9	.684
17	Sohio Building	1.3	2	.36	1.24	.4464
18	5 M gal water tank	3	1	.36	.6	.216
19	Plunkett	.6	3	.36	2	.72
20	Westward Hilton	1.3	3	.36	1.6	.576
21	Sheraton	1.5	3	.36	1.43	.5148
22	Sullivan Sports Arena	.5	2	.36	2.3	.828
23	Frontier Building	1.4	2	.36	1.2	.432
24	Library	.4	2	.36	2.5	.9
25	6th and G Street Parking	.6	3	.36	2	.72
26	Arco Building	2.2	3	.36	1.1	.396
27	Calais No. 1	.8	2	.36	1.7	.612
28	Hunt Building	2.2	3	.36	1.1	.396
29	Peterson Tower	1	3	.36	1.9	.684
30	Federal Building	.6	3	.36	2	.72
31	Historic Arts Building	.2	3	.36	2	.72
32	Providence Hospital	.5	1	.36	1.9	.684
33	Bank of Alaska (at "c")	.7	2	.36	1.82	.6552
34	Inlet Towers	1.4	3	.36	1.5	.54
35	Alaska Mutual	1	3	.36	1.9	.684
36	Hill Building	1.4	3	.36	1.5	.54
37	Port Building			.36		0
38	Port of Anch. Wharf	.5	3	.36	2	.72
39	AS&G Off-loading Bridge	.5	2	.36	2.3	.828
40	Resolution Plaza	.7	3	.36	2	.72
41	South Anch. Pipeline	-	2	.36	1	.36
42	New job on piles			.36		0

TABLE B1–b

STRUCTURES IN ANCHORAGE
P(USE) COEFFICIENT

NO	STRUCTURE	U1	U2	U3	P(USE)
1	Sheffield Hotel	.5	.5	.5	.5
2	Carr Gott Buildino	.5	.8	.5	.6
3	Captain Cook Hotel	.7	1	.7	.8
4	C Street Overpass	.7	.8	1	.8333333
5	Native Hospital	.3	.5	1	.6
6	Humana Hospital	.8	1	1	.9333333
7	Control Tower (airport)	.8	1	1	.9333333
8	Providence Buildino	.7	.6	.5	.6
9	Alaska USA Fed. Credit Union	.7	.6	.5	.6
10	Anglo Enerov Buildino	.7	1	.5	.7333333
11	Offshore drilling platforms	.3	.5	.2	.3333333
12	Ekluna Tunnel	.8	1	1	.9333333
13	Eklutna Pipline	.8	1	1	.9333333
14	Denali Towers	.7	1	.5	.7333333
15	Aleut Office Complex	.7	1	.5	.7333333
16	Elemendorf Hospital	.4	.5	1	.6333333
17	Sohio Building	.8	1	1	.9333333
18	5 M gal water tank	.5	1	1	.8333333
19	Plunkett	.6	.5	.3	.4666667
20	Westward Hilton	.5	.8	1	.7666667
21	Sheraton	.6	.8	.5	.6333333
22	Sullivan Sports Arena	.7	.7	1	.8
23	Frontier Building	.4	1	.5	.6333333
24	Librarv	.7	.4	1	.7
25	6th and G Street Parking	.8	1	1	.9333333
26	Arco Buildino	.7	1	.7	.8
27	Calais No. 1	.7	1	.5	.7333333
28	Hunt Building	.7	1	.5	.7333333
29	Peterson Tower	.7	1	.3	.6666667
30	Federal Buildino	.7	.4	1	.7
31	Historic Arts Building	.7	.4	1	.7
32	Providence Hospital	0	0	0	0
33	Bank of Alaska (at "c")	.4	.8	.5	.5666667
34	Inlet Towers	.3	1	.5	.6
35	Alaska Mutual	.5	.8	.5	.6
36	Hill Buildino	.3	1	1	.7666667
37	Port Buildino	.5	1	1	.8333333
38	Port of Anch. Wharf	.5	.7	1	.7333333
39	AS&G Off-loading Bridge	.7	1	.5	.7333333
40	Resolution Plaza	.7	.5	.3	.5
41	South Anch. Pipeline	.7	1	1	.9
42	New iob on piles	0	0	0	0

