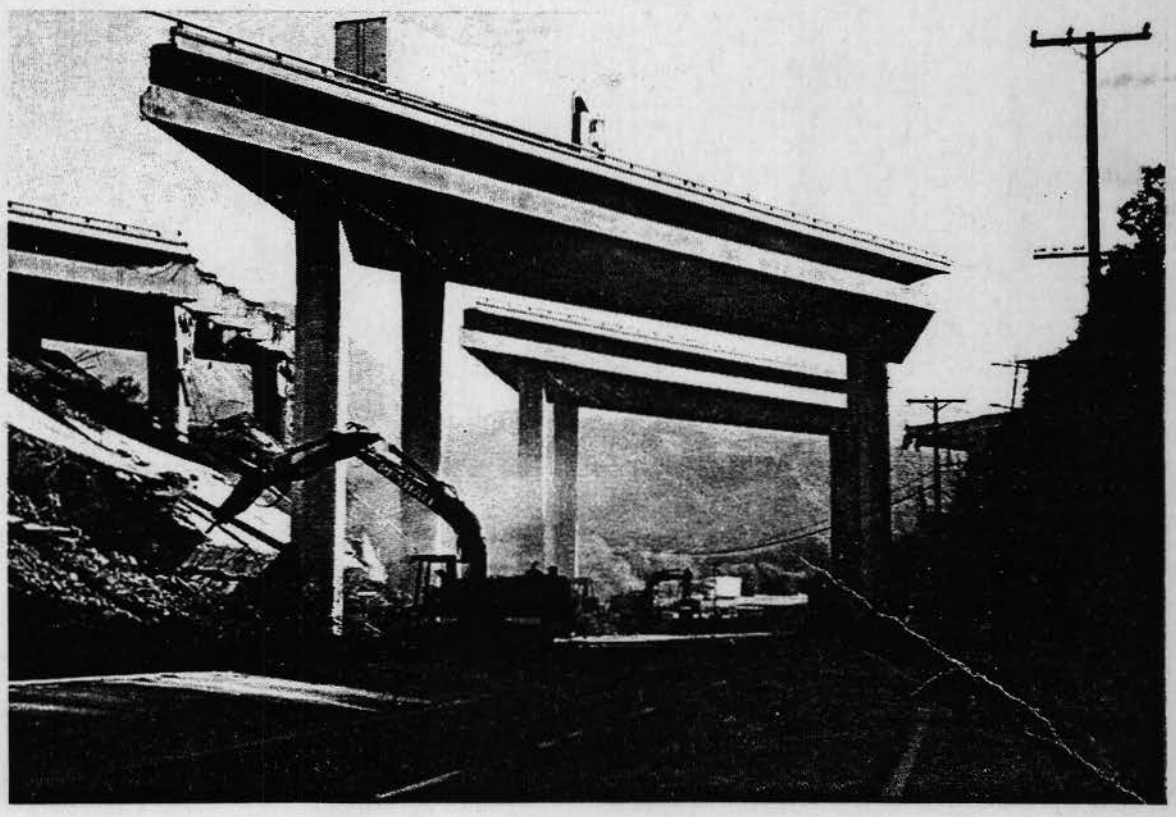
The Northridge Earthquake

Post Earthquake Investigation Report



California Department of Transportation - Division of Structures

California Department of Transportation

Division of Structures

PEQIT

(Post Earthquake Investigation Team)

Report

Northridge Earthquake

17 January 1994

ACKNOWLEDGMENTS

Members of the Northridge Earthquake Post Earthquake Investigation Teams, Ali Asnaashari, Bob Tanaka, Ann Gilbert Sardo, Tom Sardo, Joe Downing, Ruth Fernandes, Mike Keever, Jim MacIntyre, and Brian Maroney would like to thank the following people for their assistance to the PEQIT team effort.

Jim Roberts, Acting Deputy Director, Transportation Engineering; Tom Pollock, Acting Chief, Division of Structures; Mickey Horn, Acting Chief, Office of Structure Design; Jim Gates, Chief, Office of Earthquake Engineering; Floyd Mellon and Jerry McKee, Design Supervisors; and Rick Land, Special Projects Branch Supervisor for their total support and personnel resources to conduct the field investigation and this report writing effort.

Ray Zelinski, PEQIT Coordinator, was the field investigation director and central contact person for all teams. Following the completion of the field investigation, Ray directed the report writing effort.

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Gene Klein, Faye Neibauer, Glenn Fleming, Mike Brewster, Stan Johnson, and Beau Trinh for their support in numerous tasks to help complete this report.

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LOGISTICS

On Monday morning, January 17,1994, Ray Zelinski mobilized three Post Earthquake Investigation Teams (PEQIT's) who were then dispatched from Sacramento.

Team #1 departed from Sacramento Metropolitan Airport at 10:00 am for Ontario Airport. The team members were Ali Asnaashari and Bob Tanaka. Team 1 was assigned to investigate the damage to the structures along the Santa Monica Freeway (Interstate 10). They returned to Sacramento on Wednesday, January 19.

Team #2 departed from Sacramento Metropolitan Airport at 11:00 am for Orange County. The team was comprised of Tom Sardo and Ann Gilbert Sardo. Team 2 was assigned to investigate the structures in the vicinity of the 118/405 interchange. They returned to Sacramento on Friday, January 21.

Team #3 consisted of Brian Maroney, Joe Downing, Ruth Fernandes, Mike Keever, and Jim MacIntyre. They departed Sacramento by van at approximately 11:00 am and arrived at the site of the Gavin Canyon Undercrossing collapse at approximately 5:30 pm. Peqit Team #3's assignment was to investigate the damage to structures at Gavin Canyon Undercrossing and the 14/5 Interchange. They returned Wednesday, January 19.

The three PEQIT teams performed field investigations at 40 bridge sites from January 17 to January 21, 1994 in Los Angeles and Ventura counties.

The following routes in Los Angeles County were inspected:

Route	Beginning Post Mile	Ending Postmile
2	18.72	18.81
5	39.19	47.83
10	4.24	9.31
14	24.73	25.13
101	11.75	31.05
118	7.80	12.40
210	0.12	0.12
405	46.24	47.75
710	23.44	23.44

The following route in Ventura County was inspected:

Route	Beginning Postmile	Ending Postmile
101	11.75	11.75

For specific bridges, refer to the section, "List of Bridges Investigated."

INTRODUCTION

On January 17, 1994 at 4:31 am, an earthquake registering 6.8 M_S (6.7 M_W) on the Richter scale shook Los Angeles. The epicenter of the earthquake is reported to be at 34.213° North, 118.536° West, at a depth of 18.2 km* . This places the epicenter near the city of Northridge in the San Fernando Valley. The quake was felt strongly as far away as Las Vegas to the east, San Diego to the south, and San Luis Obispo to the north. At the first release of this report on January 31, aftershocks as large as 5.2 continued to rock the region and collapse buildings. Over fifty deaths have been attributed to the quake. Estimates of the damage caused by the quake have risen as high as $30 billion dollars. Buildings and bridges collapsed, over 700,000 customers were without electric power, and water service and quality were lost.

This report focuses on the responses of the bridges in the region affected by the Northridge Earthquake and documents the damage, or the lack thereof, to bridge structures. The goal of this report is present to bridge design engineers those behaviors which were unexpected or unquantified before this event, and which support analysis and design assumptions currently made in design. With this information, design engineers can incorporate lessons learned in this earthquake into future designs and/or retrofits. In general, apparent bridge behavior in this earthquake indicates that current design guidelines for both new and retrofit bridges are on-target to meet the goals of preventing collapse and protecting the traveling public from harm.

Ground motion records made available by the California Strong Motion Instrumentation Program reported peak horizontal and vertical ground accelerations of 1.82g and 1.18g, respectively, at Tarzana approximately 7 kilometers south of the epicenter. The closest free-field sensors to the 5/14 Interchange reported peak horizontal and vertical ground accelerations of 0.91g and 0.60g, respectively, about 15 kilometers from the epicenter and 6 kilometers from the interchange. Free-field sensors near the Santa Monica structures did not function but by gross estimates using free-field acceleration peaks at other sites, peak accelerations could have been as high as 0.5g horizontally and 0.2g vertically near these structures. The damaged bridge structures closest to the epicenter were those along the 118 Freeway: Bull Creek Canyon Channel and Mission-Gothic UC. They appear to be approximately 6 kilometers away from the epicenter. If the soils at the 118 freeway sites and the Tarzana site are similar, peak ground

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* Magnitudes and epicentral location and depth from National Earthquake Information Center, Golden, Colorado, 25 February 1994.

accelerations may have been near the 1.82g horizontal and 1.18g vertical peaks recorded at the Tarzana site.

Using peak horizontal ground acceleration records to define a 0.25g limit, as shown in figure 1, it can be estimated that approximately 1600 state and county bridges experienced threatening levels of horizontal ground motions. Of these 1600 bridges, 60 are state bridges which had been identified as being vulnerable to earthquake loads and had been retrofit as part of the bridge seismic retrofit program initiated after the 1987 Whittier Earthquake. Those bridges which experienced high levels of ground motion and were designed with ductile details, functioned as expected with little or minor damage. Older structures which had been retrofitted as part of the modern bridge seismic retrofit program performed well, although there were few in the immediate "high damage" area. The connector bridges at the 405/10 interchange, 5.4 km west of the collapsed bridges along Interstate 10, have been retrofitted and they performed well. These bridges were at the top of the vulnerability list of all single column state bridges in the 1987 risk survey conducted by the Division of Structures. Some older structures which had either not yet been retrofitted or only partially retrofitted with early retrofit details, experienced major damage and, in some cases, collapsed.

The bridges in this category are the two 14/5 interchange connectors, Gavin Canyon Undercrossing on Interstate 5, and the La Cienaga-Venice and Fairfax-Washington structures on Interstate 10. Two bridges on Route 118 which sustained major damage had improved seismic details, yet even these details are outdated by today's modern, new-bridge standards. The Mission Gothic UC sustained significant column shear failure which caused the eastbound bridge to slide from its abutment, causing partial collapse. The Bull Creek Canyon Channel Bridge sustained shear failure in each column of bent 2 yet did not collapse. It is believed that neither bridge would have failed had current new-bridge criteria been employed at the time of construction. Also, the damage at Bull Creek Canyon Channel Bridge was within the tolerance of acceptable damage, which should avoid loss of life (i.e. no catastrophic, immediate collapse).

5th CSMIP Quick Report of January 25, 1994

Figure 1

At the 14/5 interchange, two of the five connectors had one of their frames collapse, representing only 10% of the elevated interchange. These frames collapsed due to a combination of the narrow hinge seat and the relatively short, stiff columns near the abutments. The other frames, representing 90% of the elevated structures, remained standing primarily because of the restrainer units which were installed during the damage restoration contracts after the 1971 San Fernando Earthquake. These restrainers do not meet our current design standards; however, it is believed that these restrainers worked sufficiently during the period of strongest shaking to prevent collapse. The influence of restrainers in hundreds of bridges throughout the zone of strongest shaking is considered to be the reason why dozens of other bridges did not collapse.

Although there is a certain level of optimism regarding the performance of bridges during the Northridge Earthquake, Caltrans' Division of Structures will not be satisfied until all bridges are retrofitted to a specified performance plateau. There are approximately 5,000 bridges identified on the state and local agency transportation network which have been screened as potentially vulnerable to collapse. Until those bridges are evaluated in more detail and/or retrofitted, potential for collapses similar to those that occurred in the Sylmar, Fields Landing, Loma Prieta, and the Northridge Earthquakes exist. Furthermore, each earthquake forces a revisiting of design codes and seismic detail reliability.

The following topics are the subjects of on-going research and investigations, and are among the concerns which the Division of Structures currently focuses on :

1. Improved column ductility capacity assessments - Applied Technology Council

2. Retrofit footing details - University of California at San Diego (UCSD)

3. Column plastic hinge load paths into the superstructure - UCSD

4. Ductility design procedures for external column/cap joints - University of California at Berkeley/UCSD

5. Traffic load on bridges and bridge effects on vehicles during a seismic event

As a result of damage investigations at the Northridge Earthquake bridge sites, it is recommended that the following issues be considered for detailed evaluation:

1. Vertical acceleration
2. Bridge vulnerability screening methods
3. Column flares
4. The condition/status of existing restrainers in those existing bridges not being retrofit.

It is not expected that major revisions to Caltrans' retrofit or new-bridge design specifications will result from the studies listed above. However, as investigations result in revised design codes, procedures, and details, those revisions should be implemented immediately, which has been the practice in the past . This practice helps keep designs and construction current with the state-of-the-art knowledge. A major drawback is that there is no clearly defined method to identify the era under which designs had taken place. This issue was very much in the forefront in the Northridge Earthquake when answering questions regarding new (post 1971), and retrofit (Phase I, Phase II, and multi-column) designs. A database tracking system should be developed which relates time and implementation. Design plans would be coded with a related data base code.

For detailed damage assessment from a design perspective, refer to the body of this report.

Brian Maroney
PEQIT Team Leader

Ray Zelinski
PEQIT Coordinator

SOIL CONDITIONS

The soil conditions at the various bridge sites and throughout the region are similar. Review of the as-built, soil log of test borings indicates that the bridge sites have loose sands near the surface and transition to dense sands and then to sandstone. Depths to rock like material varied from site to site and in some instances within the site along the length of a bridge. Thus, soil effects on the motions at each site, and in some cases along the length of the structures, are expected to vary to some degree. There were no soft soil sites, similar to those recognized to be hazardous after the Loma Prieta Earthquake of 1989, identified at any of the damaged bridge sites. However, some lenses of clayey or silty material are present at the structure sites along route 118. For further information, Appendix A has a more detailed description of the geology in the area from the 1971 PEQIT Report.

As-built, bridge soil log of test borings are not included in this report due to a lack of clarity in the copies of the existing records. The as-built, soil log of test borings are on record at Caltrans.

MAPS

A number of Earthquake and site related maps follow which include information on the epicenter location and spatial distribution of the bridge damage.

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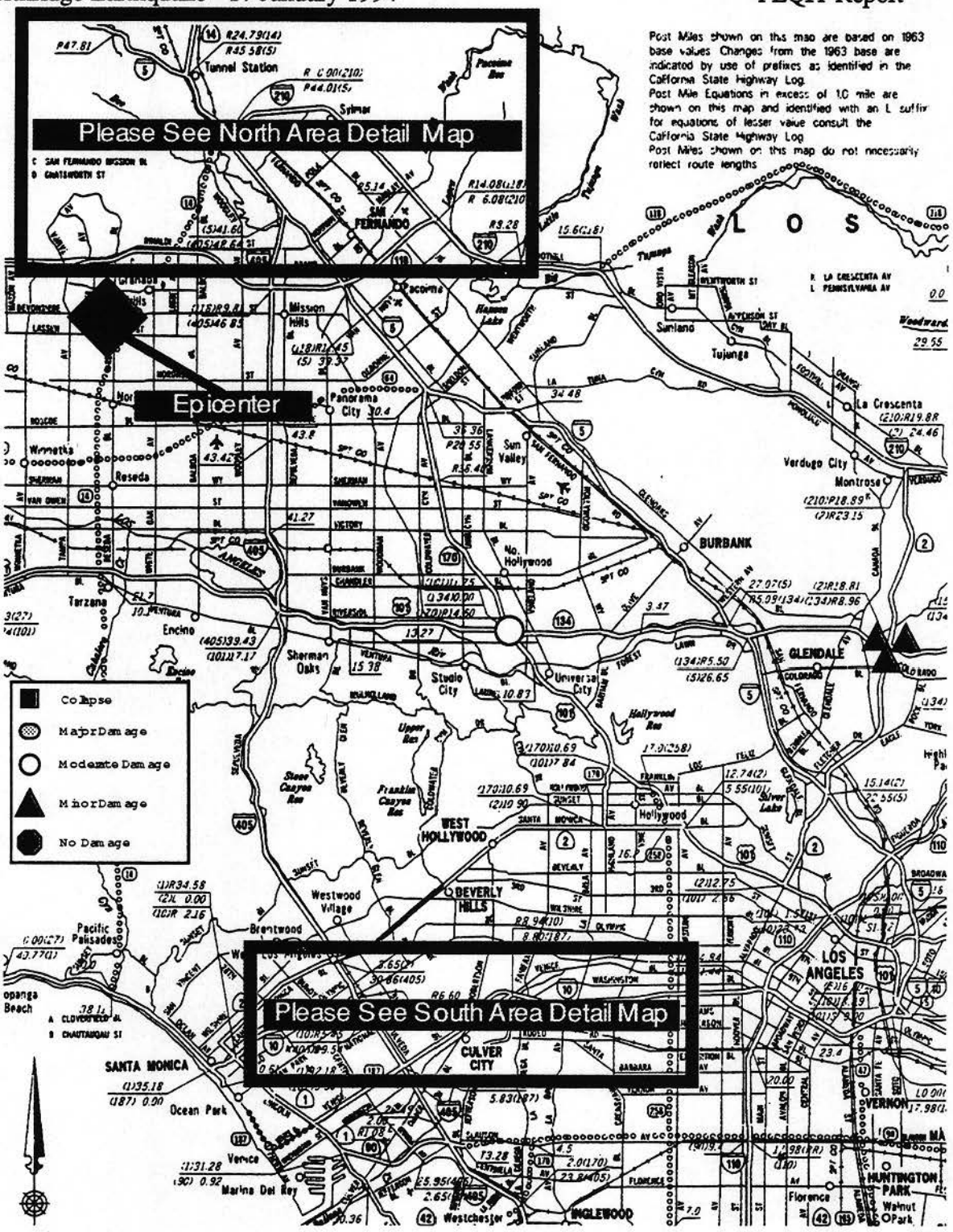

