CONTROL OF STRUCTURE INCLUDING SOIL-STRUCTURE INTERACTION EFFECT

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Introduction: The effectiveness of active control of engineering structures are very much dependent on the design of mathematical modeling. The discrepancy between the mathematical model and the real structure leads to the ineffective control design, offsetting the aim of control design and sometimes the outcome is even adverse leading to the failure of structure. A similar kind of situation may occur in the active control design of civil engineering structures against seismic forces. The control laws for civil engineering structures are usually developed considering a fixed foundation base and neglecting the effect of any interaction between the soil and the structure. On the other hand, if the soil is very soft and the structure is quite massive, the interaction between the two is quite prominent. Under the afore mentioned condition, the performance of control scheme deteriorates and hence calls for a remedy. In this study, a two step remedial approach has been adopted.

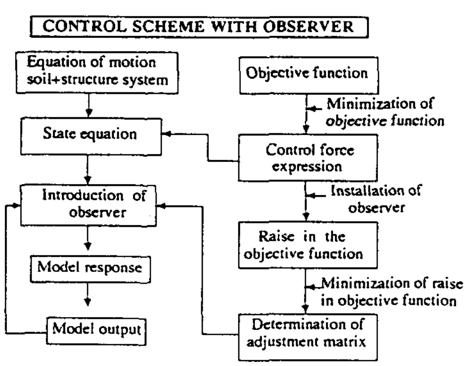


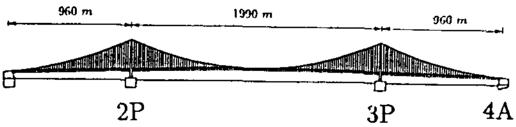
Fig. 1

In the first step a simplified model of soil-structure interaction (SSI) is included in the control law in order to represent the real structure behavior. Secondly, the error in the soil parameter prediction is avoided by the use of an observer. Observer acts as a parameter regulator which adjust the controller response with the changing parameters of structure and soil. A new control scheme using an acceleration type observer is developed and system performance with and without observer is compared.

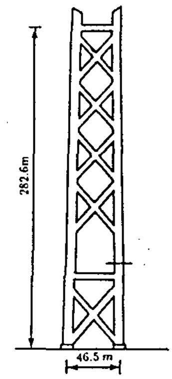
Control System Layout : The development of soil-structure system, the optimal control law and the introduction of an optimal observer is represented by a flow chart as shown in Fig. 1.

Numerical Results : The Akashi Kaikyo bridge tower resting on foundation 2P has been selected. This foundation is selected particularly as it is resting on Akashi stratum, in which the shear wave velocity V_S of seismic wave is between 400-500 m/s, whereas the design value of V_S is 910 m/s. The discrepancy between the design value and the real value of the soil parameters lead to the modeling error, which is used to observe the effectiveness of the proposed active control scheme.

Controller Design : Four types of control scheme have been designed and checked for their performance
Case I: Control model with fixed base assumption and without an observer
Case II: Control model with fixed base assumption and with an observer
Case III: Control model including soil- structure interaction and without observer. Here



(a) Elevation of Bridge



(b) Tower Elevation

Fig. 2

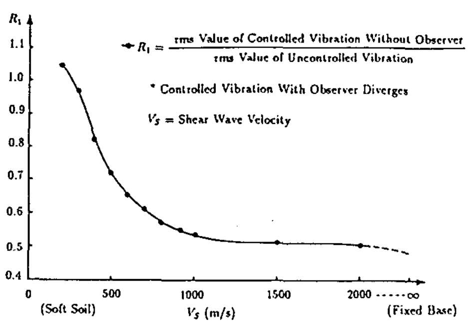


Fig. 3

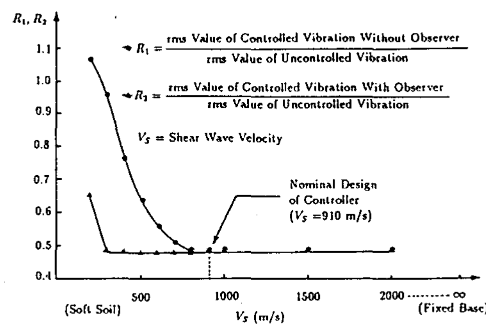


Fig. 4

the nominal value of Shear Wave Velocity V_S is taken as 910 m/s.

Case IV: Control model including soil- structure interaction and with an observer. Again the nominal value of Shear Wave Velocity V_S is taken as 910 m/s.

The performance of the control schemes are expressed by plotting the ratio of root mean square (rms) values of real structure (at top of the tower) to their corresponding uncontrolled vibrations with that of shear wave velocity V_S. Figs. 3 and 4 represent the fixed base and that with soil-structure interaction effect included, respectively.

Conclusions : The numerical results shows that the conventional control scheme with fixed base assumption is not so effective for soft soil case, whereas the control scheme with the soil-structure interaction and with an observer is robust even for the soft soil with changing parameters.