TABLE B1–c

STRUCTURES IN ANCHORAGE
P(CARE) COEFFICIENT

NO	STRUCTURE	C1	C2	C3	C4	P(CARE)
1	Sheffield Hotel	.8	1	.75	.5	.5
2	Carr Gott Building	.9	.5	.5	.5	.6
3	Captain Cook Hotel	.9	1	.5	.5	.725
4	C Street Overpass	.5	.5	.5	.5	.5
5	Native Hospital	.8	.5	.9	.5	.675
6	Humana Hospital	1	1	1	.5	.875
7	Control Tower (airport)	.5	.5	.5	.5	.5
8	Providence Building	.9	.5	.9	.5	.7
9	Alaska USA Fed. Credit Union	1	1	.5	.5	.75
10	Anglo Energy Building	.9	.5	.5	.5	.6
11	Offshore drilling platforms	.5	.5	.9	.75	.6625
12	Ekluna Tunnel	.5	.5	.9	.5	.6
13	Eklutna Pipline	.5	1	.8	.5	.7
14	Denali Towers	.9	.5	.5	1	.725
15	Aleut Office Complex	.9	1	.5	1	.85
16	Elemendorf Hospital	.8	.5	.9	.5	.675
17	Sohio Building	.9	.7	.5	1	.775
18	5 M gal water tank	.5	.5	.5	.5	.5
19	Plunkett	.8	1	.25	.5	.6375
20	Westward Hilton	.9	.5	.5	.5	.6
21	Sheraton	.9	.5	.5	.5	.6
22	Sullivan Sports Arena	.5	1	1	.5	.75
23	Frontier Building	.9	1	.9	.5	.825
24	Library	1	.5	.9	.5	.725
25	6th and G Street Parking	.8	.5	.9	.5	.675
26	Arco Building	.9	2	.5	1	1.1
27	Calais No. 1	.9	1	.5	.5	.725
28	Hunt Building	1	.5	.9	1	.85
29	Peterson Tower	.9	.5	.5	.5	.6
30	Federal Building	1	.5	.8	.5	.7
31	Historic Arts Building	.8	.5	.9	.5	.675
32	Providence Hospital	0	0	0	.5	.125
33	Bank of Alaska (at "c")	.9	.5	.5	.5	.6
34	Inlet Towers	.9	.5	.7	.5	.65
35	Alaska Mutual	.9	.5	.5	.5	.6
36	Hill Building	.9	.5	.5	.5	.6
37	Port Building	.5	.5	.5	.5	.5
38	Port of Anch. Wharf	.5	.5	.5	.5	.5
39	AS&G Off-loading Bridge	.5	.5	.9	.5	.6
40	Resolution Plaza	.6	.5	.5	.5	.525
41	South Anch. Pipeline	.5	.5	.5	.5	.5
42	New job on piles	0	.5	0	0	.125

TABLE B1–d

STRUCTURES IN ANCHORAGE
RANK (A) AND RANK (B)

NO	STRUCTURE	RANK A	RANK B
1	Sheffield Hotel	15.12	53.49333
2	Carr Gott Building	25.92	64
3	Captain Cook Hotel	25.056	65.23333
4	C Street Overpass	28.5	67.24444
5	Native Hospital	29.16	66.5
6	Humana Hospital	53.508	82.11778
7	Control Tower (airport)	25.2	65.77778
8	Providence Building	0	43.33333
9	Alaska USA Fed. Credit Union	19.44	59.4
10	Anglo Energy Building	26.928	64.84444
11	Offshore drilling platforms	3.577500	38.59444
12	Ekluna Tunnel	20.16	63.11111
13	Eklutna Pipline	23.52	66.44444
14	Denali Towers	19.7142	60.97111
15	Aleut Office Complex	56.1	82.77778
16	Elemendorf Hospital	29.241	66.41111
17	Sohio Building	32.2896	71.82444
18	5 M gal water tank	9	51.64444
19	Plunkett	21.42	60.80556
20	Westward Hilton	26.496	64.75556
21	Sheraton	19.5624	58.27111
22	Sullivan Sports Arena	49.68	79.26667
23	Frontier Building	22.572	63.01111
24	Library	45.675	77.5
25	6th and G Street Parking	45.36	77.61111
26	Arco Building	34.848	76.53333
27	Calais No. 1	32.538	69.01111
28	Hunt Building	24.684	65.97778
29	Peterson Tower	27.36	65.02222
30	Federal Building	35.28	70.66667
31	Historic Arts Building	34.02	69.83333
32	Providence Hospital	0	26.96667
33	Bank of Alaska (at "c")	22.2768	60.72889
34	Inlet Towers	21.06	59.66667
35	Alaska Mutual	24.624	62.8
36	Hill Building	24.84	63.55556
37	Port Building	0	44.44444
38	Port of Anch. Wharf	26.4	65.11111
39	AS&G Off-loading Bridge	36.432	72.04444
40	Resolution Plaza	18.9	58.16667
41	South Anch. Pipeline	16.2	58.66667
42	New job on piles	0	4.166667