General Damage Map

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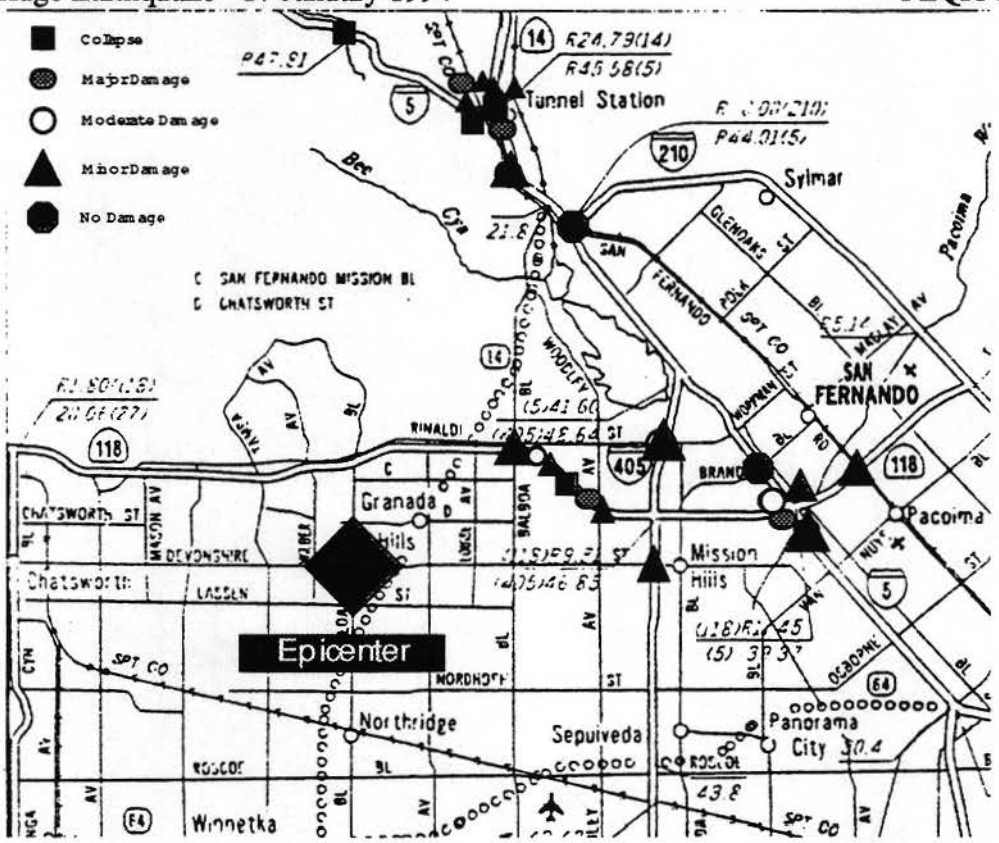
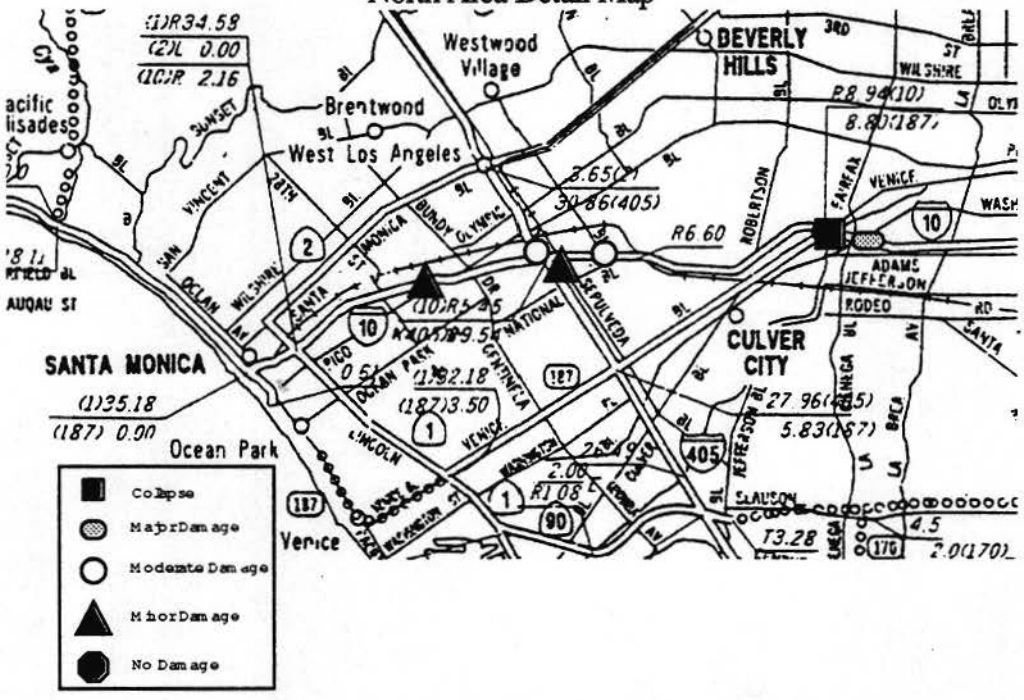


North Area Detail Map



South Area Detail Map

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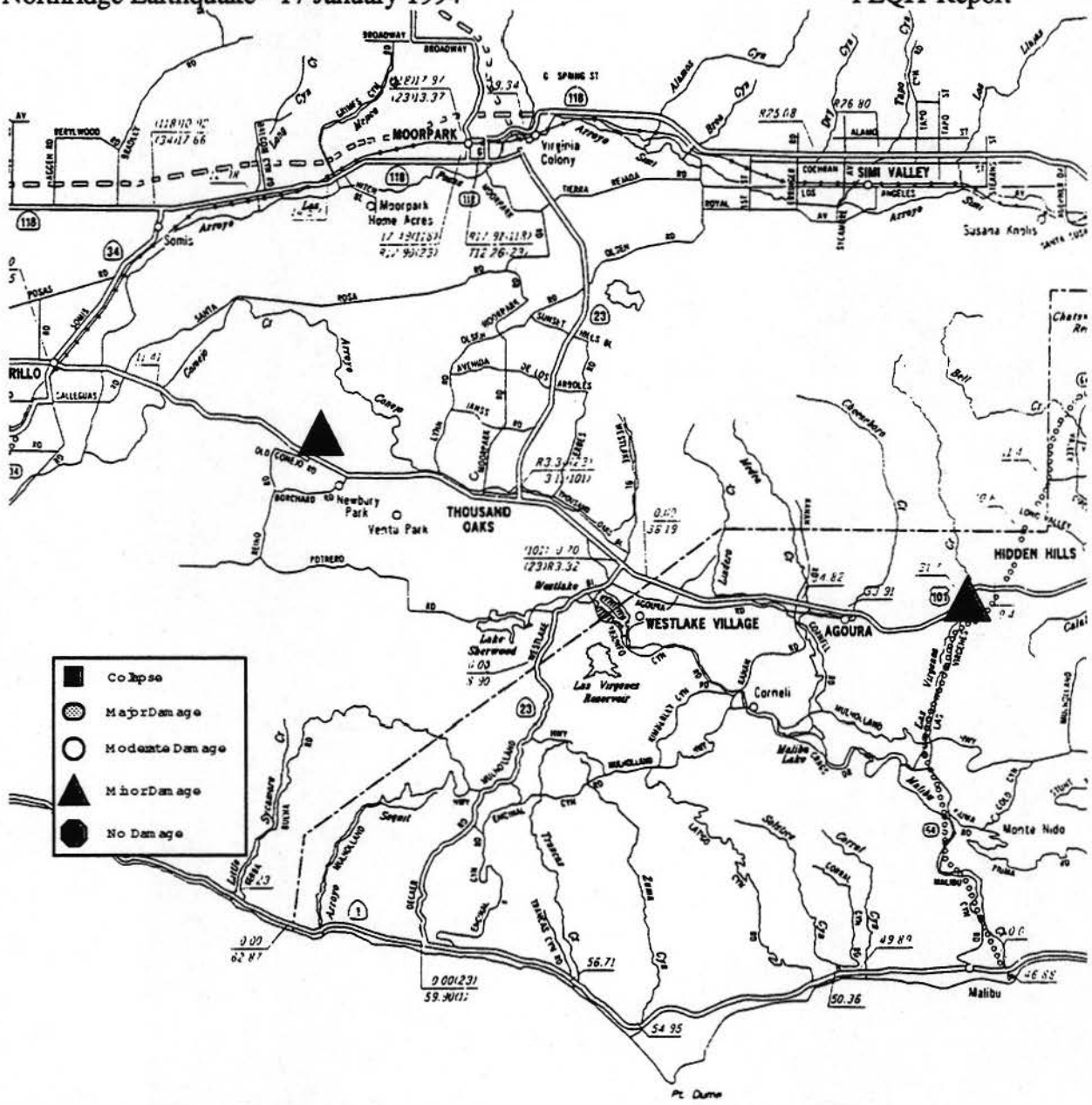

Ventura County/Western Los Angeles County Damage Map

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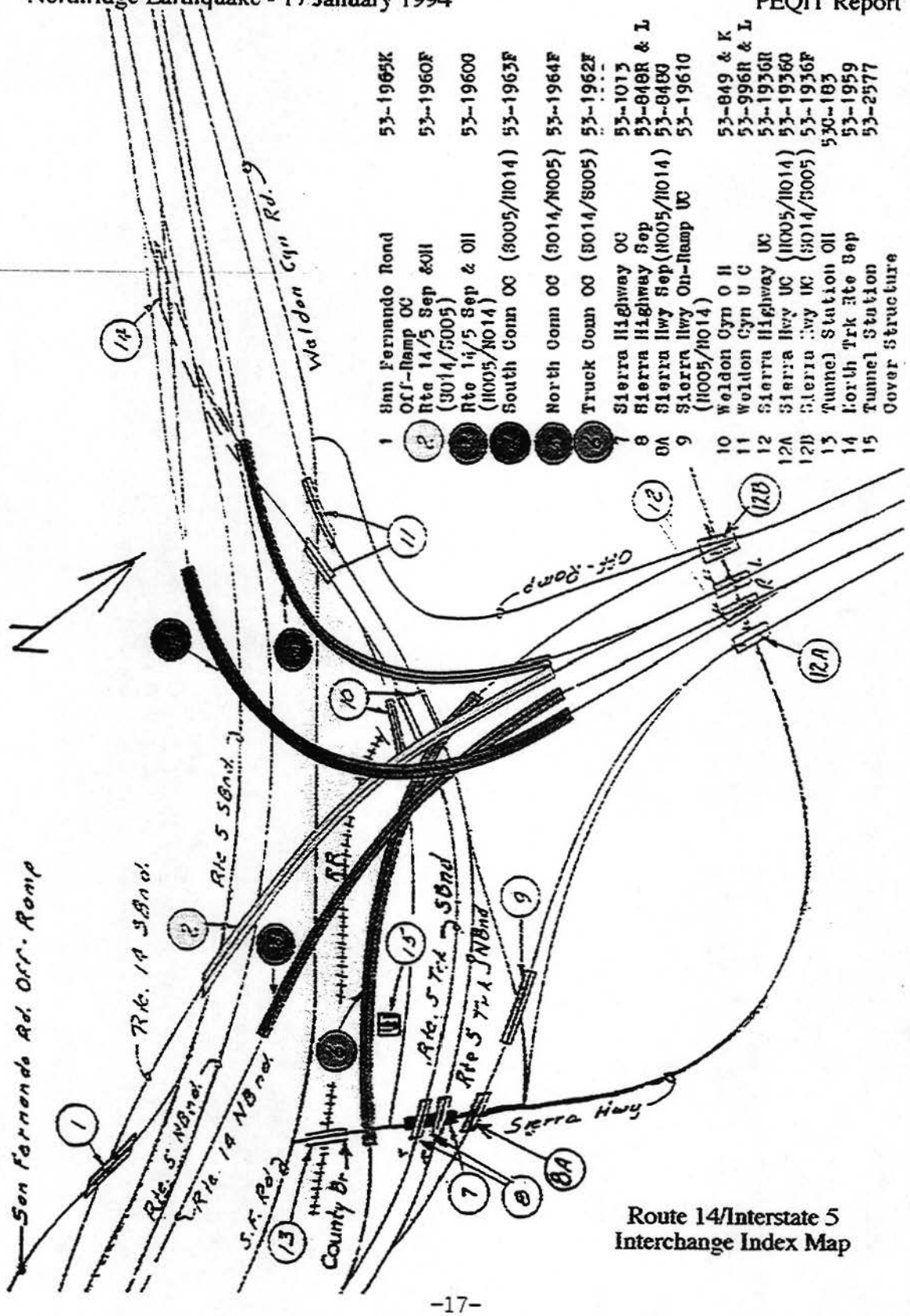

Route 14/Interstate 5
Interchange Index Map

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Alquist-Priolo Special Studies Zone

The 14/5 Interchange is within the limits of an Alquist-Priolo Special Studies Zone. The intent of the Alquist-Priolo Act of 1972 is to provide for public safety from the hazard of fault rupture by avoiding, to the extent possible, the construction of structures astride hazardous faults. A Special Studies Zone is defined as those areas the State Geologist has determined include potentially or recently active faults and thus warrant special geologic investigation to confirm the presence or absence of hazardous faults.

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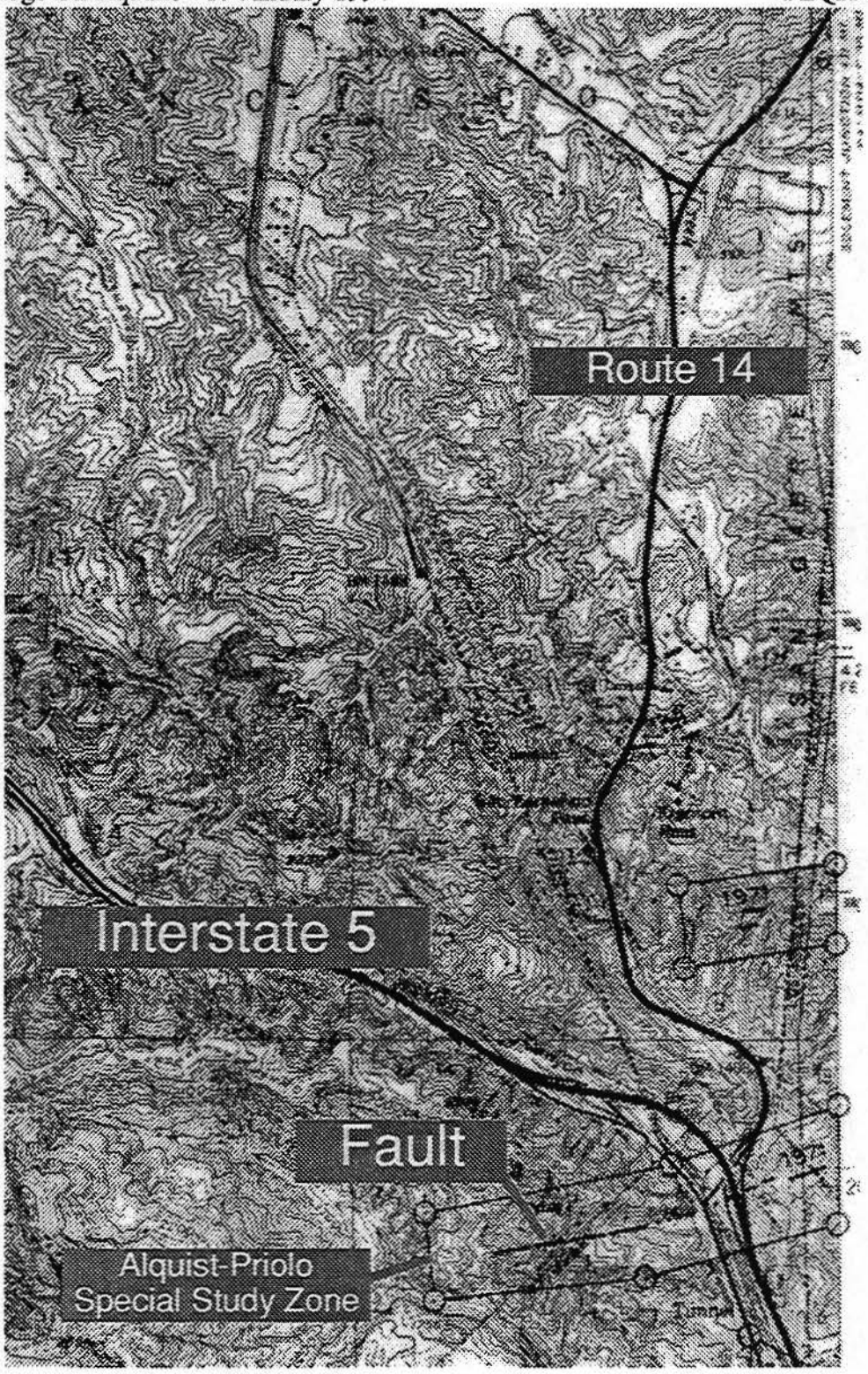

Alquist-Priolo Map Showing 14/5 Interchange

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SUMMARY OF FINDINGS

The following statements are based on a review of the bridge damage observed, which are detailed for each structure investigated in the pages that follow.

- Structures which have substructures with varying stiffness may be vulnerable to early shear failures of the stiffer elements. (e.g., 53-1964F, 53-1960F)

- Inadequate seat widths at superstructure hinges can contribute to superstructure collapse. (e.g., 53-1797R/L)

- Damaging loads were observed to be distributed with respect to effective stiffness. (e.g., 53-1580, 53-1609)

- Skew is a complexity which combines poorly with other details and conditions which are vulnerable in seismic events. (e.g., 53-2205)

- Early retrofit details used in the initial stages of the Phase I retrofit program and present in some bridges can be improved to enhance both their performance and their structure's overall performance during earthquakes. (e.g., 53-1960G, 53-1980, 53-1609) It is also believed that some of these details though less than optimum, saved a number of structures. (e.g., 53-1963F, 53-1960G)

- It is critical that design and final construction details be consistent with analysis assumptions. (e.g., 53-2206)

- Column flares did not perform as often idealized in analysis models. The flared sections did not spall as is commonly assumed. (e.g., 53-2205)

- End-diaphragm abutments protected structures, or parts of structures, in which they were present to a greater degree than seat type abutments. In some cases this was observed to the point of success or failure. (e.g., 53-1964F, 53-1963F)

- There remain many questions concerning the effects of vertical ground motions. The peak vertical ground accelerations recorded were as high as 1.18g. The peak vertical accelerations were within the usually expected 1/3 to 1/2 level of the peak horizontal accelerations with few exceptions. No bridge failures can be blamed on the vertical ground motion alone, though it obviously may have had some effect.

