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Preliminary Reports on Project 6.5
 Ground Motion Study -- Operation Ivy
 By W. R. Perret

Ref. No: 5110 (114)

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This report is based on first readings of records from the accelerometer stations on the several islands instrumented for ground motion during Operation Ivy. These data have indicated the necessity for some correction of the plotted data and revised playback of the records from two of the stations. Consequently the quoted values of peak acceleration, arrival time, and frequency are preliminary and subject to revision upon more complete analysis. The final report will be based on the revised analysis.

Only peak accelerations, arrival times, and first approximations of frequency are included in this report since integration to provide velocity and displacement information requires use of the corrected acceleration records, and sufficient time has not been available for a more thorough frequency analysis.

General Description of Instrumentation

The ground motion produced by Mike Shot of Operation Ivy was measured by means of three-component accelerometer installations. The components measured were vertical, radial (horizontal), and tangential (horizontal). The accelerometers, one for each component, were mounted in an 8-in. diameter bull-plug casing which was so designed that the density of the assembly was very closely matched to that of the sand. Six installations were made at distances between 8,302 and 114,182 feet from ground zero.

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Accelerometer assemblies at each station were installed in the native coral sand at a depth of approximately 17 feet below the ground surface. This depth, chosen on the basis of information derived from exploratory borings, placed the gauges in the sand below the water table and about 4 feet below the more massive

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IVY-0-1

CENTRAL M & R CONTROL NO. Q 27455-603
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layers of cemented or fragmented coral rock which occur in the reef. ~~of the islands (114)~~
situation.

Results of the Measurements

Data were obtained from four of the six accelerometer installations. In addition data were obtained from accelerometers attached to the recording shelter at one of the islands where underground instrumentation failed prior to the shot. No data were derived from one station as a result of failure of the recorder.

The table, appended to this report, includes data pertinent to the location of the gauge stations, set ranges, arrival times, and peak accelerations in both directions for each component at each station. A brief discussion of each installation follows which includes pertinent information regarding the instrument and recorder performance.

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Station 650.01 on Bogon -- 8,302 feet from Ground Zero

This station was less than 50 feet forward of the front wall of the recording shelter, Station 600. The carrier voltage for the recording system of Station 600 was drastically affected by motion of the shelter induced by the incident air shock wave. No usable data were derivable from the records at this station following onset of the carrier voltage fluctuations. As a consequence of this condition and the small difference in distance to ground zero from the two stations, only about 0.5 second of acceleration data is available. The first arrivals appear to be ground shock. No estimate of the air-shock-induced accelerations can be made because of the anomalous behavior of the carrier voltage. The frequencies of the first arrivals appear to be about 230 and 110 cps. These are probably high for ground shock and may be related to the natural frequency of the gauges, 145 cps.

Station 650.02 on Engebi -- 18,334 feet from Ground Zero

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This particular station was about 300 feet closer to ground zero than OCE Structure 3.1.1 and the recording shelter behind it, Station 601. The record shows distinct

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ground-transmitted and air-shock-induced accelerations independent of the carrier voltage anomaly which followed arrival of the air shock at the recording shelter. The frequency of the ground-transmitted acceleration was approximately 3.7 cps.

Station 650.03 on Muzin -- 21,264 feet from Ground Zero

The accelerometers at this station were only about 60 feet closer to ground zero than the associated recorder, Station 602. No specific carrier voltage anomalies have been found on the records of other gauges which were derived from the recorders in Station 602, and in the absence of a carrier voltage monitoring record for this station it is assumed that no carrier anomaly affected the accelerometer records. Distinct ground-transmitted and air-shock-induced acceleration pulses are evident on the records for Station 650.03. The frequency of the ground-transmitted acceleration was approximately 3.7 cps, and that of the air-shock-induced acceleration was about 7.5 cps.

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Station 650.04 on Bokon-- 30,672 feet from Ground Zero

The accelerometer installation at this station failed about two weeks before Mike Shot as a result of water seepage into the bull-plug case. Replacement of the assembly was not feasible because all construction machinery had been removed from the island prior to the gauge failure. As an alternative three accelerometers were attached to the ceiling and the rear and lagoon-side walls of the recording shelter, Station 603, to indicate the vertical, radial, and tangential components of the shelter accelerations. This shelter was 30,226 feet from ground zero. It was anticipated that these gauges would not give data identical with those derivable from buried gauges in a density-matched assembly. However, it was expected that some idea of the magnitude and pattern of the shelter motion would be obtained. The recorded accelerations for Station 602 show definite ground-transmitted and air-shock-

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induced pulses. The most notable feature of these data is that considerably greater peak values were recorded than would be anticipated in the ground from normal decay with distance. These high values are probably evidence of the reaction of the massive shelter and the underlying unconsolidated water-filled coral sand to the transient loading.

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Absolute times on this record are uncertain because of the absence of a blue-box zero-time signal at this shelter. Relative times are accurate within the precision of the 3-kc crystal-controlled timing signal. Arrival times given in the table are estimated on the basis of an apparent zero-time electromagnetic transient. These times are in reasonable agreement with estimated arrival times for the air shock. There appears to be approximately one second of acceleration signal prior to initiation of the carrier anomaly by arrival of the air shock.

