NOTE: Place all answers in the space provided. The questions are general in nature but respond specifically to key issues.

1. Describe an approach to characterize the foundation k value based on slab curling/warping behavior for multiple layers.

2. In the development of the medium thick plate equation, explain the significance of assuming plane strain boundary conditions.
3. Explain why past and present versions of the AASHTO Pavement Design Guide inadequately addressed the load behavior of CRC pavement relative to the determination of the design thickness.

4. Describe an approach to calibrate a slab cracking model for design purposes based on fatigue damage.
5. Describe how you would configure a design procedure for JCP that uses the elastic modulus of the soil as an input for construction control purposes but calculates slab stresses using a winkler foundation for design purposes.

6. Discuss the implications of using a ‘contraction design’ for the construction of low-volume concrete roads.
7. Discuss the issues regarding k-value and the computation of a composite k-value as suggested in the PCA or the FAA design procedures.

8. Relative to Dr Lytton’s lecture on subgrade theories, what subgrade model could you suggest to improve the characterization of the subgrade effects in design? Discuss the parameters and tests you would conduct to measure those parameters. Also, suggest a program of study to verify the accuracy or applicability of your model to design.
9. Where would you tell a home owner to place joints in his concrete driveway to prevent uncontrolled cracking? Distinguish between a concrete slab tied to the foundation of the home versus a slab at some distance from the home. (Note: Most driveway slabs are 4" thick.)
10. A 17" concrete runway pavement in Reno, Nevada jointed with dowels at 18' intervals displayed the following random cracking soon after construction:

This pavement was placed on a open-graded, AC stabilized subbase. It was paved at night during the spring and summer months. Make conclusion as to the possible causes of this cracking and suggest experiments you could conduct to verify your conclusions. (See the supplementary information provided with this question).
Appendix

Reno-Tahoe International Airport

The Runway 16R/34L at the Reno-Tahoe International Airport has displayed several types of uncontrolled cracking in portland cement concrete pavements which were placed during the year 1994. Other pavement was placed both in 1993 and in 1995 on the runway and associated taxiways which do not show the same magnitude of uncontrolled cracking. Three types of uncontrolled cracking were observed on the runway each due to different causes.

BACKGROUND

Location of Pavements Investigated

Runway 16L/34R was constructed in 1993, extending to the north beyond the end of Runway 16R/34L. In 1994, major repair was performed on Runway 16R/34L. The keel section along the runway was replaced, as well as other slabs adjacent to the keel section. Then, in 1995, the extension of Runway 16R/34L was constructed to Taxiway A at the north end of the airport pavement.

The pavement joint and structure designs were similar but different in each of the three years of construction. The new Runway 16L/34R was constructed with 18'-9" by 20' joint spacings with 17 inches of portland cement concrete (PCC) on an asphalt treated permeable base (ATB). In 1993, construction notes indicate that the ATB was compacted more tightly than the ATB that was placed in 1994 or 1995. The structure of the Runway 16R/34L reconstruction is identical, but the joint spacing is 12'-6" by 16'-8" which is shorter in both directions than the joint spacing of 16L/34R. In 1995 Runway 16R/34L was extended using the same joint spacing as the reconstructed portion of the runway, but the pavement structure was changed.

The longitudinal construction joints were drilled and 1- 1/4" dowels 20" long were placed with a 15" spacing on centers. Longitudinal contraction joints had #11 tie bars which are 20" long and 15" on centers. The transverse contraction joints had 1- 1/4" dowels, 20" long, and 15" on centers.
**Observed Cracking on Runway 16R/34L**

Some time after the concrete pavement slabs were placed on Runway 16R/34L, a certain amount of cracking was observed. Three distinct causes were identified to explain the different types of cracking observed. Longitudinal cracking was found at the centerline of many of the paving lanes, transverse cracking at the beginning and end of several concrete pours was found, and many joints had transverse cracking very near the dowels along those joints.

*Longitudinal Cracking*

Longitudinal contraction joints were provided at the third points of the paving lane, making three slabs 12.5 feet wide in the longitudinal direction in each paving lane. The original design called for two 12.5 feet slabs per paving lane for a total paving width of 25 feet. This change in the paving pattern was suggested by the contractor and approved by the designer. Uncontrolled cracking was found at the centerline of the paving lanes, instead of at the intended sawcut joints at the third point.

*Transverse Cracking*

Transverse cracking is manifested in two types. The first is a transverse crack that is found about 1 1/2 longitudinal slab lengths from the beginning or the end of the daily paving operation.

*Pavement Design*

The runway pavement consists of 17 inches of portland cement concrete on an asphalt treated base. The concrete placed in 1995 on Runway 16R/34L has, in addition to the pavement structure previously indicated, a thin layer of sand at the interface between the slab and the subbase. This layer of sand reduced the friction between the two structural layers.

The joint design originally consisted of 6 paving lane passes of 25 feet wide for a total runway width of 150 feet. Each paving lane was to have one longitudinal sawcut down the centerline of the lane, resulting in two slabs per paving lane each 12.5 feet wide. The sawcut joints at the middle of the paving lane contain tie bars to hold the cracks closed after the concrete had cracked at the sawcut location.

Contrary to the original pavement design, the contractor asked for permission to pave the runway
in four 37.5' wide passes. To compensate for the extra width of each paving lane, two longitudinal sawcut joints were placed with tie bars at the third points of each paving lane. Thus, the resulting slabs are still 12.5 feet wide, but instead of a total of six longitudinal sawcut joints across the width of the runway, there is a total of eight, or two on each of four paving lanes.