- Grouting restrainer cables affects the effective length of the restraining cables. (e.g., 53-1963F)

- Bridges on a tight radius tend to move radially outward. (e.g. 53-1963F, 53-1964F)

- Damage that occurs in an earthquake is likely to be repeated in subsequent earthquake unless steps are taken to change the nature of the bridge's response. (e.g. 53-1960F, 53-1506)

- When column spiral reinforcement ruptures it has a tendencey to uncoil, reducing confinement in a region larger than that of the immediate damage. (e.g. 53-2205)

DESIGN RECOMMENDATIONS

- Variations in stiffness from column to column within a bent and from bent to bent within a frame should be kept to a minimum. Displacement capabilities should be checked against expected displacement demands respecting compatibility.

- Effective moments of inertia should be respected in a seismic analysis.

- High skew in bridge structures should be avoided. Bents within the same structure with skews in opposite directions should be avoided to an even greater degree.

- If any element of a structure or surrounding structures, such as channel walls, sidewalks, AC pavement, etc., can affect the response of that structure during an earthquake, then they should be incorporated into the seismic analysis. Isolating such elements from the structure would be the preferred solution.

- Flared column behavior under earthquake loads should be investigated thoroughly for both long and short columns as their impacts will be different. In the meantime, flared columns should be carefully evaluated, considering especially their effects on predicted plastic hinge locations.

- End-diaphragm abutments, or seat-type abutments that provide restraint to the superstructure, should be considered for use in high seismic regions.

- The use of continuous, longitudinal mild steel should be used accross bent caps to provide continuity of the superstructure in the event of unforseen seismic damage to substructure elements.

- The use of seat-type hinges in the superstructure creates a potential vulnerability which requires careful attention when analyzed and detailed. These elements should be eliminated whenever possible

- Designers evaluating restrainer units in seismic-retrofit analyses should consider actual construction detailing such as grouted/ungrouted restrainer lengths.

DESIGN RECOMMENDATIONS (Continued)

- The Division of Structures should investigate the effects of vertical ground motions on bridges.

- The Division of Structures should initiate a more detailed field restrainer-unit investigation program.

- The Division of Structures should consider developing a database which tracks time and implementation of seismic technologies into bridge details.

LIST OF STRUCTURES INVESTIGATED

Bridge No.	Bridge Name	Dist./County/Rte/PM
53-1917F	South Connector OC	07-LA-2-R18.72
53-1921F	Northeast Connector OC	07-LA-2-R18.81
53-1919S	Route 134/2 Separation	07-LA-2/134-R18.80/R8.92
53-1128	Pacoima Wash	07-LA-5-39.19
53-1220	Chatsworth Drive UC	07-LA-5-39.92
53-1797RL	Gavin Canyon UC	07-LA-5-R47.83
53-1984RL	West Sylmar OH	07-LA-5-R44.87
53-849	Weldon Canyon OH	07-LA-5-C45.75
53-849K	Weldon Canyon OH	07-LA-5-C45.76
53-996RL	Weldon Canyon OC	07-LA-5-C45.86
53-2327F	Southeast Connector OC	07-LA-5-39.30
53-1580	Fairfax-Washington UC	07-LA-10-R9.31
53-1603	Centinela-Pico UC	07-LA-10-R4.24
53-1609	La Cienega-Venice UC	07-LA-10-R8.83
53-1615	National Blvd. OC	07-LA-10-R6.31
53-1637F	Southeast Connector OC	07-LA-10-R5.65
53-1960F	Route 14/5 Separation & OH	07-LA-14/5-R24.73/R45.58
53-1960G	Route 14/5 Separation & OH	07-LA-14/5-R24.77/R45.52
53-1962F	Truck Connector OC	07-LA-14/5-R24.81/C45.74
53-1963F	South Connector OC	07-LA-14/5-R24.82/R45.69
53-1964F	North Connector OC	07-LA-14/5-R24.97/C45.95
53-1936RL	Sierra Hwy UC	07-LA-14/5-R25.13/C45.74
53-1936G	Sierra Hwy UC	07-LA-14/5-R25.13/C45.74
53-1936F	Sierra Hwy UC	07-LA-14/5-R25.13/C45.74
52-0266	Wendy Drive OC	07-Ven-101-7.89
53-1336R	Route 101/170/134 Separation	07-LA-101-11.75/R14.6/0.01
53-1442	Las Virgenes Road OC	07-LA-101-31.05
53-2204	Hayvenhurst Avenue UC	07-LA-118-R8.34
53-2205	Mission-Gothic UC	07-LA-118-R8.63
53-2206	Bull Creek Canyon Channel Bridge	07-LA-118-R8.84
53-2207	Woodley Avenue UC	07-LA-118-R9.04
53-2095	San Fernando Road OH	07-LA-118-R12.40
53-2395	Balboa Blvd. OC	07-LA-118-R7.80
53-2396	Ruffner Avenue OC	07-LA-118-R8.05
53-2329G	Southwest Connector OC	07-LA-118/5-R11.40/39.31
53-1989F	Southwest Connector OC	07-LA-210/5-R0.06/R43.99
53-1988F	North Connector Separation	07-LA-210-R0.12
53-1500	Devonshire Street UC	07-LA-405-46.24
53-1506	Rinaldi Street UC	07-LA-405-47.75
53-1044	Olympic Blvd. OC	07-LA-710-23.44

DAMAGE CATEGORIZATIONS

MAJOR DAMAGE (Collapsed Structure)

Gavin Canyon UC	53-1797R/L
Route 14/5 Separation & OH	53-1960F
North Connector OC	53-1964F
Mission-Gothic UC	53-2205
La Cienega-Venice UC	53-1609

MAJOR DAMAGE (No Collapse)

Fairfax-Washington UC	53-1580
Bull Creek Canyon Channel Bridge	53-2206
Route 14/5 Separation & OH	53-1960G
South Connector OC	53-1963F

MODERATE DAMAGE

Southwest Connector OC	53-2329G
Route 101/170/134 Separation	53-1336R

MINOR DAMAGE

Balboa Blvd. OC	53-2395
Rinaldi Street UC	53-1506
Ruffner Avenue OC	53-2396
South Connector OC	53-1917F
Northeast Connector OC	53-1921F
Pacoima Wash Bridge	53-1128
West Sylmar OH	53-1984RL
Southeast Connector OC	53-2327F
Centinela-Pico UC	53-1603
National Blvd. OC	53-1615
Southeast Connector OC	53-1637F
Truck Connector OC	53-1962F
Wendy Drive OC	53-0266
Las Virgenes OC	53-1442
Hayvenhurst UC	53-2204
Woodley Avenue UC	53-2207
San Fernando Road OH	53-2095
Southwest Connector OC	53-1989F
Devonshire Street UC	53-1500

NO DAMAGE

Olympic Avenue OC	53-1044
Chatsworth Drive UC	53-1220
Route 134/2 Separation	53-1919S
North Connector Separation	53-1988F
Weldon Canyon OH	53-849
Weldon Canyon OH	53-849K
Weldon Canyon OC	53-996RL
Sierra Hwy UC	53-1936RL
Sierra Hwy UC	53-1936G
Sierra Hwy UC	53-1936F

STATUS OF SUPERSTRUCTURE AND SUBSTRUCTURE RETROFITS:

Inspected Bridges

(Current as of 17 January 1994)

Bridge Number	Name	Route	Superstructure (post 1971)	Substructure (post 1989)
53-1917F	South Connector OC	2	not needed	EA 117311- construction complete
53-1921F	Northeast Connector OC	2	CCO	EA 116491 - construction complete
53-1919S	Route 134/2 Separation	2/134	not needed	EA 117311 - construction complete
53-1128	Pacoima Wash	5	not needed	SRP# 175
53-1220	Chatsworth Devonshire UC	5	not needed	SRP# 175
53-1797RL	Gavin Canyon UC	5	EA 07-322124	SRP# 185
53-1984RL	West Sylmar OH	5	not needed	EA 130801- in design
53-2327F	Southeast Connector OC	5	not needed	EA 119831 - struct. PSE 1/24/94
53-1580	Fairfax-Washington UC	10	EA 07-327964	EA 119761 - struct. PSE 11/16/93
53-1603	Centinela-Pico UC	10	EA 07-327694	EA 119311 - under construction
53-1609	La Cienega-Venice UC	10	EA 07-415184	EA 119761 - struct. PSE 11/16/93
53-1615	National Blvd. OC	10	not needed	EA 119761 - struct. PSE 11/16/93
53-1637F	Southeast Connector OC	10	EA 07-297054	EA 114841 - construction complete
53-1960F	Route 14/5 Separation & OH	14/5	EA 07-287844	EA 130801 - in design
53-1960G	Route 14/5 Separation & OH	14/5	EA 07-287844	EA 130801 - in design
53-1962F	Truck Connector OC	14/5	EA 07-287844	EA 130801 - in design
53-1963F	South Connector OC	14/5	EA 07-287844	EA 130801 - in design
53-1964F	North Connector OC	14/5	EA 07-287844	EA 130801 - in design
53-1936RL	Sierra Hwy UC	14/5	not needed	SRP# 179
53-1936G	Sierra Hwy UC	14/5	not needed	SRP# 179
53-1936F	Sierra Hwy UC	14/5	not needed	SRP# 179
52-0266	Wendy Drive OC	101	not needed	SRP# 557
53-1336R	Route 101/170/134 Separation	101	EA 07-297074	EA 119751 - adv 1/31/94
53-1442	Las Virgenes OC	101	EA 07-415224	SRP# 191 - excluded
53-2204	Hayvenhurst UC	118	not needed	SRP# 188 - excluded
53-2205	Mission-Gothic UC	118	not needed	SRP# 188 - excluded
53-2206	Bull Creek Canyon Channel Br.	118	not needed	SRP# 188 - excluded
53-2207	Woodley Avenue UC	118	not needed	SRP# 188 - excluded
53-2095	San Fernando Road OH	118	not needed	SRP# 177
53-2395	Balboa Blvd. OC	118	not needed	SRP# 188 - excluded
53-2396	Ruffner Avenue OC	118	not needed	SRP# 188 - excluded
53-2329G	Southwest Connector OC	118/5	not needed	
53-1988F	North Connector Separation	210	not needed	SRP# 179
53-1989F	Southwest Connector OC	210/5		
53-1500	Devonshire UC	405	not needed	SRP# 188 - excluded
53-1506	Rinaldi Street UC	405	not needed	SRP# 176 - excluded
53-1044	Olympic Blvd. OC	710	not needed	

MAJOR DAMAGE (COLLAPSED STRUCTURE)

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Gavin Canyon UC 53-1797L/R 07-LA-5-R47.83

Description of Structure

Gavin Canyon Undercrossing is located approximately 2 miles north of the intersection of Routes 5 and 14 in Los Angeles County. There are two separate bridges, right and left. Both are approximately 741 feet in length and 68 feet wide. They were built in 1955, and retrofitted in 1974 with restrainer cables and diaphragm bolsters at the hinges.

The superstructure is a RC box girder from abutment 1 to the hinge in span 2, and from the hinge in span 4 to abutment 6. It is a CIP P/S box girder from the hinge in span 2 to the hinge in span 4. The skew is 66°. The structure depth is 8'-6". The hinge seats are 8 inches. There are equalizing bolts parallel to the structure at the center of each bay in the hinges (24 required).

The bents are multi-column, RC, fixed frame. The columns are 6'-3" x 10' octagonal sections with a one-way flare over a transition length of 20 feet. Main longitudinal reinforcement along the octagon's 6 short sides are cut 10 feet below soffit line while the rest continue into the flare and bent. The flare is formed with smaller reinforcement (#8 bars). All the longitudinal reinforcement is confined with #4 @ 12 ties. The main longitudinal reinforcement is lapped with the #14 dowels at the footings. The footings have only a bottom mat of steel, and 100 ton driven piles.

The abutments are diaphragm type on spread footing with a shear key. Type-1A retaining walls are on either side of the abutment.

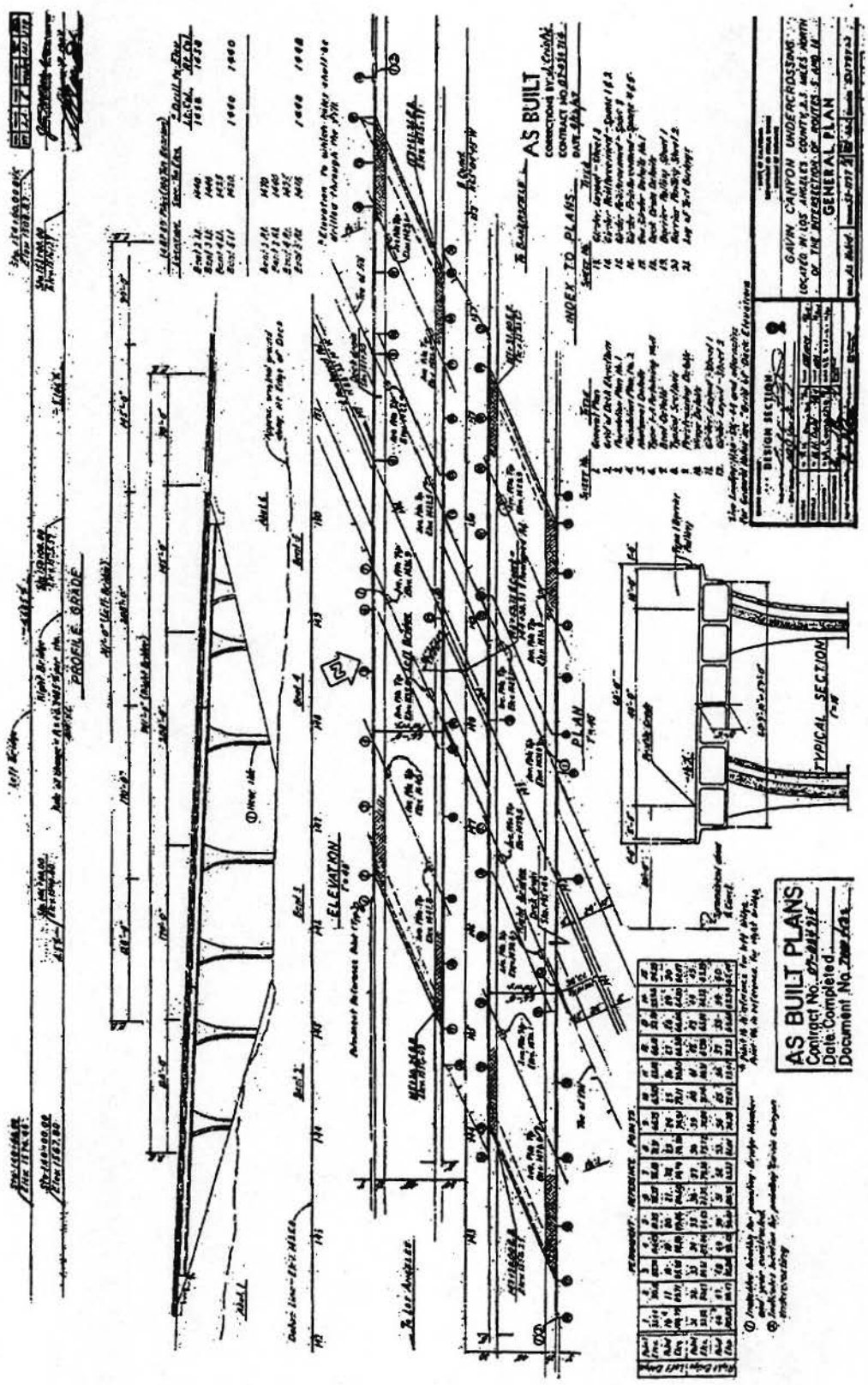
Description of Damage

On the southbound bridge the second span collapsed. The fourth span of the southbound bridge was near collapse with the top half of the hinge no longer seated. On the northbound bridge both the second and the fourth spans collapsed. The center frame of both bridges appeared to be undamaged as did all the columns. Minor damage was observed at the abutments.

Analysis of Damage

The collapse of the spans was due to the unseating of the hinges. Once the structure became unseated, the superstructure was unable to carry the cantilevered load and failed in flexure at the columns. There were several factors contributing to the failures. First, the hinges had only an 8-inch seat width and the bridges were on a 66° skew. Also, the columns at the center frame were very tall allowing the structure to deflect and rotate substantially.

The structures did have restrainers; however, the restrainers were placed parallel to the centerline of the bridge. This allowed the structure to rotate with minimal elongation of the restrainers. When the structure became unseated, the restrainers either failed or they pulled through the diaphragm. In some locations restrainer units, including plates and bolts, could be seen hanging from hinge diaphragms. In other locations ruptured restrainer cable sections could be seen.


AS BUILT
PROFILE GRADE
ELEVATION
PLAN
TYPICAL SECTION
GAVIN CANYON UNDERCROSSING
GENERAL PLAN
AS BUILT PLANS
Contract No.
Date Completed
Document No.

