ACCELERATOR FOUNDATION MOVEMENT

OBSERVATION AND CONTROL PROGRAM

REPORT TO STANFORD LINEAR ACCELERATOR CENTER - NO. ABA-51

STANFORD UNIVERSITY SUBCONTRACT S-128

UNDER AEC CONTRACT AT(04-3)-400

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12 December 1962

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Variability in earth materials encountered on the Sand Hill site and the complexity of subsurface geological structure (both of which are typical of Coastal Range geology) introduce considerable uncertainty into the forecasts of accelerator housing movement. The severe limitations on allowable accelerator housing movement, together with the inescapable uncertainty in movement forecast, require that empirical confirmation of the forecast be obtained by instrumentation and observation on the site. The program outlined below has been planned to obtain the detailed information needed, particularly in the less stable areas along the accelerator centerline. The record of movement will be plotted and extrapolated to verify or modify the forecast movement and to permit offsetting the accelerator housing as necessary to compensate for subsequent movements and keep the accelerator within prescribed tolerances. In addition, the measurements after construction will provide data to check predicted settlement.

The proposed instrumentation includes rebound markers, settlement markers, and piezometers. The rebound markers will measure elastic response to load removal and will provide a means for determining initial (elastic) settlement under accelerator housing and surcharge fill load. Settlement markers in filled areas will permit an initial determination of long-term settlement due to consolidation under load and will provide a basis for verifying or modifying predicted settlements early enough to make any necessary changes in accelerator housing grades. Piezometers in the

surcharge fill area will similarly provide an early determination of the progress of consolidation at various depths which will again furnish the means for verifying or modifying predicted settlement in the area of maximum movement between stations 58+00 and 65+00.

It will very likely also be necessary to make field modifications in earthwork design, to alleviate potential earth movements for reasons of safety or to minimize accelerator housing movement. Following is an outline of the proposed ABA program for observing and controlling, where possible, movement of the accelerator foundation, and cut and fill slopes.

SURCHARGE FILLS

The accelerator centerline crosses a broad valley between stations 58+00 and 65+00. This valley is floored with a clayey alluvium, overlying a deep layer of silty claystone. Excessive settlement would occur in this area unless remedial measures were taken as noted in Dames and Moore Soils Report dated November 14, 1962. The clayey alluvium has been stripped to a depth of up to 20 feet in this area and replaced with select fill material borrowed from the hill east of the valley. A surcharge fill will be placed in this area as an early phase of the Initial Excavation contract to preconsolidate the underlying claystone as much as possible prior to accelerator housing construction. The surcharge fill will be brought to a height 10 feet above final fill grade.

A surcharge fill will also be placed on and to the south side of the accelerator centerline, approximately between stations 37+00 and 46+00. This fill is needed to preload and preconsolidate deep alluvium in the San Francisquito Creek valley, which will lie beneath the southern half of the

shielding fill in this area. The accelerator housing will cross this area on competent foundation material just north of the deep alluvium. It is therefore not necessary to strip and replace the alluvium to prevent excessive settlement of the housing itself, as was done in the area between stations 58+00 and 65+00.

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REBOUND MARKERS

Primary markers have been placed in exploratory boreholes kept open for this purpose. This was not completely satisfactory because of uncontrollable caving of the borehole walls during backfilling of the hole to bring the marker to the desired elevation. Additional markers were placed during a supplementary drilling program in the surcharge fill area between stations 58+00 and 65+00, prior to commencement of stripping cut operations. These were unrecoverable because of subsequent changes in the depth of cut required. Table 1 following shows actual location of the rebound markers placed (excluding the unrecovered supplementary markers in the surcharge fill area), their elevations, and the elevation of the subgrade below accelerator housing at the same stations.

REBOUND MARKERS

Designation	Location		Elevation of Markers	Elevation of Subgrade below Accelerator Housing
BR 6	1+38.5	(S-6)	296.95	296.5
BR 1	4+03	(S-11.6)	302.90	295
-	7+60.6	(S-3)	291.53	293.6
BA 10	9+09	(N-11.5)	298.21	292.6
BA 12	12+16	(S-6.6)	285.64	291
BR 3	14+00	(N-2)	289.78	290
BR 8	15+50	(N-7)	287.29	289
BR 9	16+77	(S-36)	309.69	289
-	18+39	(℄)	283.57	288
BR 11	22+81	(N-9.4)	281.66	285
BA 26	25+49	(N-18.4)	293.17	284
BR 12	26+25	(S-3)	284.50	283
BA 25	27+08	(N-15)	287.19	283
-	27+20.3	(℄)	280.93	283
BR 13	29+30	(N-17.7)	293.38	282
BR 14	36+25	(℄)	274.95	278
BA 37	50+85	(N-8)	265.62	271
BR 19	51+85	(N-13)	281.01	271
BA 7	54+00	(N-5)	265.82	269
BR 18	70+34	(℄)	261.41	262
BA 49	80+90	(N-1)	262.79	256
-	82+25.3	(℄)	251.86	256
BR 17	86+66	(N-5)	272.21	254
-	95+10.7	(℄)	245.45	250
BA 54	109+86	(S-2)	243.68	244

Initial measurements on markers placed at the base of the replacement fill show settlement ranging from 6 millimeters in shallow fill area up to 35 millimeters at the deepest point in the fill. Some of this settlement is attributable to compaction of a few inches of loose fill material placed to level the base plates of the settlement markers.