The frequency of the ground-transmitted acceleration was approximately 3.7 cps. The frequency of the air-shock-induced acceleration appears on first analysis to be very nearly the same as the natural frequency of the accelerometers, 69 cps. The resonance probably associated with this fact may account to some extent for the unusually high peak accelerations of the air-shock-induced pulse.

Station 650.05 on Aomon -- 47,617 feet from Ground Zero

The recorder into which the outputs of the accelerometers for this station were fed failed to run, and no record of the accelerations was obtained.

Station 650.06 on Parry -- 114,182 feet from Ground Zero

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The acceleration records from this station show a ground-transmitted pulse for each component and an air-shock-induced pulse for the vertical component only. Absolute times for this station are uncertain because of the absence of a zero-time blue-box signal. However, relative times are precise within the accuracy limits of

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the 3-kc crystal-controlled timing signal. Arrival times given in the appended table are based on estimated arrival time for the air shock. A more precise definition of absolute times may become available from a revised playback of the records for this station.

Observed frequencies of ground-transmitted accelerations were approximately 4 and 1.4 cps. The frequency of the air-shock-induced acceleration was about 63 cps.

Discussion of Results

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Acceleration components recorded at Stations 650.02 and 650.03 on Engebi and Muzin are complete and should be satisfactory for reduction to velocity and displacement data after correction for some zero drift. The data from Station 650.06 on Parry should be suitable for velocity and displacement analysis, but the small magnitudes may make the results of only minor significance.

Analysis of the acceleration records from Station 603 on Bokon to give velocity and displacement data should be satisfactory, but the results must, of course, be considered in the light of structure response rather than purely ground response.

It is noteworthy that the set ranges indicated on the appended tables are in general higher than measured peak accelerations by a factor of 5 or more. These set ranges were derived from an LASL memorandum, J-9122, in which an estimate of the ground accelerations for Mike Shot was made. This estimate was based on Greenhouse George Shot accelerations and was scaled to the anticipated yield of Ivy Mike Shot with an included factor of 50 in the portion of total energy transmitted to the ground because of the decreased burst height. The data indicate that the factor of 50 was too high.

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 IVY ACCELERATION DATA (Preliminary)

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Station & Island	Distance from GZ ft	Component	Set Range	Time of Arrival sec	Source	Peak Acceleration		
						Positive g	Direction	Negative g Direction
650.01 Bogon	8302	Vert	18	1.38	Grd. 2.6	up	3.7	Down
		Rad	18		Grd. 3.8	In	1.5	Out
		Tang	9		Grd. 0.6	Counter	0.4	Clockwise
						Clockwise		
650.02 Engobi	18,334	Vert	4	1.30	Grd. 0.26	Up	0.21	Down
				6.69	Air. 1.27	Up	1.53	Down
		Rad	4		Grd. 0.28	In	0.22	Out
					Air. 0.52	In	0.39	Out
		Tang	2		Grd. 0.16	Counter	0.09	Clockwise
						Clockwise		
						Air. 0.23 Counter 0.33 Clockwise		
						Clockwise		
650.03 Muzin	21,264	Vert	3	2.14	Grd. 0.172	Up	0.211	Down
				8.60	Air. 0.726	Up	2.09	Down
		Rad	3		Grd. 0.188	In	0.185	Out
					Air. 0.675	In	0.460	Out
		Tang	2		Grd. 0.119	Counter	0.071	Clockwise
						Clockwise		
						Air. 0.205 Counter 0.265 Clockwise		
						Clockwise		
650.04 Bokon (603- Shelter)	30,672 (30,226)	Vert	2	2.60	Grd. 0.160	Up	0.165	Down
				14.54	Air. 0.880	Up	2.25	Down
		Rad	2		Grd. 0.132	Out	0.171	In
					Air. 0.063	Out	0.188	In
		Tang	2		Grd. 0.157	Clockwise	0.168	Counter
						Clockwise		
						Air 0.384 Clockwise 0.487 Counter Clockwise		
						Clockwise		
650.05 Aomon	47,617	Vert	0.8	No Record				
		Rad	0.8	No Record				
		Tang	0.8	No Record				
650.06 Parry	114,182	Vert	0.2	8.35	Grd. 0.028	Up	0.026	Down
				83.75	Air. 0.034	Up	0.039	Down
		Rad	0.2		Grd. 0.024	In	0.019	Out
					Air Not Played Back			
		Tang	0.2		Grd. 0.029	Counter	0.014	Clockwise
						Clockwise		
						Air Not Distinguishable		

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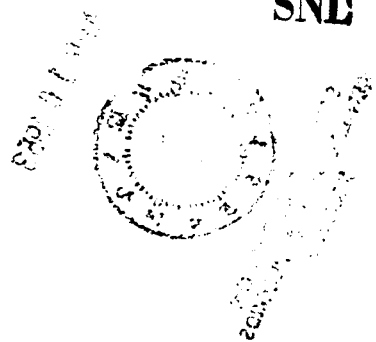
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