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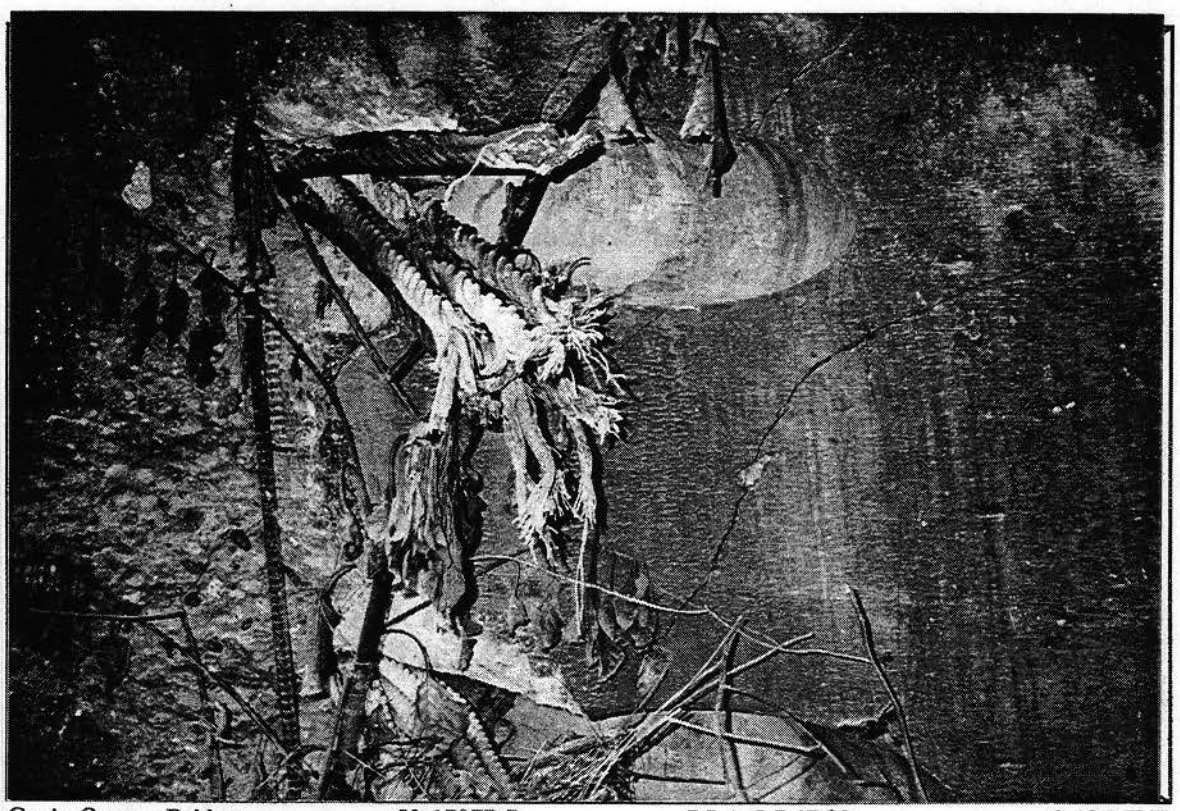
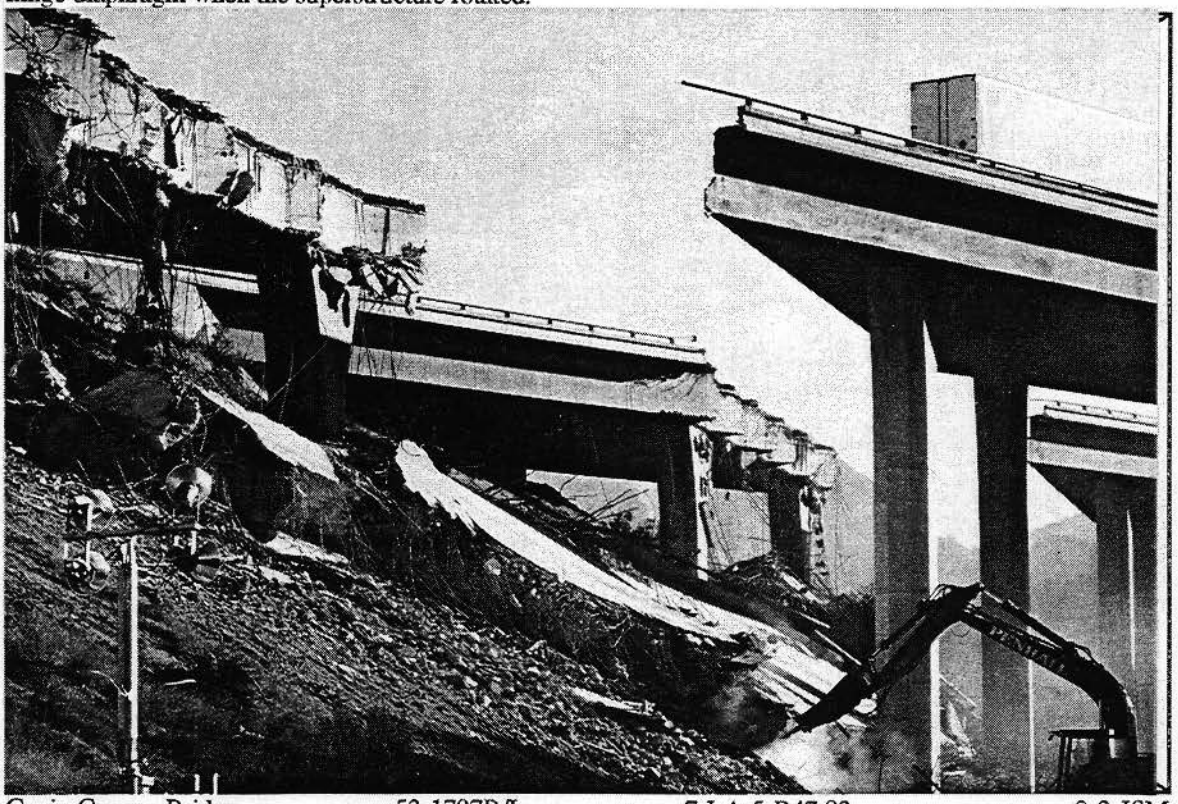


Gavin Canyon Bridge 53-1797R/L 7-LA-5-R47.83 3-12-MDK
The cable restrainer assembly was placed parallel to the centerline of the bridge and spalled the cored void in the hinge diaphragm when the superstructure rotated.



Gavin Canyon Bridge 53-1797R/L 7-LA-5-R47.83 3-2-JSM
Demolition in progress, span 4, southbound structure

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Route 14/5 Separation & OH 53-1960F 07-LA-14/5-R24.73/R45.58

Description of Structure

Route 14/5 Separation & Overhead connects southbound Route 14 to southbound I-5. This bridge is comprised of five frames with a total length of 1582 feet. There are ten spans which range in length from 103 feet to 206 feet. This bridge was under construction in 1971 and was damaged in the San Fernando Earthquake. At the time of the San Fernando Earthquake, all columns had been constructed. The bottom slab and stem concrete had been placed from abutment 1 to the hinge in span 3. All concrete had been placed from the hinge in span 9 to abutment 11, but this frame had not yet been prestressed. Final construction of this bridge was completed in 1974.

The superstructure consists of alternating CIP P/S and RC box girder frames with a structure depth of 7'-0". Hinge seat width is 14". The superstructure is supported on elastomeric bearing pads on cantilevered seat type abutments which are founded on spread footings.

The bents consist of single 12' x 4' to 12' x 6' octagonal columns that flare to a 26 foot width at the soffit and extend into the ground as a pier shaft. The main longitudinal column reinforcement consists of 20 to 32 #18 bars that follow the flare and extend into the bent cap. Lateral column reinforcement is #5 @ 12.

The four hinges of this bridge were retrofitted with cable restrainers as part of the damage restoration contracts.

Description of Damage

The first frame of the structure collapsed. At the abutment, the diaphragm was found unseated and lying on the ground approximately 5 feet from the face of the abutment seat. The right exterior shear key failed completely, and the left exterior shear key appeared undamaged. The abutment seat had no internal shear keys. There was no evidence of any significant longitudinal movement in the backwall. The backwall remained intact, with no signs of cracking.

At pier 2, the column failed completely. The main reinforcing steel in the column remained

attached to the bent cap. The top of the column at pier 2 had translated several feet ahead of the base of the column (along the centerline of the bridge) towards pier 3. The exterior girders on both sides of the bent cap had large vertical cracks at the face of the bent cap (looking in elevation).

Pier 3 remained standing. Pier 3 did not have cracking on the transverse face, while some vertical cracking (≈ 3/8" wide) was evident on the longitudinal face (looking in elevation). The superstructure on both sides of the pier was on the ground. The main bent cap reinforcement at pier 3 was also on the ground. The #18 bars appeared undamaged and all the concrete was cleaned from the bars. The #5 stirrups in the bent cap had been ripped from the bent cap. Furthermore, there was no longitudinal, mild steel through the bent cap. When the prestressing was over-stressed and failed, the superstructure had almost no negative moment capacity.

Hinge 1 had 4 - 7 cable restrainer units with an available seat width of 10 inches. The cable lengths were 5 feet and had been grouted. Both the restrainer units and equalizing bolts had failed in tension. The cables had failed near the swaged fittings and/or thread portion of the swaged fittings. Necking occurred in the equalizing bolts within the threaded portion. There was some localized damage at the face of the hinge, indicative of pounding.

Analysis of Damage

This structure had many frames with columns of varying heights. The column at pier 2 was substantially shorter than most of the other columns in the structure. Also, all of the columns in the structure had column flares at the top. Longitudinal column reinforcement flared with the column and extended into the bent caps. In the very tall columns, the column flares did not affect the performance of the column, while in shorter columns such as pier 2, the flares played a larger role. The shortness of the column at pier 2 combined with the flare, attracted significantly higher shears to pier 2 than those developed at the taller, and therefore more flexible, frames. The resulting loads at pier 2 overloaded and failed the column, contributing to the collapse of the frame.

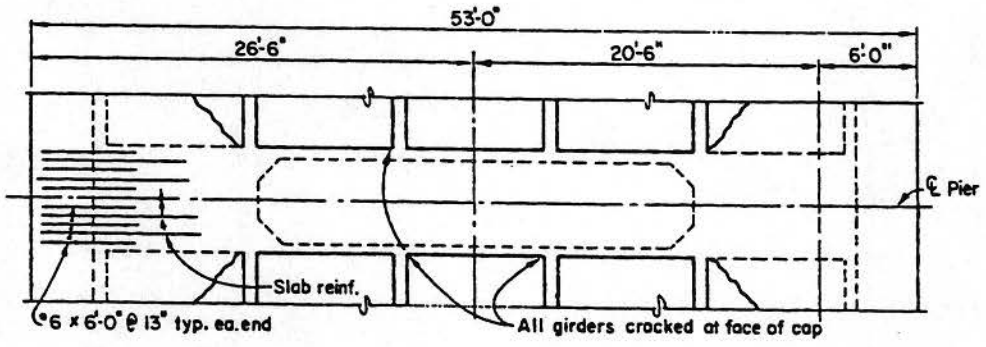
Looking at the overall structure, frame 1 was much stiffer than frame 2. Hinge 3, the hinge between the two frames, did not have sufficient seat width to handle the difference in deflections between the two frames. Frame 2 appeared to move radially outward, as is typical for a long, curved connector. This outward motion can be seen in the soil displacement at pier

4, which had a gap between the soil and column of approximately 6 inches. Frame 1, with its stiffer columns, was not able to deflect as much as frame 2. The combination of an outward motion of the structure and the differences in stiffness between frames 1 and 2 led to the unseating of hinge 1.

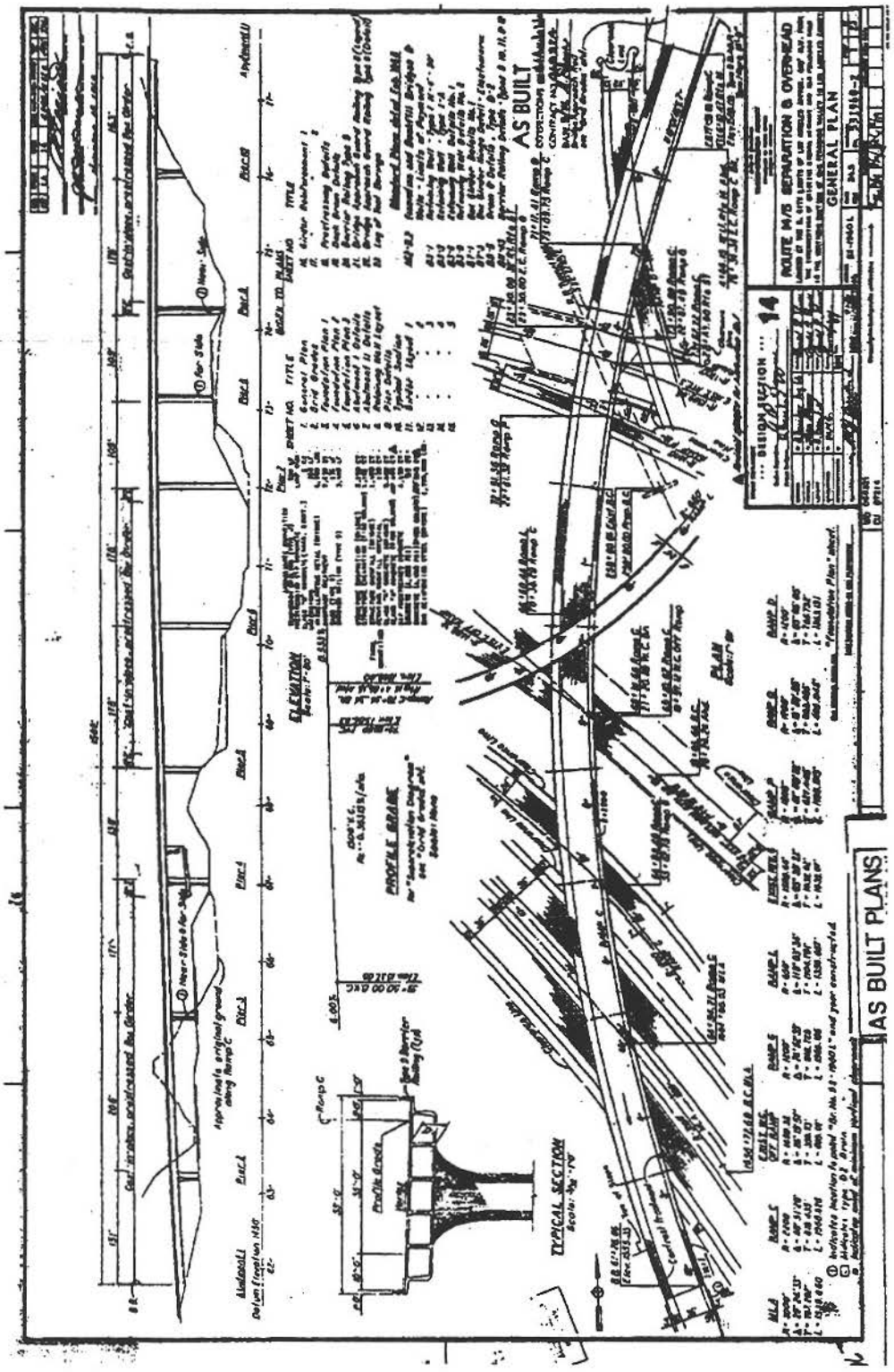
The outward motion of frame 2 introduced a counter-clockwise rotation in frame 1. This can be seen by the failed shear key at the right exterior shear key at the abutment.

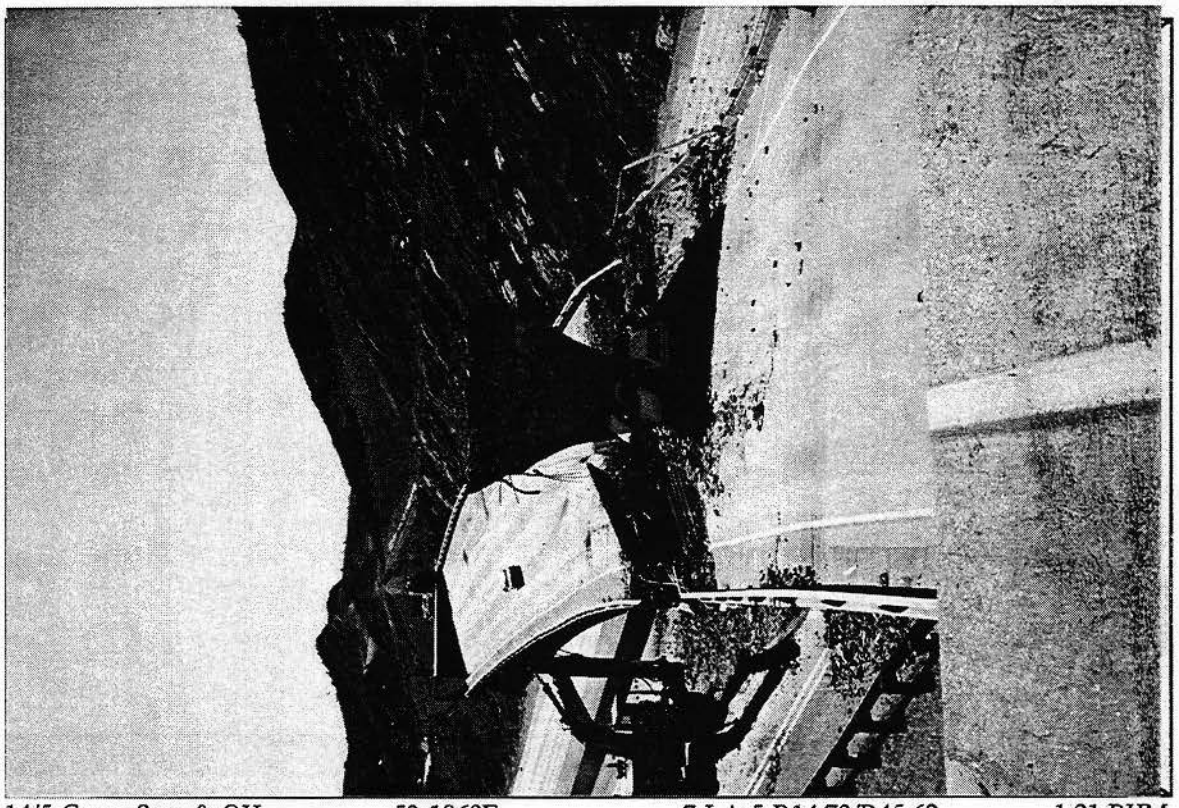
Pier 3 had the problem of having a column collapsing on one side and the long side of hinge 1 unseating on the other side. The superstructure was unable to carry the cantilevered loads from both sides and failed, not only taking the longitudinal steel from the superstructure with it ,but also the top bent cap steel.

