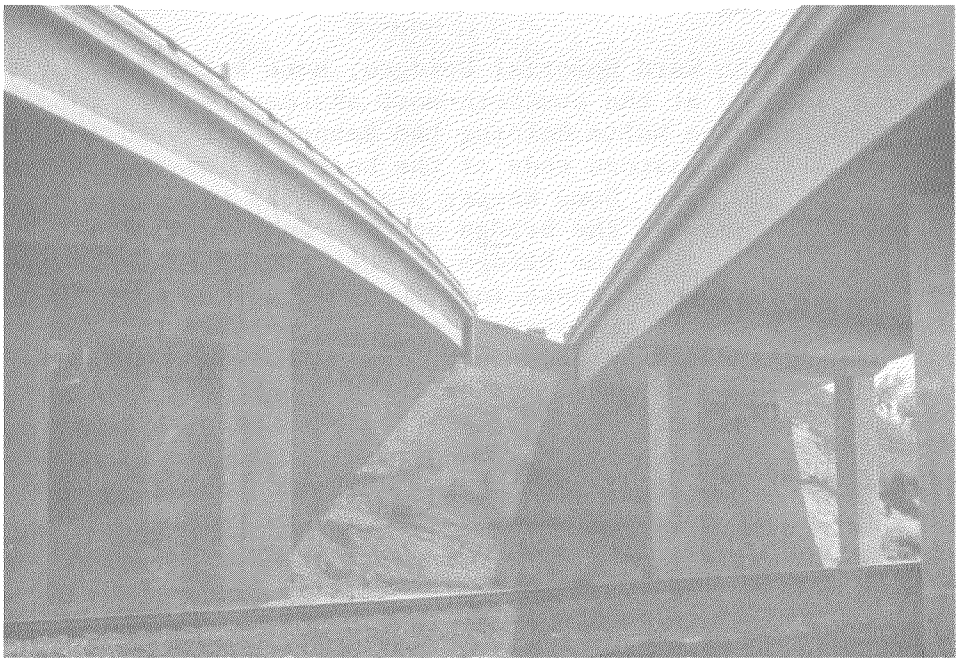

Fig. 5.5 Ward Memorial Boulevard bridges. View looking south towards southern abutment.

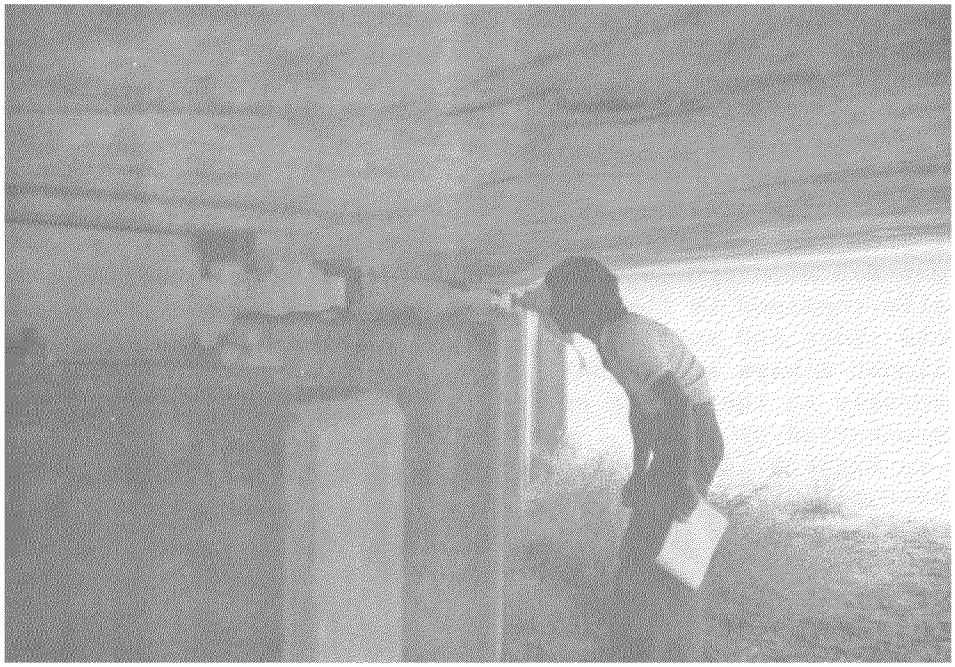

Fig. 5.6 Support of Ward Memorial Boulevard bridge deck at southern abutment. View shows piers capped by damaged rocket bearing assemblies under bridge on left in Fig. 5.5.

bearings as seen in Fig. 5.8. Additional lateral restraint is provided by two 1" anchor bolts that protrude from the masonry plate in front and back of the bearing.

On both of the Ward Memorial bridges, some bolts holding the keeper plates were sheared at the southern-most abutment. More specifically, it was found that the bolts holding the keeper plates to the sole plates were sheared at the eastern ends of the bearings, as can be observed from Figs. 5.7 and 5.8. Some keeper plate bolts were also sheared at the northern abutment of the bridge on the right in Fig. 5.4, and at the intermediate supports of the bridge on the left in Fig. 5.4. Although the pattern of failure at these locations was more random than at the southern-most abutment, the overall evidence pointed to an earthquake induced clockwise rotation of both bridge decks when viewed from above. The magnitude of the permanent lateral shift at the southern abutment, measured between masonry and sole plates, was found to be more than one inch. The deck rotation caused the bridge decks to slam against the southern abutment thereby cracking the abutment backwalls, and cracking, spalling, and pushing away the wingwalls and curtain walls. A close-up of a broken curtain wall alongside the bridge on the left in Fig. 5.5 is shown in Fig. 5.9. The rotational motion also displaced the concrete bridge decks at the expansion joints. A typical example is shown in Fig. 5.10, which shows a view north from the southern abutment along the edge of the bridge on the right in Fig. 5.4. Figure 5.11 shows a wingwall that cracked due to the bearing action against it of the abutment backwall. There was also evidence of considerable longitudinal motion at the southern abutment as seen from Fig. 5.12 which shows the disengagement of an aluminum pipe railing at a sleeve joint in the vicinity of the deck expansion joint. The movement there must have exceeded 3" to cause the separation. The gaps between the expansion joints at the southern abutment were found to have widened indicating that the abutment backwalls were pushed towards the approach fill. In general, the shifting of the decks caused adjacent deck sections to impact at several expansion joint locations which cracked and spalled the concrete along the deck edges. An example is shown in Fig. 5.13.

Most of the Ward Memorial bridge bents sustained damages that ranged from light cracking, incipient spalling, to localized deep spalling that exposed reinforcement bars. The location of these damages was generally confined to the tops of columns extending sometimes to the vertical sides and soffits of the bent caps. The spalling and cracking were almost always at diagonally opposite corners of the columns oriented transversely to the bridge centerline. Deep spalling that exposed rebars occurred at corner locations of three columns, of which two are shown in Figs. 5.14 and 5.15. Note the exposed #10 rebars which have been bent out.