TABLE B2–a

STRUCTURES OUTSIDE OF ANCHORAGE
P(DATA) COEFFICIENT

NO	STRUCTURE	PERIOD	SITE	Ab	S(T)	P(DATA)
1	VALDEZ					
2	Civic Auditorium	.5	1	.4	1.9	.76
3	Min. Creek Bridge	.5	1	.4	1.9	.76
4	Watertank (tall)	3	1	.4	.6	.24
5	Watertank (short)	3	2	.4	.75	.3
6	Grain Silo	.5	1	.4	1.9	.76
7	Solomon Gulch Dam	1	1	.4	1.3	.52
8	Alveska Tank Farm	3	1	.4	1.6	.64
9	Alveska Docks	.5	1	.4	1.9	.76
10	Alveska RE Walls	.5	1	.4	1.9	.76
11						
12	HOMER					
13	So. Penn. Hospital	.3	2	.4	2.5	1
14	Bradley Lake Dam	2	1	.4	.8	.32
15						
16	JUNEAU					
17	State Office Building	.6	1	.5	1.7	.85
18	Federal Building	1	1	.5	1.3	.65
19						
20	SEWARD					
21	Grain Silos	.5	2	.4	2.3	.92
22	Jail	.5	2	.4	2.3	.92
23						
24	KENAI					
25	Performing Arts Building	.5	1	.38	1.9	.722
26						
27	ADAK					
28	Hangar Buildings	.5	1	.4	1.9	.76
29						
30	SOLDOTNA					
31	Soldotna High School	.5	1	.38	1.9	.722
32						
33	KODIAK					
34	Container Dock	.5	1	.4	1.9	.76
35	Coast Guard Fac.	.5	1	.4	1.9	.76
36						
37	WHITTIER					
38	Buckner Building	1.2	2	.4	1.3	.52
39						
40	FAIRBANKS					
41	Basset Army Hospital			.25		
42	Noel Wein Library	.15	2	.25	2.5	.625
43	Federal Court House			.25		0
44	State Courthouse			.25		0
45	Police Headquarters	.25	2	.25	2.5	.625
46	1st National Bank Building	.5	2	.25	2.3	.575
47	Golden Towers	.5	2	.25	2.3	.575
48	Great Land Hotel	.5	2	.25	2.3	.575
49	Lathrop Building	.5	2	.25	2.3	.575
50	Fairbanks Hospital	.4	2	.25	2.5	.625
51	Nerco Building	.7	2	.25	1.82	.455
52	New Borough Building	.3	2	.25	2.5	.625
53	Old Borough Building	.4	2	.25	2.5	.625
54	Polaris Hotel	1.1	2	.25	1.4	.35
55	Tanana Clinic	.4	2	.25	2.5	.625
56	Northward Building	.9	2	.25	1.6	.4
57	Eilson High School	.1	2	.25	2.5	.625
58	Lathrop High School	.2	2	.25	2.5	.625
59	North Pole High School			.25		0
60	Pearl Creek Elementary School	.1	1	.25	2.5	.625
61	West Valley High School	.1	1	.25	2.5	.625
62	Duckering Building	.8	1	.25	1.43	.3575
63	Gruening Building	.8	1	.25	1.43	.3575
64	Elvey Building	.8	1	.25	1.43	.3575
65	Rasmusson Library	.4	1	.25	2.2	.55
66	Statewide Services Building	.4	1	.25	2.2	.55