Another contributing factor to the failure was that this structure was under construction along with the rest of the 14/5 Interchange during the 1971 Earthquake. Frame 1 was on falsework with the girder stems and soffit in place but the top deck had not been placed. Photos from the 1971 Earthquake show that the falsework settled enough to induce cracks in the soffit and the girders at the face of the bent caps. The photo showing the cracks at the faces of the bent cap that was taken from the Northridge Earthquake resemble the photos from the 1971 Earthquake. This could account for the reason that the bent cap at pier 3 failed so completely. The following drawing is reprinted from the 1971 San Fernando Earthquake Report and illustrates the damage discovered in frame 1 at piers 2 & 3.

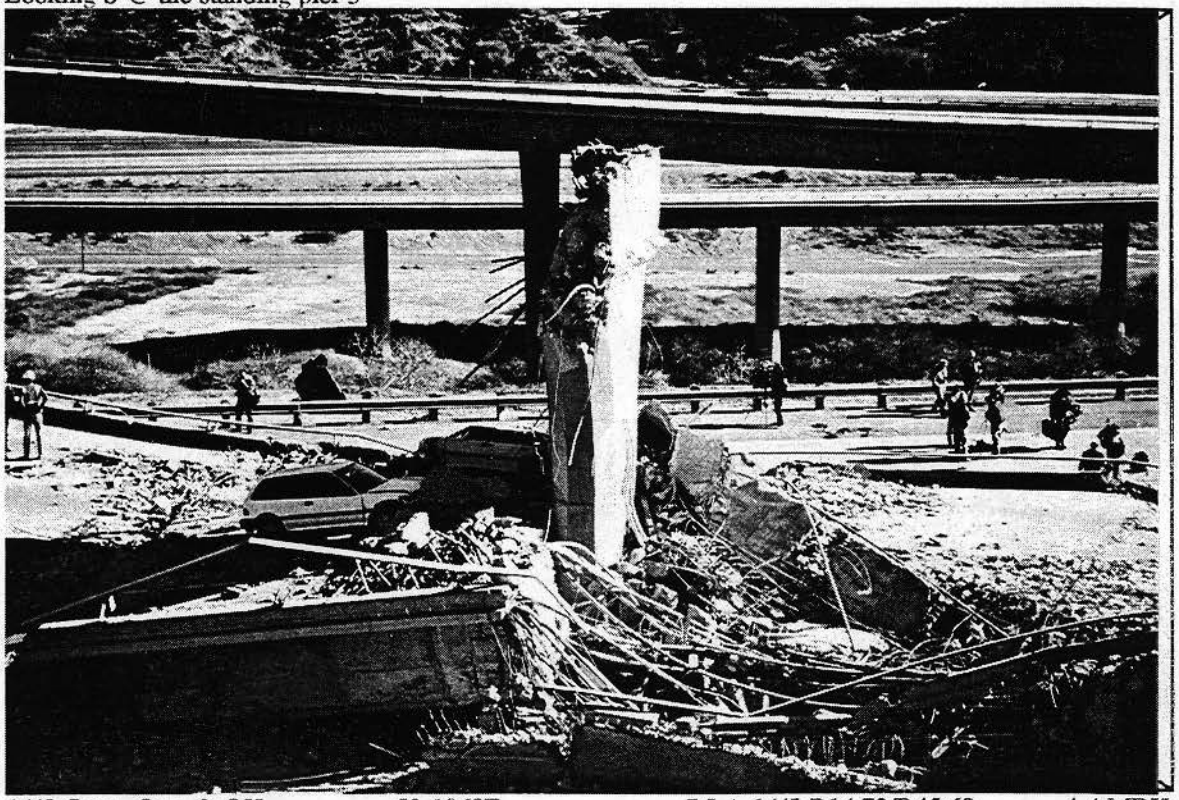


Drawing of damage at Pier 3 following 1971 San Fernando Earthquake.


AS BUILT
AS BUILT PLANS
GENERAL PLAN
ELEVATION
PROFILE GRADE
TYPICAL SECTION
PLAN



14/5 Conn. Sep. & OH 53-1960F 7-LA-5-R14.73/R45.62 1-21-BHM
Looking S @ the standing pier 3



14/5 Conn. Sep. & OH 53-1960F 7-LA-14/5-R14.73/R45.62 4-4-MDK
Bent 3 looking E.

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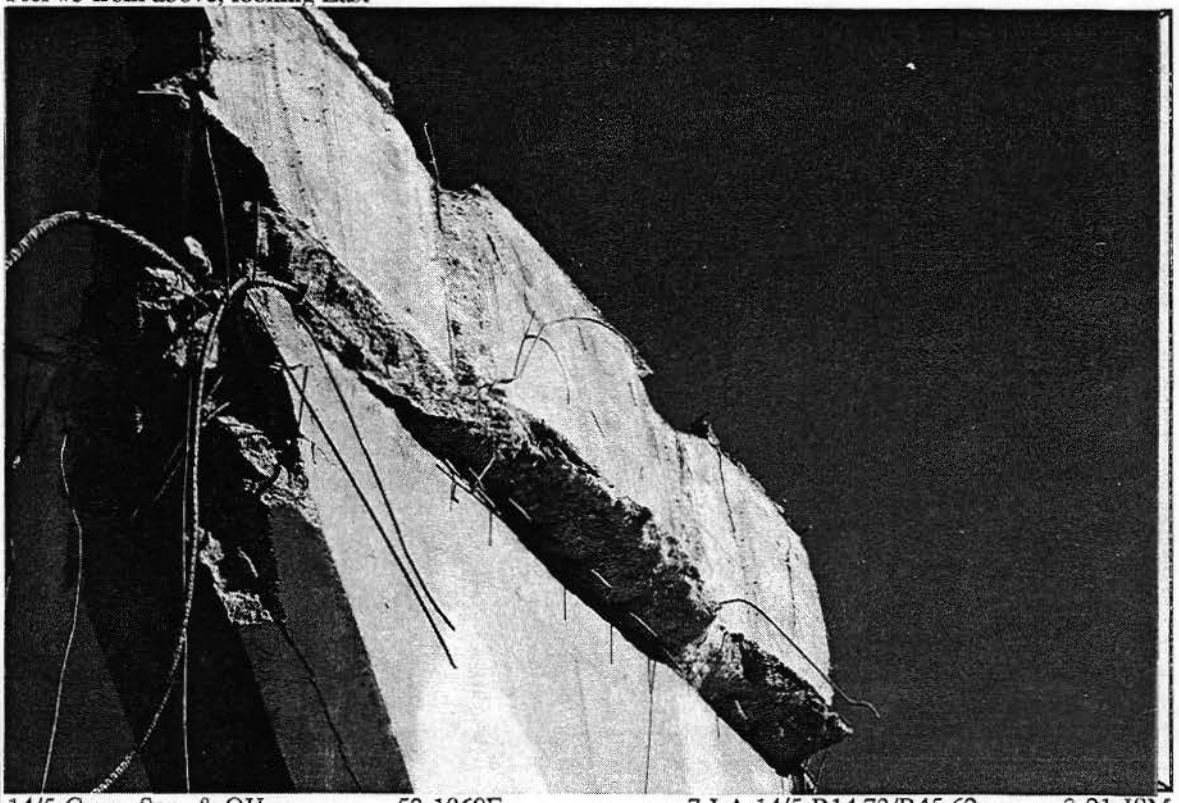
14/5 Conn. Sep. & OH 53-1960F 7-LA-14/5-R14.73/R45.62 3-36-JSM
Pier #3 from above, looking East



14/5 Conn. Sep. & OH 53-1960F 7-LA-14/5-R14.73/R45.62 3-21-JSM
Pier #3, Span #2 side

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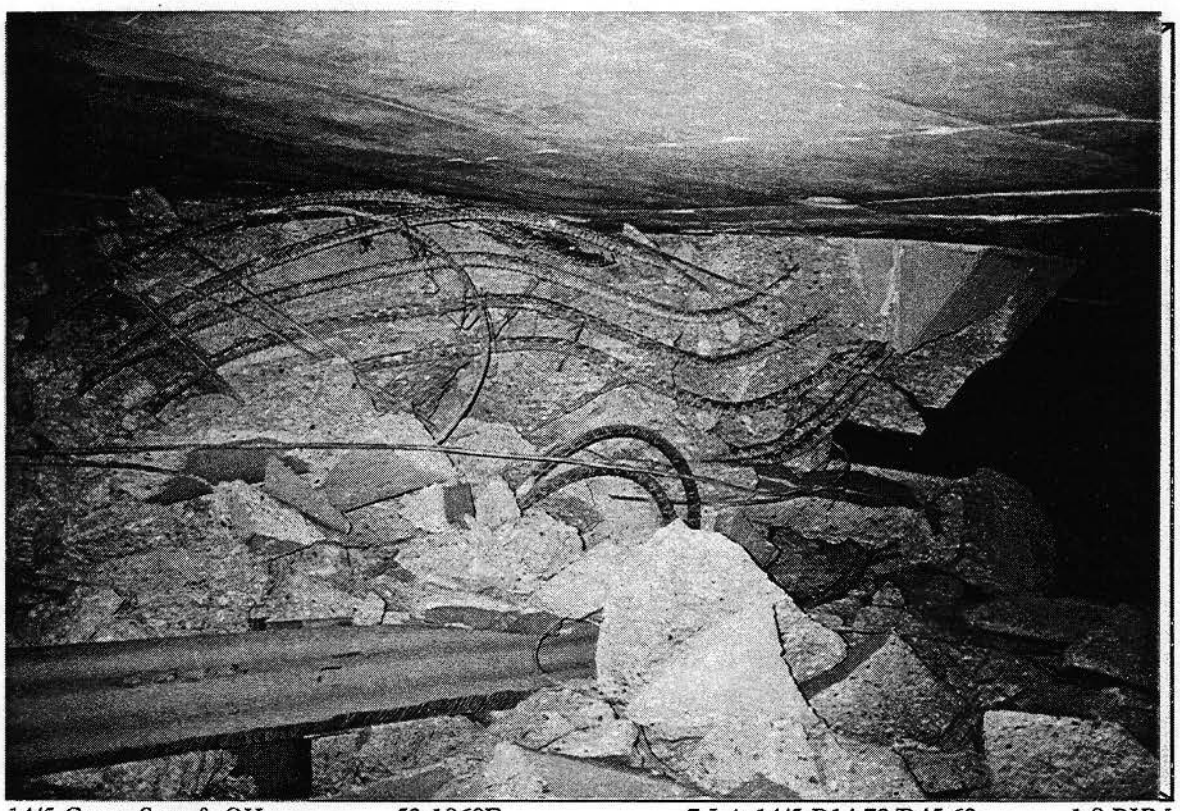

14/5 Conn. Sep. & OH 53-1960F 7-LA-14/5-R14.73/R45.62 1-8-BHM
Looking W @ pier 2

14/5 Conn. Sep. & OH 53-1960F 7-LA-14/5-R14.73/R45.62 4-23-RLF
Pier 2.

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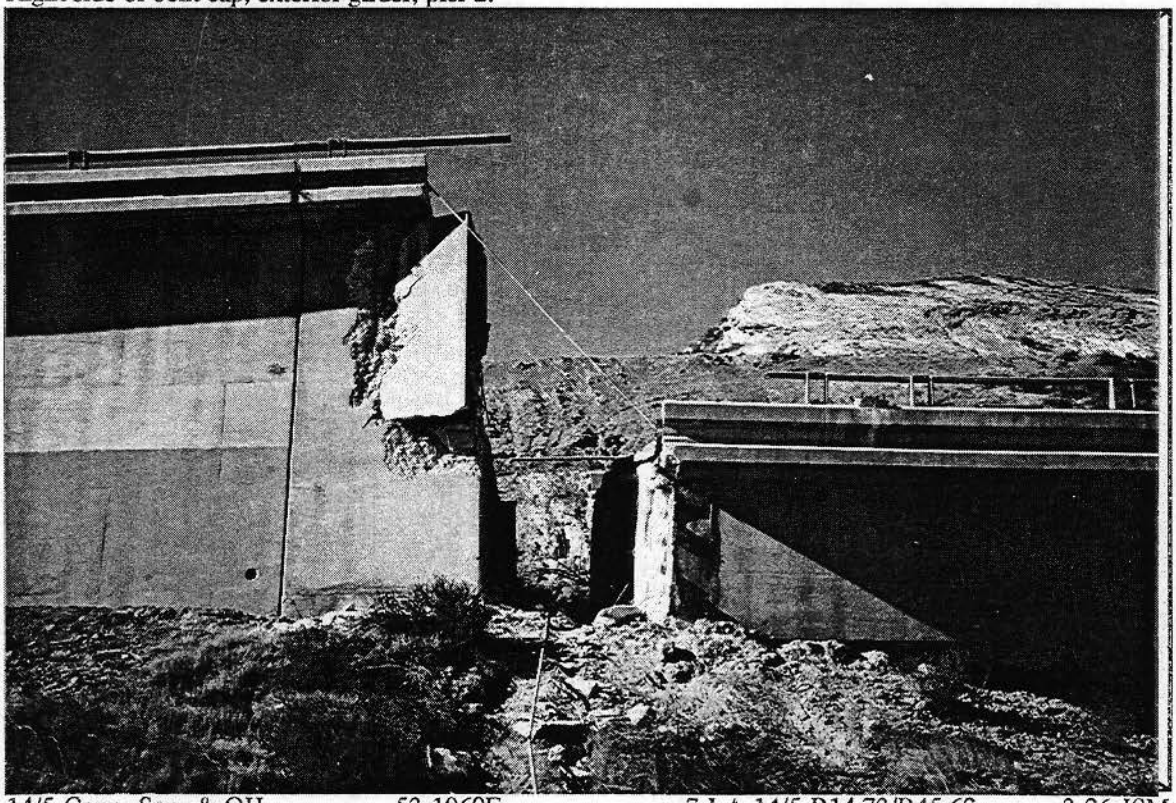
14/5 Conn. Sep. & OH 53-1960F 7-LA-14/5-R14.73/R45.62 5-15-TES
Right side of bent cap, exterior girder, pier 2.



14/5 Conn. Sep. & OH 53-1960F 7-LA-14/5-R14.73/R45.62 3-26-JSM
Abutment #1.

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North Connector OC 53-1964F 07-LA-14/5-R24.97/C45.95

Description of Structure

The North Connector Overcrossing at the Route 14/5 Interchange was a five frame concrete box girder bridge 1532 feet long and 26 to 34 feet wide. There were ten spans which ranged in length from 97 to 200 feet. The structure was originally designed in 1968, had modifications in 1972, and was completed in 1975.

The superstructure depth was 7.75 feet. The first and third frames were prestressed, while the second, fourth, and fifth frames were conventionally reinforced. Frame 1 was simply supported, and the third frame had only a single column. In-span thermal expansion joints were located in spans 1, 4, 5, and 8. The hinge seat widths were 14 inches.

All bents were single column bents. Column heights varied from near 25 feet to near 75 feet. The columns were octagonal, 8 feet by 4 feet. The foundations were mixed; both spread and pile footings were present.

Abutment 1 was a seat type with internal shear keys, while abutment 11 was an end-diaphragm type. Hinge restraining systems were present at all in-span thermal expansion joints.

Description of Damage

The first two spans of this structure collapsed and pier 2 failed. The abutment became unseated and was partially supported by the retaining wall underneath. The internal shear keys did not appear to have been engaged since they remained intact. Pier 3 appeared to have no damage at the bent cap or the column. The restrainers at hinge 1 failed either inside the grouted pipe or the whole assembly pulled through the diaphragm.

