CHAPTER 6

CONCLUSION

A jointless construction of multi-span simply supported girders may be considered as a link slab, which is a continuous reinforced concrete deck slab. Continuity of the bridge deck to eliminate gaps or expansion joints between adjacent spans is desirable to improve serviceability and durability of structures. The link slab supposes to accommodate end movements of highway girders which are axial deformation, end rotation and end translation. The finite element method of the microplane model (MASA) will be a tool for the structural analyses of crack patterns, crack width, modes of failure and structural responses of each action with different details and thickness-to-span ratios. Full-scale experimental investigation of 3 specimens of different reinforcing details of hinge, semi-continuity and full continuity with mid-span loading has been conducted to verify the results of the analyses. Monitoring of actual behaviors of real structures has also been done for comparison of some essential behaviors. The structural behavior with regard to principal parameters in the study following conclusion can be made:

1. End movements of typical precast highway girders are studied to understand the end movement behavior due to girder type, span length, creep, shrinkage, steel relaxation, live load, temperature gradient and ambient temperature. The amount of end movements of simply supported girders is major related to span length and minor related to section type and construction time. Ambient temperature is dominated for axial deformation, and live load is dominated for end rotation. The combination of extreme cases for maximum shortening and downward rotation would be significant to the link slab boundary and end restraints.

2. Link slab model of the MASA finite element method has been employed as a tool to the study of crack pattern, crack width, load-deflection relationship and failure mode. The behavior of link slabs with various lap reinforcement details and thickness-to-span ratio has shown that the reinforcing details would affect the stress distribution along the span due to axial deformation, end rotation, end translation and mid-span loading. The cracking behavior under each action is presented and the model of effective moment of inertia under each action after cracking is also proposed.

3. A full-scale test series of three slab specimens with different details of lap reinforcement and mid-span loading are tested to failure to verify the numerical solutions and their actual behavior. They have proved the flexural and shear strengths under load with respected to deformation, cracks and the mode of failure.

4. An interaction model among three component of restraints of axial deformation, end rotation and end translation can be formulated through the relative stiffnesses of link slabs, adjacent girders and support conditions. The support conditions by means of the structural system as number of girder spans as hinges (H-H) or rollers (R-R) are also considered in the model. The restrained end rotation and axial deformation in link slabs due to axial deformation and end rotation in highway girder are less affected by the support level (*x/H*) in the R-R support condition and are less affected by the centroid of girders (*Cb/H*) in the H-H support condition.

5. The use of elastomeric bearings supports for the precast girders would have treated the overall structural system to float on the supports, then the end moments due to rotation is dominant instead of the axial force. It have shown that the stiffness of the link slab is much smaller than the stiffness of composite girders, then the continuity of the girders introduced by the link slab is negligible and this is shown in the rotational interaction model. If the relative stiffness between composite girders and link slabs is less than 10, the continuity is introduced by link slabs and the end rotation can be reduced more than 10 percent of end rotation of simply supported girders. Under this rotational restraint, the axial deformation and end rotation can be generated in the link slab boundary which can be converted to axial force and moment related to link slab stiffness.

6. The stiffness of elastomeric bearing would be related to the structural systems with the number of continuous jointless spans with link slabs and its position. The elastomeric bearing pad is designed for allowable movements at each position due to elongation along the route. The additional axial force in link slabs due to elastomeric bearing deformation is determined by summation of elastomeric friction forces through the free end. The additional moment and shear from translational restraint (end translation and moving load) due to differential settlement of elastomeric bearings are also the actions of link slabs. The moment due to wheel load is also determined.

7. On-site monitoring of an existing elevated highway girders of the structural system with link slabs is done to verify the interaction model. The horizontal movement of girders is looped movement following the looped ambient temperature with 2 hours time lag. The longitudinal movement of end girders at free end of the continuous deck is

more than one at the mid-route of continuous deck because of the horizontal stiffness of elastomeric bearing. And the end rotation of end girders at free end of the continuous deck is also much more than at the mid-route of continuous deck because of the restraint of link slab and elastomeric bearing stiffness.

8. Under the determination of restraint in link slab and understanding of link slab behavior, the design criteria and design approach for link slabs of multiple spans with elastomeric bearings of specific provisions are developed to accomplish the service life under the strength and serviceability limit state. The structural response as the internal forces and deformations can be determined from the interaction model.

9. To design for strength of link slab, the maximum axial force must be controlled by tensile reinforcement as which the bending moments at mid-span and both ends shall be controlled by coupling of compression of concrete and the tensile of the reinforcing steel to encounter the resisting moment. Shear which is subjected to the moving loads is designed for concrete resistance.

10. To design for serviceability, crack control by means of tensile reinforcement with regard to specific details. Support conditions as per its position in the structural system and the stiffness of elastomeric bearing pad can be adjusted to proper manner in operation and maintenance. Finally, the crack width and crack distribution can be controlled by a larger size bar, reducing the bar spacing and reinforcement detailing. If the crack width can not be controlled, it is forced by reinforcement detail to happen at one position to be easily maintained.