A PRELIMINARY REPORT ON RATE OF CHANGE OF CURVATURE ALONG THE ACCELERATOR ALIGNMENT

REPORT TO STANFORD LINEAR ACCELERATOR CENTER - NO. ABA-63

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This preliminary discussion of the estimated rate of change of curvature is primarily concerned with changes caused by vertical movements, and is considered in terms of departure from a straight line for any one of two consecutive points spaced 40 feet apart along the entire length of the accelerator housing. No "small scale" data on horizontal movements at housing level have been developed to date. The estimates all apply to the 10 year period following October, 1965.

BASIS OF ESTIMATES

Several simplifying assumptions were made in arriving at the estimated rates of change of curvature. Basically the estimates are based on predicted settlements from the Dames and Moore soils report, the geological map of the site, and assumptions regarding the geometry of the soil settlements and interaction of the accelerator housing. The estimates have been made for three separate cases.

Case I is for the housing as an articulated structure.

Case II is for the housing as a continuous structure.

Case III is for the accelerator tube independently supported by piles through unfavorable areas.

Curvature due to a differential settlement is a function of the shape of a given settlement as well as the magnitude. The greatest uncertainty of the estimates arises in evaluating the shape

The rate of change of curvature under consideration is caused by the consolidation, or long term portion, of the earth settlements. The effects of the overexcavation and the surcharge which is to be placed near station 60 have been considered. It is also assumed that minor overexcavation of 5 to 10 foot depth will be made at various locations as recommended in the Dames and Moore report.

CASE I, HOUSING AS AN ARTICULATED STRUCTURE

For Case I, the accelerator housing as an articulated structure, it is estimated that the maximum rate of change of curvature will be 0.05 inches in 90 days but might range from 0.02 inches to 0.12 inches.

The structural behavior of the accelerator housing as an articulated structure is somewhat analagous to a floating log boom. Each joint in the housing has no appreciable longitudinal bending strength and acts as a hinge. In terms of its' entire length the housing readily conforms to movements of the surrounding soil, but each segment is relatively stiff and undergoes no appreciable change in shape. Articulation would be in 40 foot modules so that each accelerator tube support point would be close to the center of rotation of that segment thereby providing some attenuation of curvature on short to moderately long zones of settlement.

CASE II, HOUSING AS A CONTINUOUS STRUCTURE

For Case II, the housing as a continuous structure, the estimated rate of change is 0.02 inches in 90 days, but might range from 0.01 inches to 0.12 inches.

If the accelerator housing is built with full longitudinal bending strength through the construction joints it behaves as a continuous structure. Figure 1 was used as a guide in evaluating the interaction of the housing, shielding fill, and foundation materials. Although based on an assumed geometry it is probably as accurate as warranted by presently available data on the curvature the soil materials will assume by themselves. For a radius of curvature which creates a low bending stress in the concrete housing, the housing will essentially follow the curvature of the adjacent soils. For radii of curvature which create relatively high stresses in the concrete the housing offers appreciable resistance to the curvature, and, up to the limit of the housing's strength, will reduce the curvature. Along the extended area of large predicted settlements near station 60 the housing will essentially follow the predicted settlements whether continuous or articulated. In the western portion of the alignment where narrow zones of compressible foundation material are anticipated the behavior will vary. For very narrow zones, say 5 or 10 feet, a continuous housing will essentially resist a major portion of the settlement which a completely flexible housing would undergo. An articulated structure would behave almost as well as a continuous one for these narrow zones of weak materials.

Through areas where the thickness of weak strata range somewhat wider, say 20 to 60 feet, the continuous structure will deflect considerably less than the articulated structure. A more exact knowledge of the geological structure of these areas will have to await the earthwork excavation since it was not economically feasible to obtain this detailed geology by other means.

CASE III, ACCELERATOR TUBE ON PILES

For Case III, the accelerator tube supported by piles which are independent of the housing and the most critical foundation materials, the estimated rate of vertical curvature is 0.01 inches in 90 days but might range from 0.005 inches to 0.02 inches.

As discussed in ABA-62, supporting the accelerator tube on independent piles has no effect on accelerator housing and klystron gallery settlements. Problems such as wave guide bending which result from the differential movement between the accelerator tube and klystron gallery are not solved.

DEEP SEATED MOVEMENTS

Vertical ground movement surveys to date have indicated that vertical deep seated movements will be of less significance than the construction earthwork effects. The vertical surveys have included reference points at 100 foot spacings along the surface but the deeper vertical marks are at least 800 feet apart. A few of the vertical marks at 100 foot spacing have shown significant rates of change, but the improved stability of the deep marks gives reason to believe these movements may be surficial in nature.

Effects of the Ladera Flood Control Project and large magnitude earthquakes are not included in the estimates. Although an intensive investigation was not made, the Dames and Moore report indicates that movements induced by the Ladera Flood Control Project would be of minor significance.

Even if severe flood flows were to induce elastic movements which exceeded the estimated rates of change of curvature these movements should follow a predictable pattern and a measure of advance warning would be available. Present indications are that if the dam is built it will be much smaller and hence have only a minor effect on housing movements.

Earthquake effects cannot be accurately forecast in time. All geological investigations to date have disclosed no historically active faults crossing the alignment, hence the possibility of an offset in the housing is considered extremely remote. The most likely result of a strong earthquake in the immediate vicinity is the release of shear strain in the eastern block of the San Andreas fault. This would result in a bow in the alignment concave southerly. Based on Byerly's estimate of strain such an action might produce as much as a 6 inch bow in the accelerator housing. Although this magnitude of bow could be obtained by a uniform rate of change of .001 inch per 40 feet throughout the accelerator length, such regularity along the entire accelerator alignment appears very unlikely, and in localized areas the rate of change would probably be 1 or 2 orders higher.

Horizontal ground movement measurements to date have indicated rates of movement which are of the same order of magnitude as the predicted soil settlements when the measured rates are extrapolated. There is no reason for believing that horizontal movements will attenuate with time in a manner similar to soil settlements caused by construction earthwork.

The reference marks, however, are at least 700 feet apart hence these measurements provide practically no basis for determining rates of change of curvature per forty feet. A few of the horizontal marks are referenced to deeper marks up to 50 feet below the surface. These deeper marks show considerable attenuation of movement with depth.

The estimated maximum rate of change of horizontal curvature is 0.02 inches in 90 days but with a possible range of from 0.005 inches to 0.08 inches. It should be noted that these estimates of the rate of change of curvature are based on quite meager data.

CONCLUSIONS

Until measurements of horizontal movement can be made with closer spacing of marks at accelerator housing level, estimates of rate of change of horizontal curvature will have low reliability.

As excavation for the accelerator housing construction proceeds and as results of the rebound and settlement marker measurement program become available, the estimates of rate of change of vertical curvature will also be subject to further refinement.

The design of the accelerator housing is proceeding on the basis of providing a continuous structure except where abrupt section changes or overstressing will require joints giving articulation.