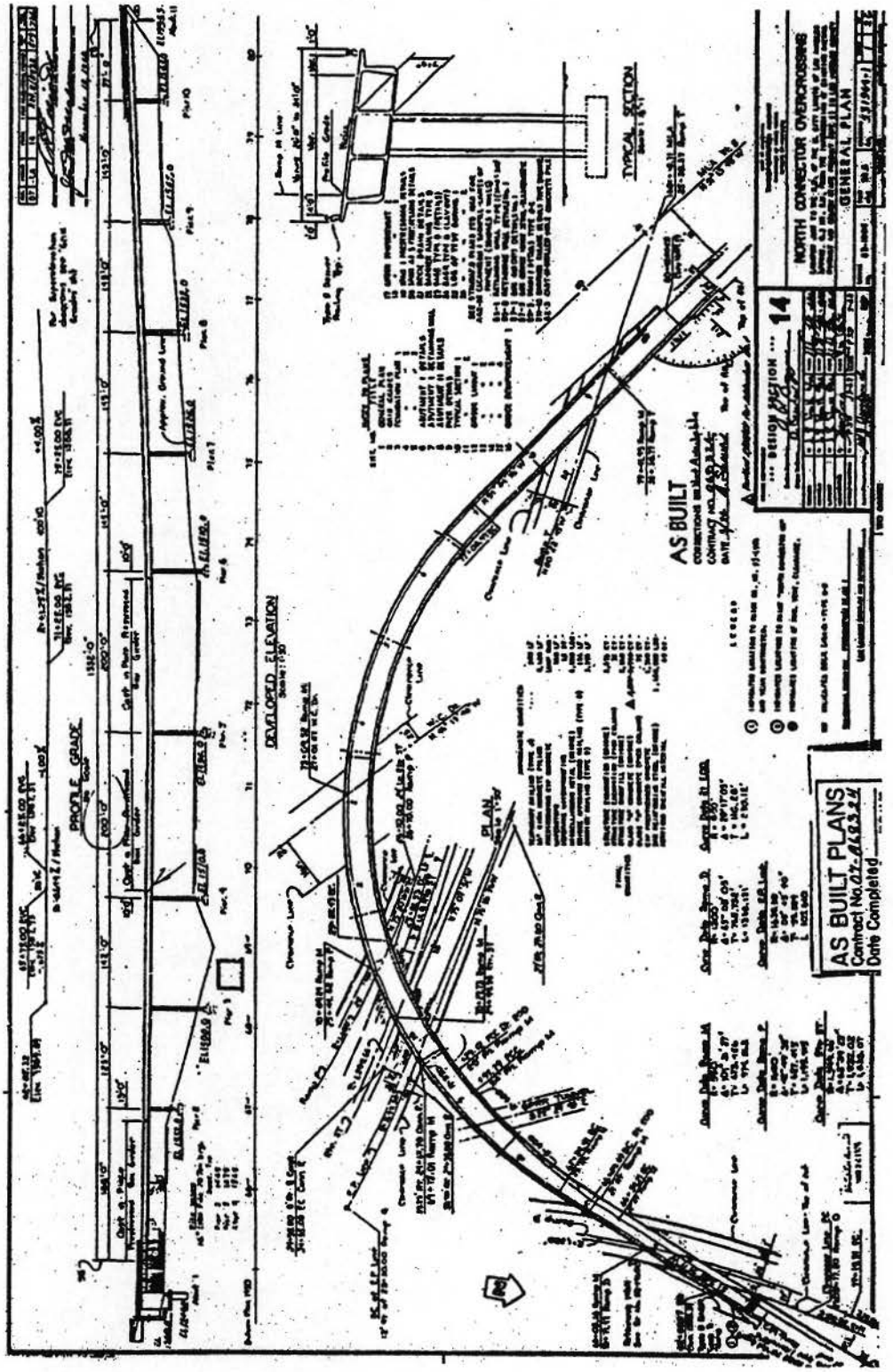
At hinge 2, the long end of the hinge was bearing on about 2" of concrete.

Analysis of Damage

The only longitudinal restraint present in frame 1, the simply supported frame, was supplied by the restrainers at hinge 1. Frame 2 was the most unbalanced of the frames; and consisted of

piers 2, 3 and 4. Pier 2 was shorter than piers 3 and 4 by 52 feet and 42 feet, respectively. This made pier 2 much stiffer than the other piers, which in turn meant that pier 2 absorbed a greater load than the remaining piers in the frame . Another contributing factor was the simply supported superstructure at span 1. With the first span essentially free to move, pier 2 did not receive any restraint from abutment 1. With pier 2 being short and stiff, it ended up failing in shear.

Frame 3 suffered little damage due to the similar lengths and stiffness of the columns. Frame 4 also suffered little damage. Abutment 11, in frame 4, had an end diaphragm type abutment. Although the columns varied in height, they varied gradually with the shortest one being near the diaphragm type abutment. It is believed that the end diaphragm abutment, with its significant restraint, contributed to the superior performance of frame 4 as compared to frames 1 and 2.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AS BUILT PLANS
Contract No. 07-168324
Date Completed
NORTH CONNECTOR OVERCROSSING
GENERAL PLAN
TYPICAL SECTION
PROFILE GRADE
DEVELOPED ELEVATION
PLAN

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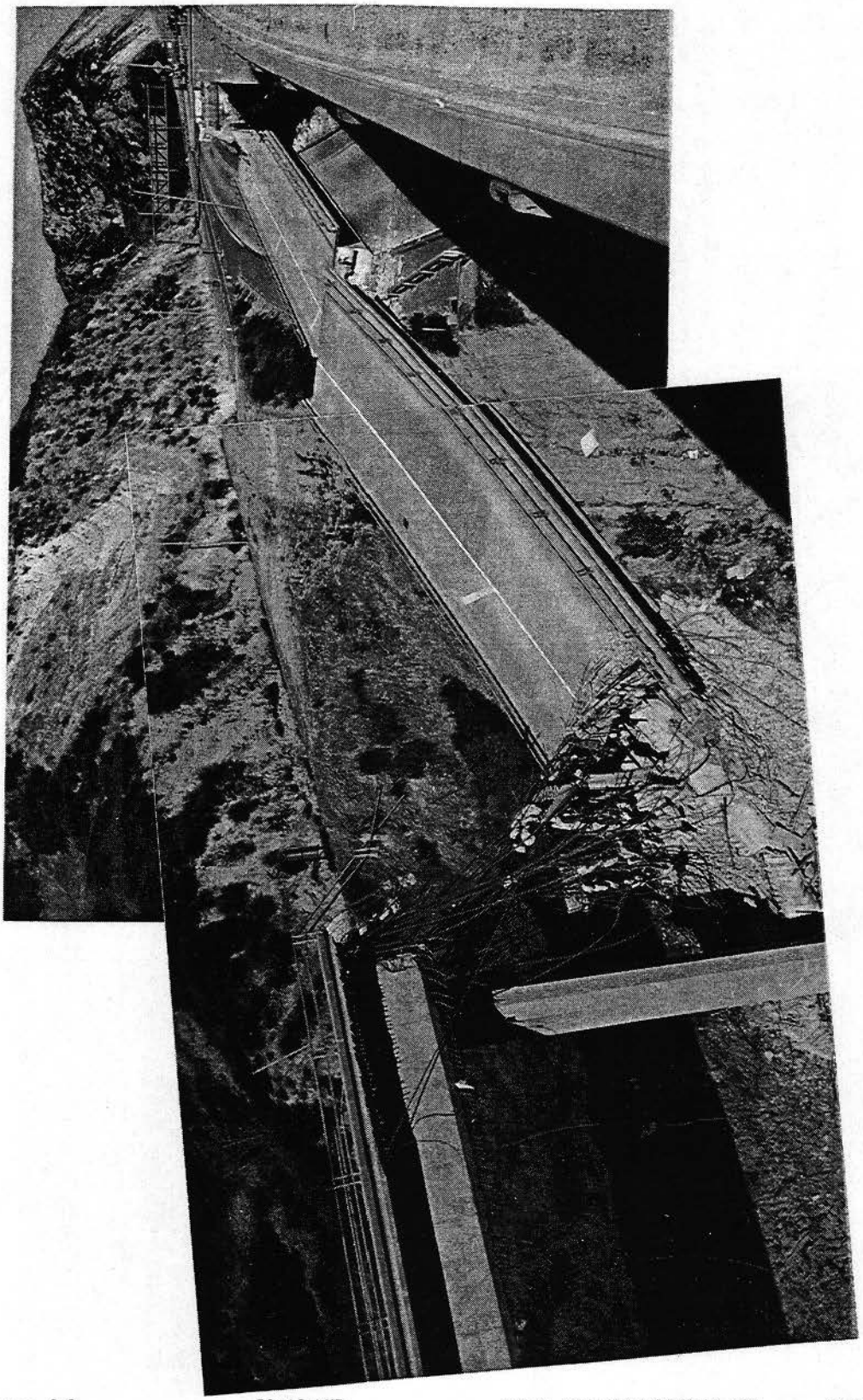

North Conn. OC 53-1964F 7-LA-14/5-R24.97/R45.103 2-6-BHM
Looking north @ (L>R) span 2, pier 2 (under span 2), and span 1 down

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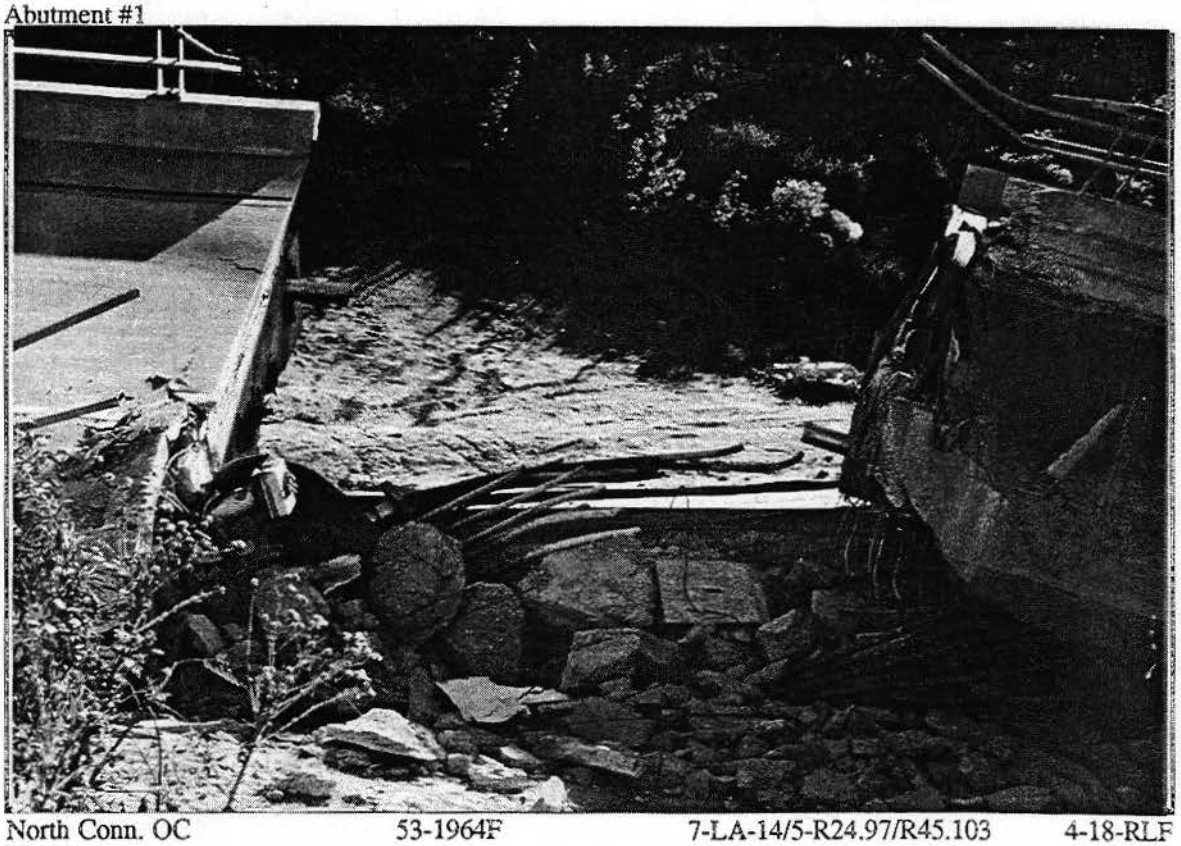
North Conn. OC 53-1964F 7-LA-14/5-R24.97/R45.103 3-17-JSM
Abutment #1



North Conn. OC 53-1964F 7-LA-14/5-R24.97/R45.103 4-18-RLF
Hinge 1.

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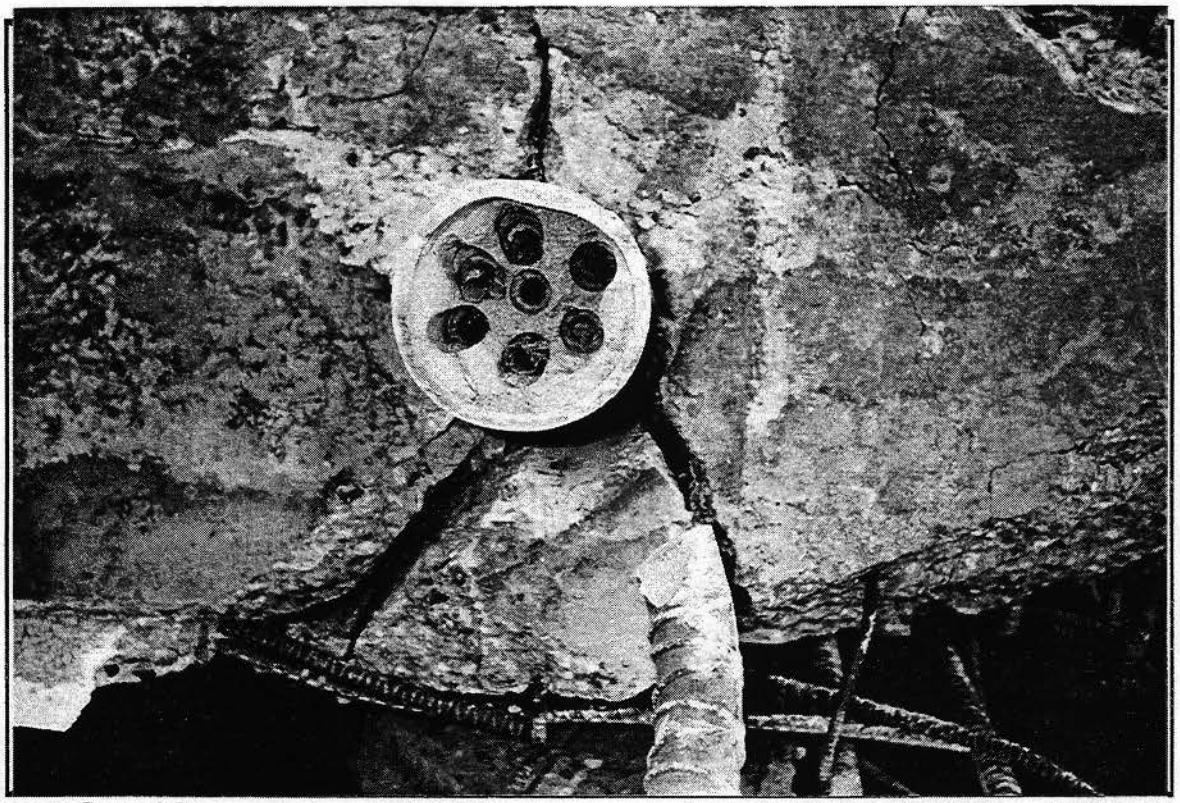
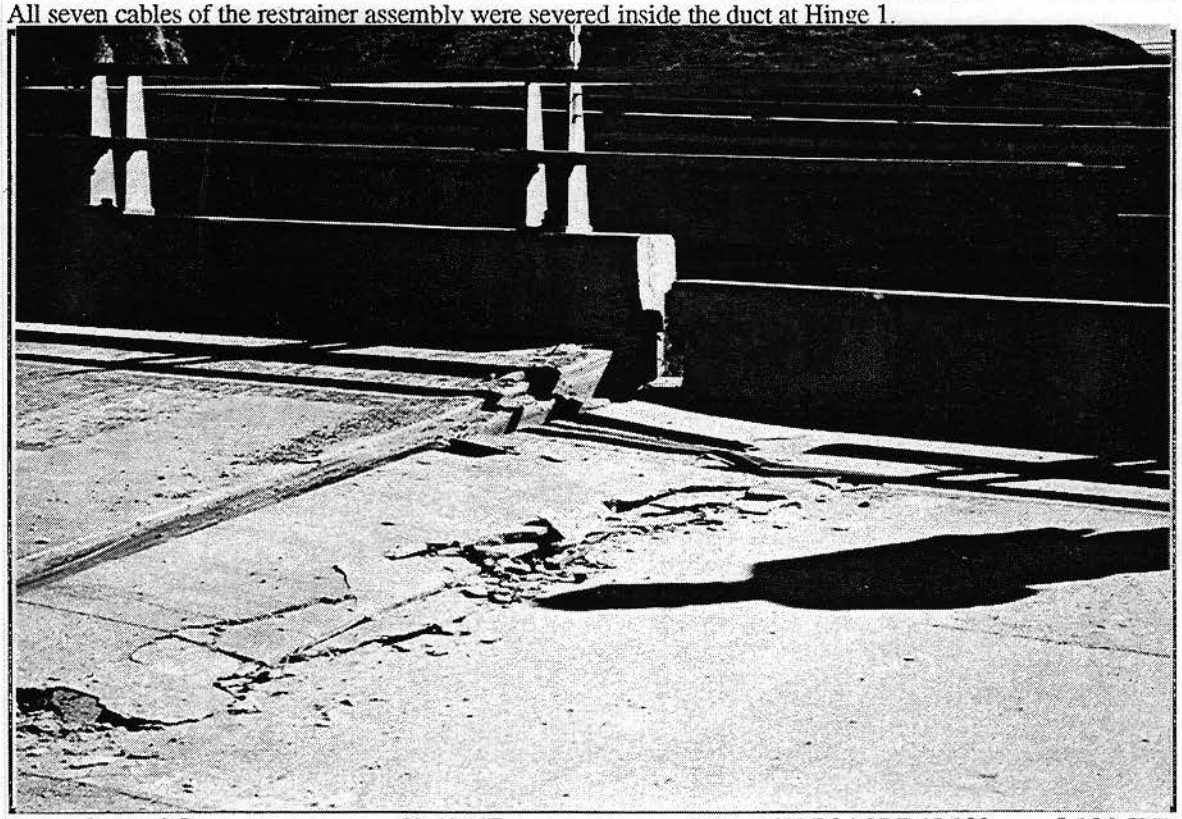


North Conn. OC 53-1964F 7-LA-14/5-R24.97/R45.103 3-20-MDK
All seven cables of the restrainer assembly were severed inside the duct at Hinge 1.



North Conn. OC 53-1964F 7-LA-14/5-R24.97/R45.103 5-15-MDK
Hinge 2 shows evidence of 5"-8" of longitudinal movement. There is a 2" residual opening in the joint. Note greater than a 6" vertical drop in the long span at the south edge of deck.

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Mission-Gothic UC 53-2205 07-LA-118-R8.63

Description of Structure

Mission-Gothic Undercrossing is located at the intersection of San Fernando-Mission Blvd. and Gothic Avenue on Route 118 in the city of Los Angeles. The structure consists of two bridges, left and right, separated by a longitudinal joint seal. The left bridge is a 3 span bridge approximately 506 feet in length and 98 feet wide. The right bridge is a 4 span structure approximately 566 feet in length and varying width from 98 feet. They were designed in 1973 and built in 1976.