TABLE B2–b

STRUCTURES OUTSIDE OF ANCHORAGE
P(USE) COEFFICIENT

NO	STRUCTURE	U1	U2	U3	P(USE)
1	VALDEZ				
2	Civic Auditorium	.5	.5	1	.6666667
3	Min. Creek Bridoe	.9	1	1	.9666667
4	Watertank (tall)	.9	1	1	.9666667
5	Watertank (short)	.9	1	1	.9666667
6	Grain Silo	.9	1	1	.9666667
7	Solomon Gulch Dam	.4	.5	1	.6333333
8	Alveska Tank Farm	.3	1	.3	.5333333
9	Alveska Docks	.3	.8	.3	.4666667
10	Alveska RE Walls	.3	.8	.3	.4666667
11					
12	HOMER				
13	So. Penn. Hospital	.7	.7	1	.8
14	Bradlev Lake Dam	.7	.5	1	.7333333
15					
16	JUNEAU				
17	State Office Buildino	.5	.5	1	.6666667
18	Federal Buildino	.5	1	1	.8333333
19					
20	SEWARD				
21	Grain Silos	0	0	0	0
22	Jail	0	0	0	0
23					
24	KENAI				
25	Performino Arts Buildino	.7	.8	1	.8333333
26					
27	ADAK				
28	Hanoar Buildinos	.4	.8	.3	.5
29					
30	SOLDOTNA				
31	Soldotna Hioh School	.6	.5	1	.7
32					
33	KODIAK				
34	Container Dock	.4	.8	1	.7333333
35	Coast Guard Fac.	.8	1	1	.9333333
36					
37	WHITTIER				
38	Buckner Buildino	.4	1	.5	.6333333
39					
40	FAIRBANKS				
41	Basset Armv Hospital				
42	Noel Wein Librarv	0	0	0	0
43	Federal Court House	0	0	0	0
44	State Courthouse	0	0	0	0
45	Police Headouarters	0	0	0	0
46	1st National Bank Buildino	0	0	0	0
47	Golden Towers	0	0	0	0
48	Great Land Hotel	0	0	0	0
49	Lathrop Building	0	0	0	0
50	Fairbanks Hospital	0	0	0	0
51	Nerco Building	0	0	0	0
52	New Borouoh Building	0	0	0	0
53	Old Borough Building	0	0	0	0
54	Polaris Hotel	0	0	0	0
55	Tanana Clinic	0	0	0	0
56	Northward Buildino	0	0	0	0
57	Eilson Hioh School	0	0	0	0
58	Lathroo Hioh School	0	0	0	0
59	North Pole Hioh School				
60	Pearl Creek Elementarv School	0	0	0	0
61	West Vallev Hioh School	0	0	0	0
62	Duckorino Buildino	0	0	0	0
63	Gruening Building	0	0	0	0
64	Elvev Buildino	0	0	0	0
65	Rasmusson Librarv	0	0	0	0
66	Statewide Services Buildino	0	0	0	0