Auxiliary rebound markers will be placed at intervals of approximately 50 feet along the floor of cut areas after the excavation is open, with the location and interval depending upon the geology exposed. Observation of these markers will permit measurement of rebound occurring after the load has been removed. Measurement of rebound occurring during unloading will be dependent upon the recovery and reobservation of markers placed prior to excavation, such as listed on Table 1.

Initial observation of rebound markers will be made immediately upon recovery, as soon after excavation is completed as possible. Auxiliary markers will be placed and observed as quickly after completion of excavation as possible. Subsequent observation will take place at about two-week intervals.

SETTLEMENT MARKERS

Settlement markers will be placed at the base of foundation fill along the accelerator centerline, at intervals of 40 to 100 feet, with the spacing dependent upon geological conditions uncovered. Markers will also be placed in the floor of the accelerator housing at 40 foot intervals, to check actual movement of the housing during the remainder of the construction period and prior to beam turn-on. Supplementary markers will be placed in areas of particular concern in the fill, adjacent to the housing, to compare settlement of the fill with settlement of the housing.

Markers will also be placed at the top of the fill at intervals corresponding to the settlement marker location and spacing in the housing below. Comparison of the readings taken on the markers at the top of the fill with those taken in the housing will provide measurements of differential settlement between accelerator housing and klystron housing which would affect the wave guides. Settlement markers at the bottom of the fill will record movement in the underlying materials, with those in the housing showing housing response to the deep settlement.

Markers will be observed upon placement which will occur as soon after completion of the cut, housing, or backfill (whichever is appropriate) as possible. Markers will be observed at about two-week intervals thereafter.

Settlement markers have already been placed, as noted earlier, at 50 foot intervals along the base of the replacement fill in the surcharge fill area, from stations 57+00 to 63+00. These markers are composed of a horizontal base plate to which a vertical pipe riser is attached and carried up through the fill. Movement of the base plate is measured by observations of the elevation of the top of the pipe riser.

Additional markers of a different type have been installed in the surcharge fill area at stations 58+00 to 62+00 inclusive at the top of the pipe risers which are attached to the base plate at the bottom of the replacement fill. These markers are the California Division of Highways water-level markers, which consist of a device for establishing a water level at a settlement marker inside the fill and carrying the same water level to an observation point outside the fill. The advantage of this type of marker is the lack of obstruction to construction equipment which is

afforded by eliminating the vertical pipe risers. A disadvantage is the necessity for making the observation at the same level inside and outside the fill. In the case of the replacement fill, the markers at the base of this fill were at the bottom of a cut, and it was not therefore possible to establish a level line outside the fill without digging a hole the same depth as the cut. Therefore the base plate and riser type was used at the base of the fill and the water-level device at the top of the replacement fill.

Additional settlement markers, of the water-level type, are planned for installation in the second surcharge fill area, on the south side of the centerline between stations 37+00 and 46+00. The water-level type will probably be used rather than the base plate and riser type for the bottom-of-fill locations, if they are found to operate satisfactorily in the surcharge fill area.

PIEZOMETERS

Piezometers will be installed at two locations on centerline in the surcharge fill area, near station 60+00. Sensing points will be established at 3 levels in each hole to observe pore pressure changes at these levels in the underlying materials. No other piezometer installations are planned at present. The installation of these piezometers is expected to start as soon as the equipment is received.

Observation of piezometer pressures will be made upon initial installation, during surcharge fill placement, and at two-week intervals after completion of the surcharge fill. Piezometer readings will provide indication of the progress of consolidation and will verify or disprove the predicted settlement at an early stage in the settlement process.

INITIAL EXCAVATION OBSERVATION

Actual conditions will be observed during excavation of the initial 3000 foot length and necessary modifications in design slopes made. Instrumental and visual observations will be made to determine slope behavior following excavation. Surveys will be conducted on the floor of the excavation to measure rebound in the various materials exposed. Some over-excavation and replacement of materials exposed in the floor of the cut may be necessary to avoid stress concentration at boundaries of sharply-differing bearing capacities. The floor of the cut will also be used to make precise horizontal surveys to determine the amount of horizontal movement in the western portion of the site at accelerator housing level. Measurements made to date have observed surficial movement, with reference to deep marks at only 3 locations along the 14,000 foot length of the site. These do not provide sufficient information to determine the character of horizontal movement at depth. The western end of the site, in close proximity to the San Andreas fault, has shown greater movement than the eastern end, and should be observed in detail at the housing level to establish the nature and magnitude of the movement in this location.

FIELD MODIFICATION

Actual conditions observed during excavation will require design modifications in order to insure appropriate slope stability. The initial 3000 foot excavation will be observed carefully during the period prior to housing construction and the information obtained on slope behavior and remedial measures used to make any necessary modifications in the design for the remaining 7000 feet of accelerator length.

RECOMMENDATIONS

It is recommended that the cut be kept open for approximately 9 months' time in order to permit the accumulation of the various types of information discussed above.

During housing construction and backfilling, settlement markers will be observed to check the settlement forecast, which will probably have been modified by information obtained from previous observations. This program of observation will be continued through the entire construction period, and results will be used to check the rate and amplitude of predicted settlement. Observations should also be continued during accelerator operation, for continuing check on rate and amplitude of accelerator response to ground movement.

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