The superstructure for both bridges is CIP P/S box girder with a structure depth of 7'-6". The skews vary and reverse direction on both bridges. The left bridge has skews of 46° (SE) for abutment 1 and bent 2, 15° (NE) at bent 3, and 44° (NE). The right bridge has skews of 46° (SE) for abutment 1, bent 2 and bent 3, 15° (NE) for bent 4, and 44° (NE) for abutment 5. The superstructure of both bridges sits on elastomeric bearing pads at the abutments, with an available seat width of approximately 4 feet.

All bents are prestressed, except for bent 4 of the left bridge, allowing for unually large spacing between columns. Each multi-column bent consists of two, 6' octagon columns with a one-way flare. The flared section is a 6' x 14' rectangular section over a 12 foot transition length. The main longitudinal reinforcement (core) and transverse reinforcement of #5 spiral @ 3 1/2 extend into the bent cap but not into the footing. The flare section is formed with #11 bars which extend into the bent cap and tied with #5 @ 12. The footing has a 2'-6" collar which surrounds the pinned column base with 2 inches of expansion joint filler. The footings have a top and bottom mat of steel, but no shear reinforcement. The pedestals have stirrups that extend to the bottom of the footing. The footings are on 16" diameter 70 ton CIDH concrete piles.

The abutments are seat type for both bridges. The footings are on 16" diameter 45 ton CIDH concrete piles as are the retaining walls coming from the abutments.

Description of Damage

The right bridge collapsed completely in spans 3 and 4. Spans 1 and 2 did not collapse completely. Abutment 1 remained seated and had very little longitudinal movement. It had approximately 13 inches of transverse movement. At bent 2, the right column failed the concrete collar which was acting as a pin, thus allowing the column to move. The left column, at bent 2, failed dropping the flare to the side of the column. At bents 3 and 4, the columns both failed below the flare. The bent was able to rest on the flares which were not extremely damaged. At abutment 5, the end diaphragm became unseated.

At bent 2, there was indication the column had moved due to the heaving of the soil to one side of the column. After excavating, the broken collar was found, substantiating the theory that the column had moved.

The left bridge suffered major damage but did not collapse. Most of the columns were failed below the flare but remained standing. The end diaphragms remained seated. There was 3 inches of longitudinal movement and 2 inches of transverse movement at abutment 1. At abutment 4, there was transverse movement of 10 inches.

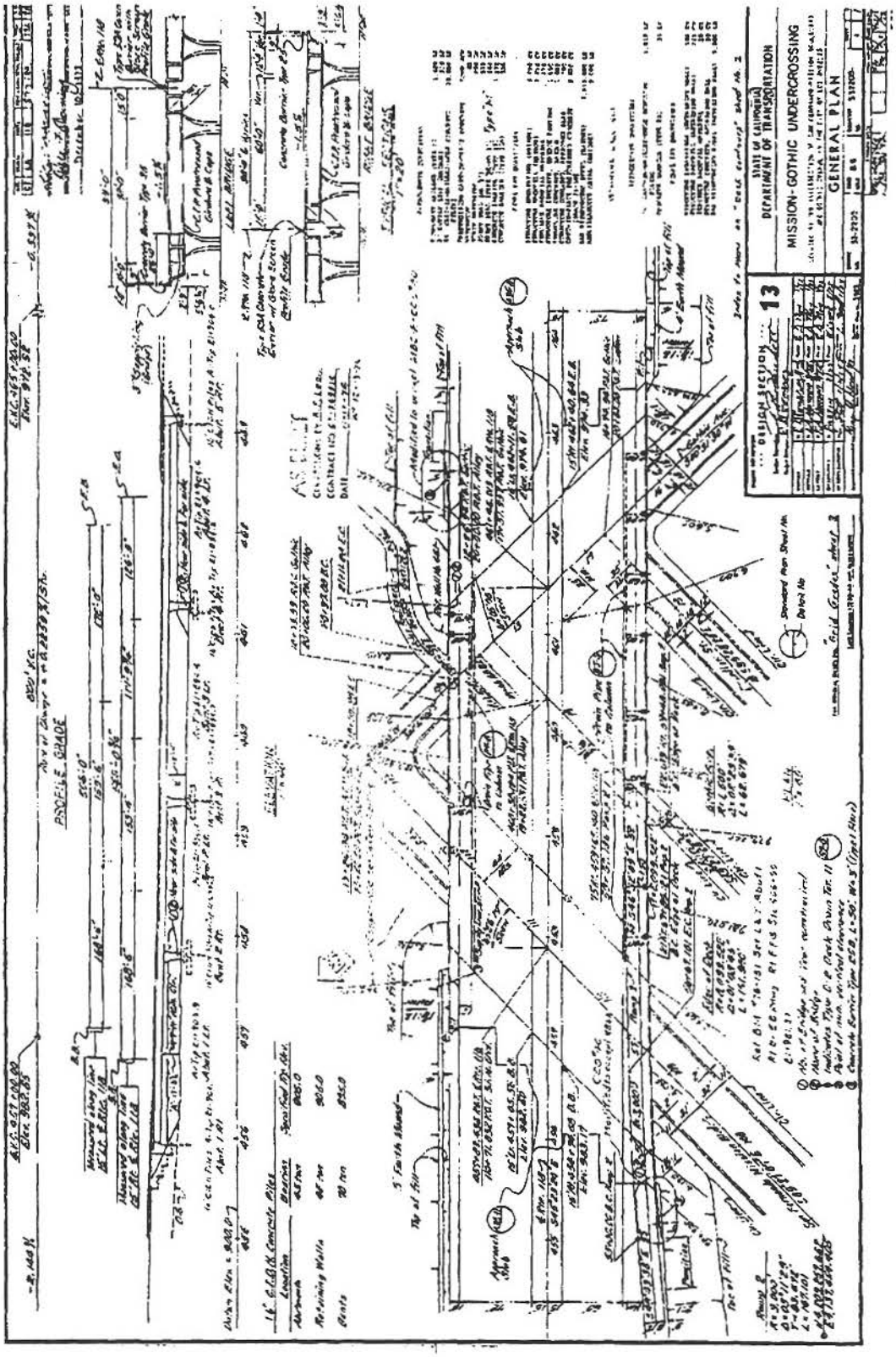
There was an indication that both bridges rotated in a clockwise direction. In the columns that failed, the spiral reinforcing necked down and finally failed. The spirals were welded together at the ends, and there was no evidence of failure of the welds.

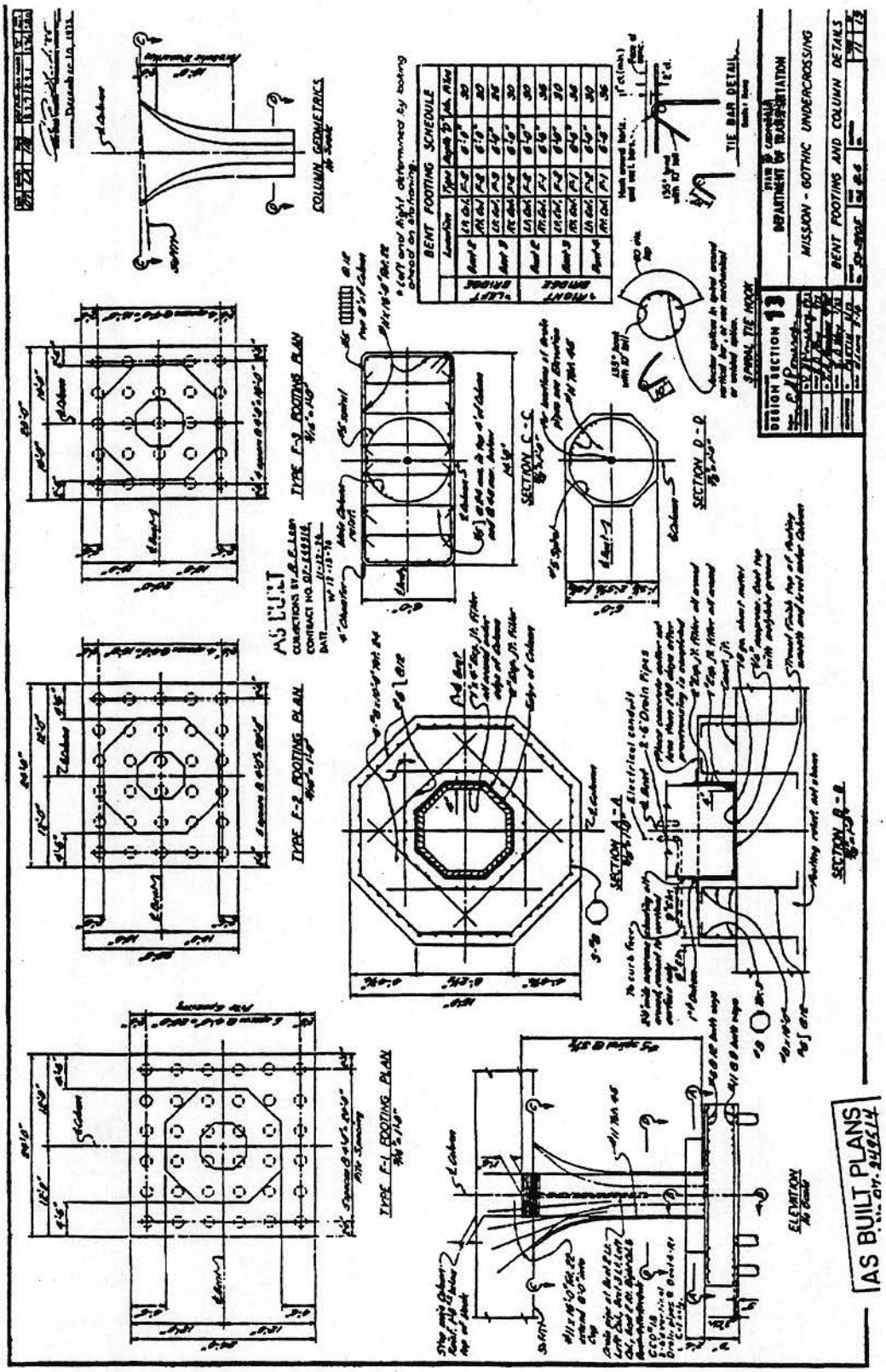
Analysis of Damage

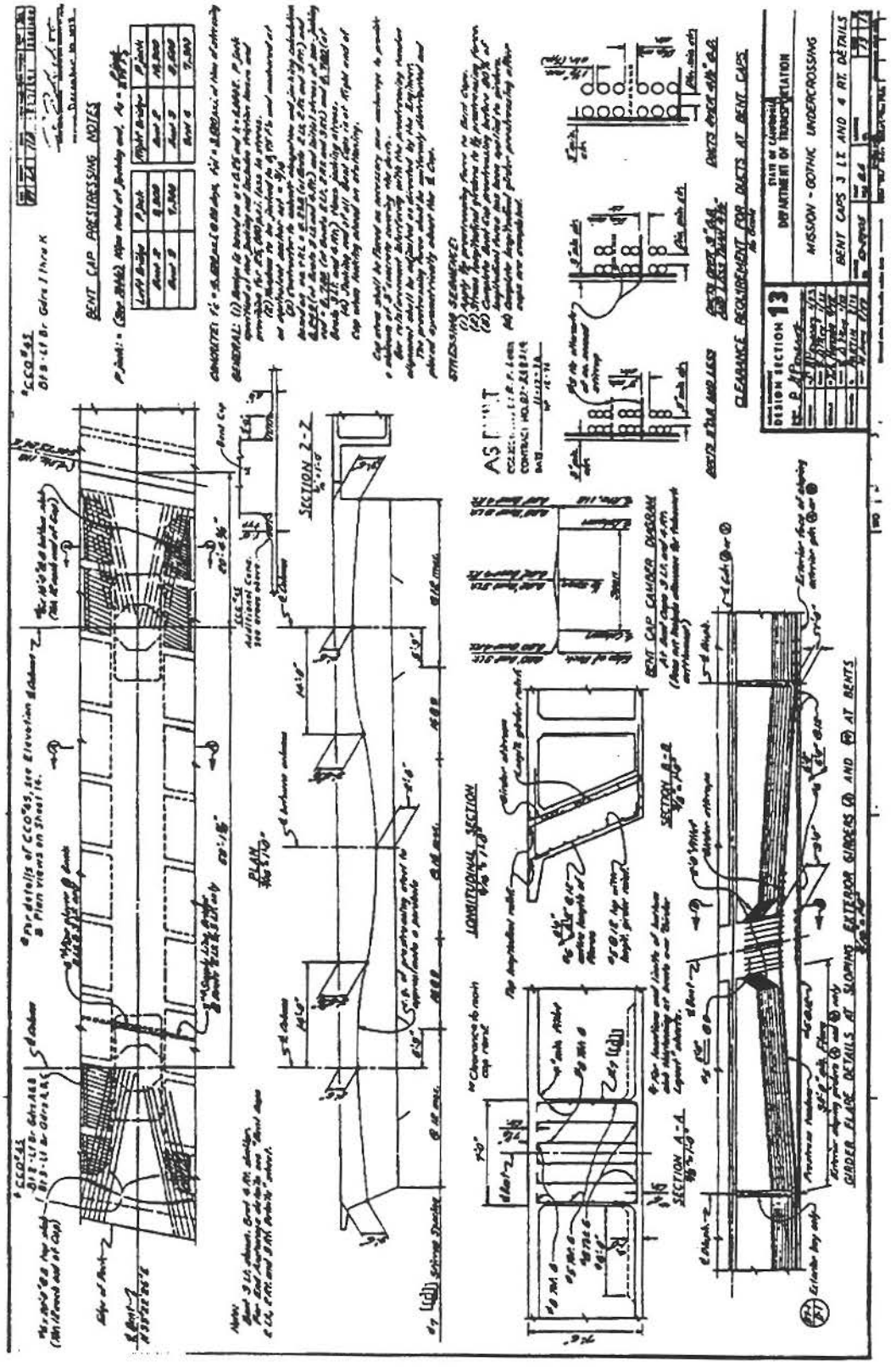
The collapse of the right bridge and the major damage to the left bridge were due to a combination of 1) the unusual layout of the bent geometry (including bent span length), 2) the directional dependence of column stiffness on the flare of the column's, and 3) the amount of transverse column reinforcing steel.

The bridges appear to have failed in a generally transverse mode (though complicated by the skew). Bents 4R and 3L were alligned more in their stiff direction with the damaging motions than were bents 2R, 3R, and 2L. This caused the columns of bents 4R and 3L to attract larger loads than those attracted by 2R, 3R, and 2L. These effectively stiffer bents and their columns were overloaded causing a yielding mechanism to form in the reduced sections of the columns below the flares. It is believed the columns failed in shear through a region of plastic hinging.

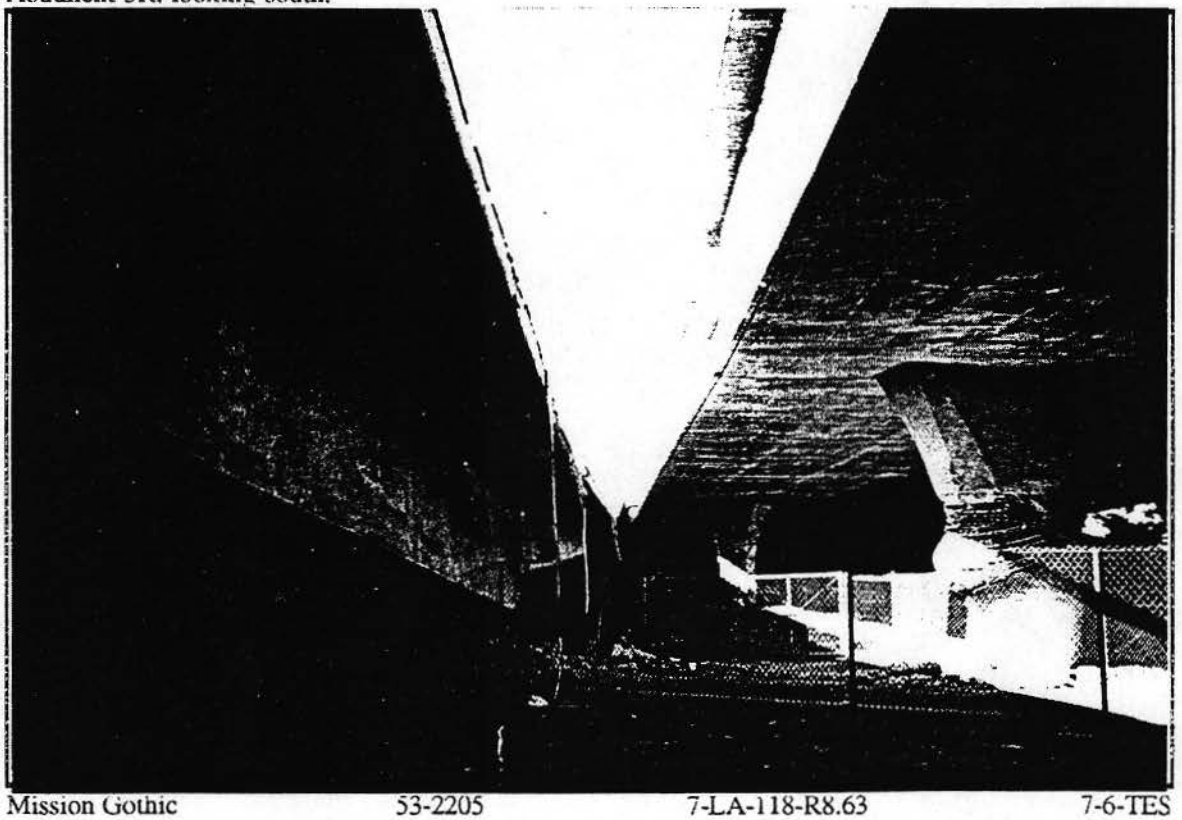
As these columns were completely sheared or severely damaged, abutment 5 of the right bridge dropped. The columns of bents 2R, 3R, and 2L may or may not have been damaged before the failures at bents 4R and 3L occurred. Certainly secondary effects from the large deformations that occurred after bents 4R and 3L failed generated various types and levels of damage and displacements at other columns and abutments.