TABLE B2–c

STRUCTURES OUTSIDE OF ANCHORAGE P(CARE) COEFFICIENT

NO	STRUCTURE	C1	C2	C3	C4	P(CARE)
1	VALDEZ					
2	Civic Auditorium	.8	1	.4	.3	.625
3	Min. Creek Bridge	.5	1	1	.5	.75
4	Watertank (tall)	.5	.5	.5	.3	.45
5	Watertank (short)	.5	.5	.5	.5	.5
6	Grain Silo	.5	.7	.9	.3	.6
7	Solomon Gulch Dam	.5	1	.5	.3	.575
8	Alveska Tank Farm	.5	.5	.5	.3	.45
9	Alveska Docks	.5	.5	.5	.3	.45
10	Alveska RE Walls	.5	.5	.5	.3	.45
11						
12	HOMER					
13	So. Penn. Hospital	1	1	.8	.7	.875
14	Bradley Lake Dam	.5	1	.5	.3	.575
15						
16	JUNEAU					
17	State Office Building	.8	1	.9	.3	.75
18	Federal Building	.8	1	.5	.3	.65
19						
20	SEWARD					
21	Grain Silos	0	0	0	0	0
22	Jail	0	0	0	0	0
23						
24	KENAI					
25	Performing Arts Building	.6	1	1	.5	.775
26						
27	ADAK					
28	Hangar Buildings	.6	1	.5	.4	.625
29						
30	SOLDOTNA					
31	Soldotna High School	.7	1	1	.5	.8
32						
33	KODIAK					
34	Container Dock	.5	.5	.5	.3	.45
35	Coast Guard Fac.	.6	1	.25	.3	.5375
36						
37	WHITTIER					
38	Buckner Building	.8	1	.9	.6	.825
39						
40	FAIRBANKS					
41	Basset Army Hospital					
42	Noel Wein Library	0	0	0	0	0
43	Federal Court House	0	0	0	0	0
44	State Courthouse	0	0	0	0	0
45	Police Headquarters	0	0	0	0	0
46	1st National Bank Building	0	0	0	0	0
47	Golden Towers	0	0	0	0	0
48	Great Land Hotel	0	0	0	0	0
49	Lathrop Building	0	0	0	0	0
50	Fairbanks Hospital	0	0	0	0	0
51	Nerco Building	0	0	0	0	0
52	New Borough Building	0	0	0	0	0
53	Old Borough Building	0	0	0	0	0
54	Polaris Hotel	0	0	0	0	0
55	Tanana Clinic	0	0	0	0	0
56	Northward Building	0	0	0	0	0
57	Eilson High School	0	0	0	0	0
58	Lathrop High School	0	0	0	0	0
59	North Pole High School					
60	Pearl Creek Elementary School	0	0	0	0	0
61	West Valley High School	0	0	0	0	0
62	Duckering Building	0	0	0	0	0
63	Gruening Building	0	0	0	0	0
64	Elvey Building	0	0	0	0	0
65	Rasmusson Library	0	0	0	0	0
66	Statewide Services Building	0	0	0	0	0

TABLE B2–d

STRUCTURES OUTSIDE OF ANCHORAGE RANK (A) AND RANK (B)

NO	STRUCTURE	RANK A	RANK B
1	VALDEZ		
2	Civic Auditorium	31.66667	68.38889
3	Min. Creek Bridge	55.1	82.55556
4	Watertank (tall)	10.44	55.22222
5	Watertank (short)	14.5	58.88889
6	Grain Silo	44.08	77.55556
7	Solomon Gulch Dam	18.93667	57.61111
8	Alveska Tank Farm	15.36	54.11111
9	Alveska Docks	15.96	55.88889
10	Alveska RE Walls	15.96	55.88889
11			
12	HOMER		
13	So. Penn. Hospital	70	89.16667
14	Bradlev Lake Dam	13.49333	54.27778
15			
16	JUNEAU		
17	State Office Building	42.5	75.55556
18	Federal Building	35.20833	71.11111
19			
20	SEWARD		
21	Grain Silos	0	30.66667
22	Jail	0	30.66667
23			
24	KENAI		
25	Performing Arts Building	46.62917	77.67778
26			
27	ADAK		
28	Hangar Buildings	23.75	62.83333
29			
30	SOLDOTNA		
31	Soldotna High School	40.432	74.06667
32			
33	KODIAK		
34	Container Dock	25.08	64.77778
35	Coast Guard Fac.	38.12667	74.36111
36			
37	WHITTIER		
38	Buckner Building	27.17	65.94444
39			
40	FAIRBANKS		
41	Basset Armv Hospital		
42	Noel Wein Librarv	0	20.83333
43	Federal Court House	0	0
44	State Courthouse	0	0
45	Police Headquarters	0	20.83333
46	1st National Bank Building	0	19.16667
47	Golden Towers	0	19.16667
48	Great Land Hotel	0	19.16667
49	Lathrop Building	0	19.16667
50	Fairbanks Hospital	0	20.83333
51	Nerco Building	0	15.16667
52	New Borough Building	0	20.83333
53	Old Borough Building	0	20.83333
54	Polaris Hotel	0	11.66667
55	Tanana Clinic	0	20.83333
56	Northward Building	0	13.33333
57	Eilson High School	0	20.83333
58	Lathrop High School	0	20.83333
59	North Pole High School		
60	Pearl Creek Elementarv School	0	20.83333
61	West Vallev High School	0	20.83333
62	Duckering Building	0	11.91667
63	Gruening Building	0	11.91667
64	Elvev Building	0	11.91667
65	Rasmusson Librarv	0	18.33333
66	Statewide Services Building	0	18.33333