PROFILE GRADE
DEPARTMENT OF TRANSPORTATION
MISSION-GOTHIC UNDERCROSSING
GENERAL PLAN


AS BUILT
AS BUILT PLANS
BENT FOOTING SCHEDULE
TIE BAR DETAIL
SPIRAL TIE HOOK
DIVISION SECTION 13
DEPARTMENT OF TRANSPORTATION
MISSION - GOTHIC UNDERCROSSING
BENT FOOTING AND COLUMN DETAILS
TYPE F-2 FOOTING PLAN
TYPE F-1 FOOTING PLAN
COLUMN GEOMETRICS
SECTION A-A
SECTION B-B
SECTION C-C
SECTION D-D
ELEVATION


BENT CAP PRESTRESSING NOTES
SECTION 2-2
PLAN
LONGITUDINAL SECTION
SECTION A-A
SECTION B-B
BENT CAP CANTILEVER DIAGRAM
CLEARANCE REQUIREMENT FOR DUCTS AT BENT CAPS
DESIGN SECTION 13
DEPARTMENT OF TRANSPORTATION
MISSION - GOTHIC UNDERCROSSING
BENT CAPS 3 LT AND 4 RT. DETAILS
GIRDER BLOCK DETAILS AT SLOPING EXTERIOR GIRDERS (A) AND (B) AT BENTS

Mission Gothic 53-2205 7-LA-118-R8.63 1-20-TES
Abutment 5R, looking south.



Mission Gothic 53-2205 7-LA-118-R8.63 7-6-TES
Looking west towards abutment 1 between the left and right bridge.

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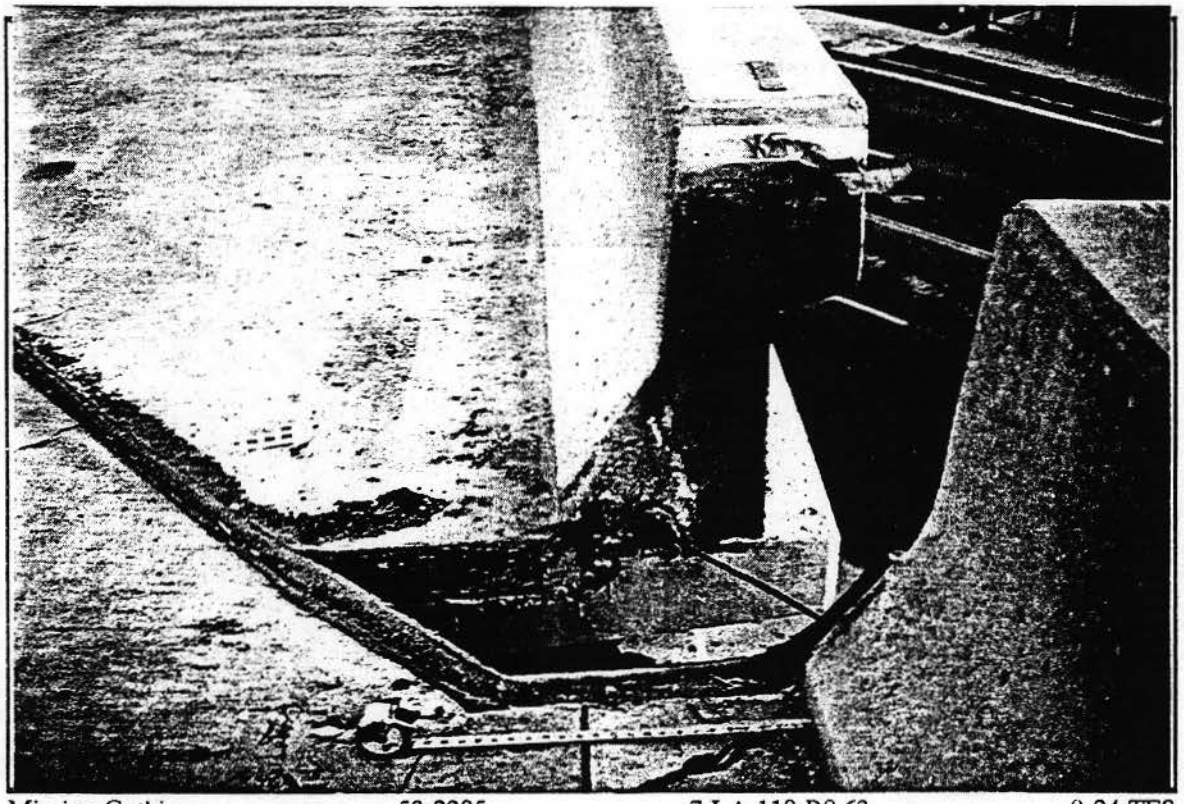
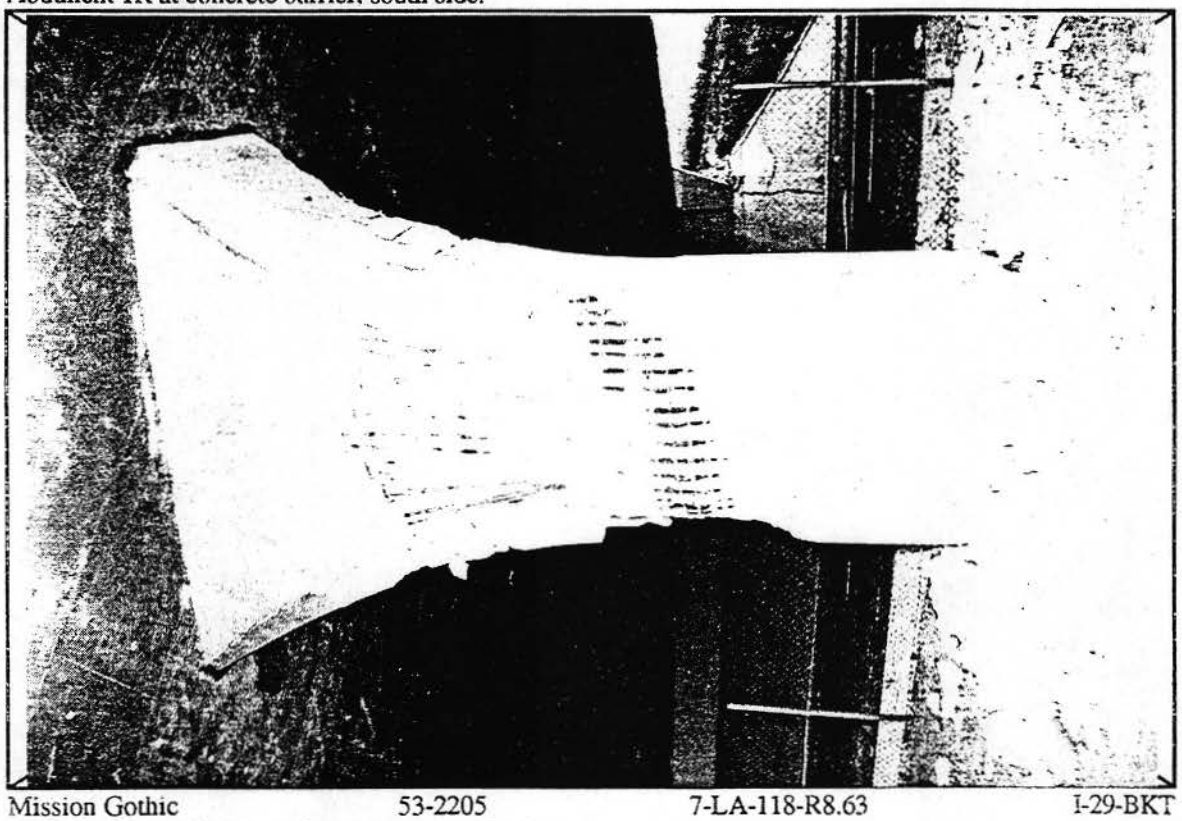


Mission Gothic 53-2205 7-LA-118-R8.63 9-24-TES
Abutment 1R at concrete barrier, south side.



Mission Gothic 53-2205 7-LA-118-R8.63 I-29-BKT
Column 2, Bent 2 of Left Struc., Looking North

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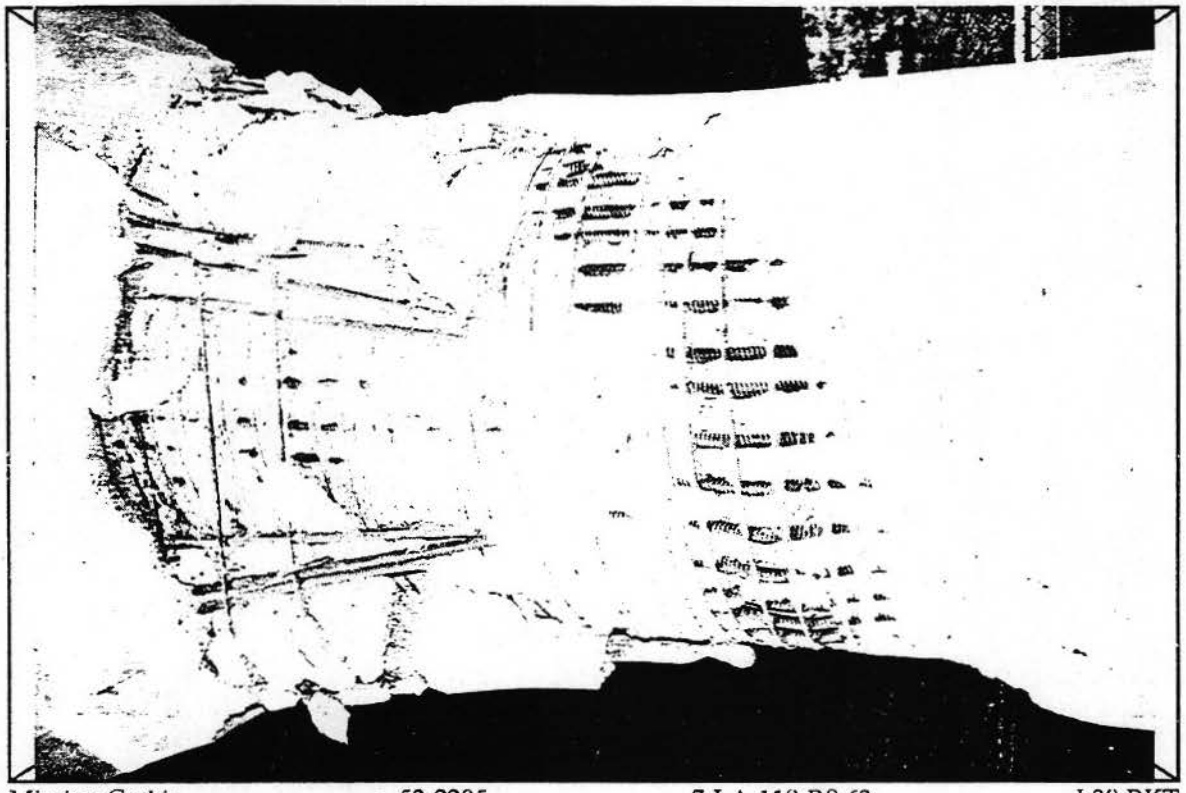
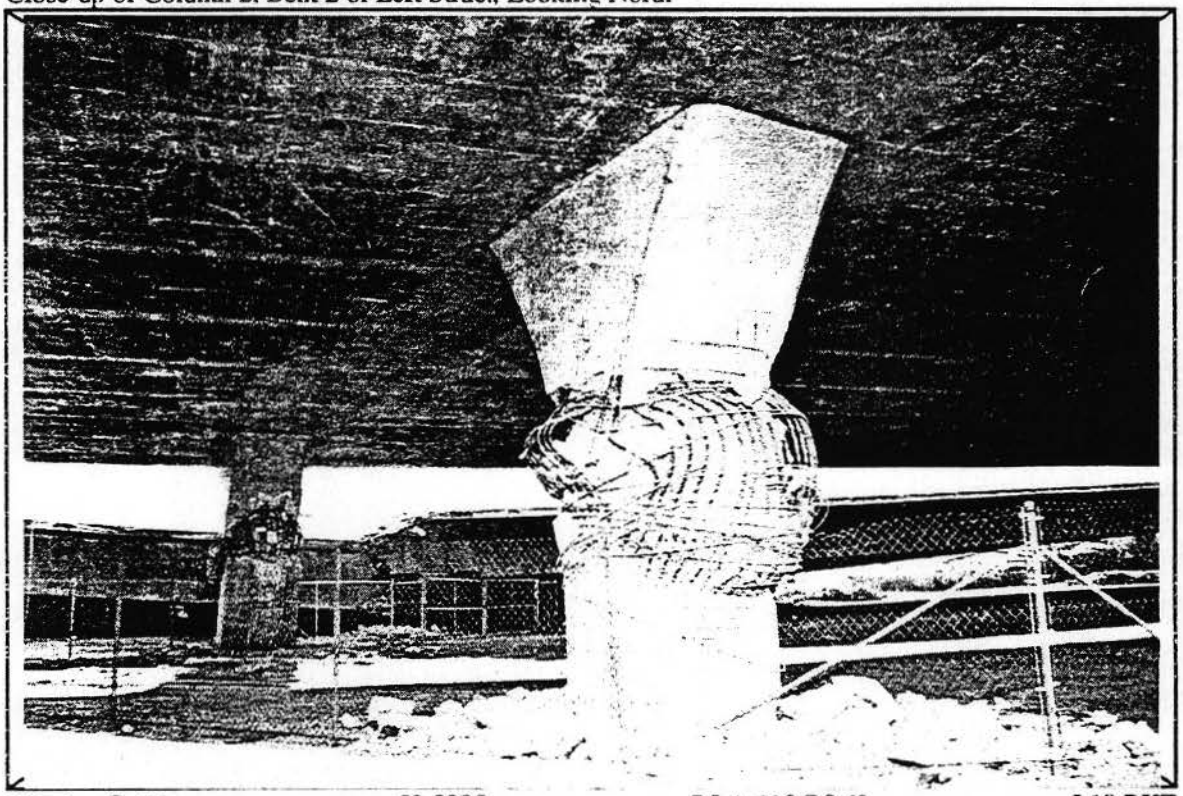


Mission Gothic 53-2205 7-LA-118-R8.63 I-30-BKT
Close-up of Column 2, Bent 2 of Left Struc., Looking North



Mission Gothic 53-2205 7-LA-118-R8.63 I-18-BKT
Overview of Bent 3 of Left Struc., Looking Southwest

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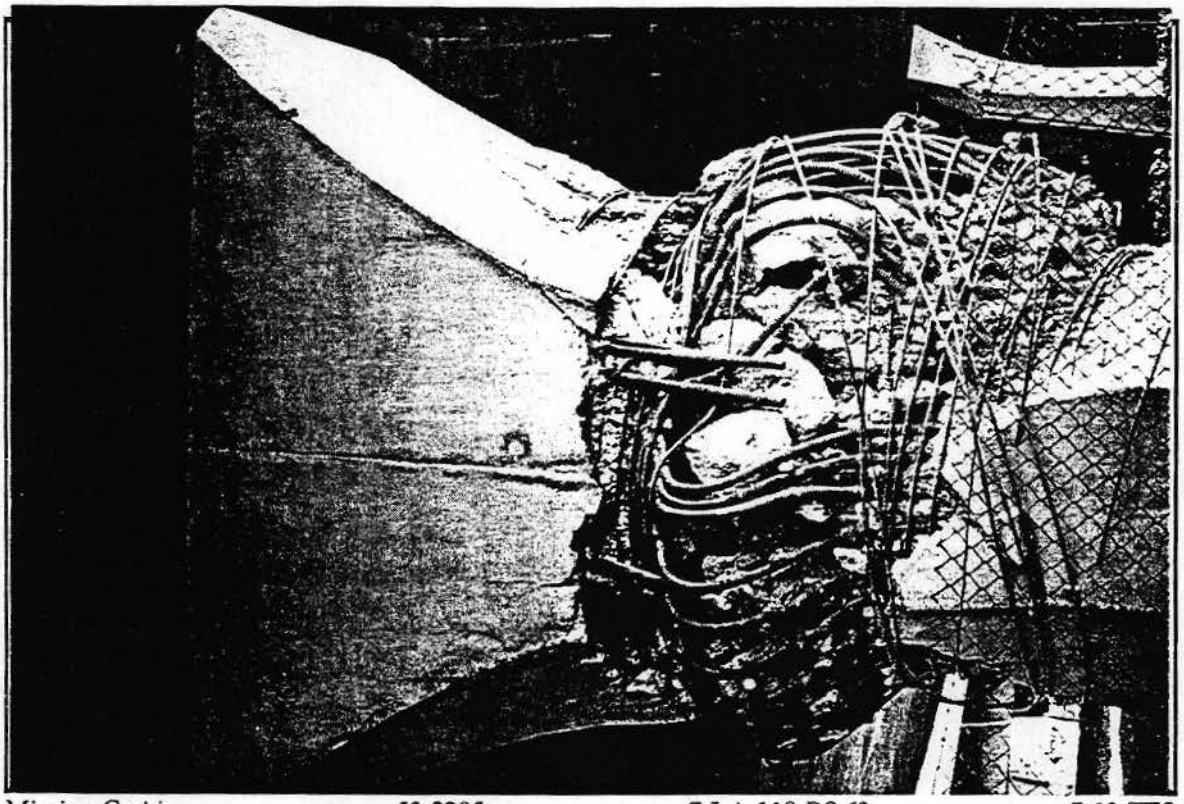
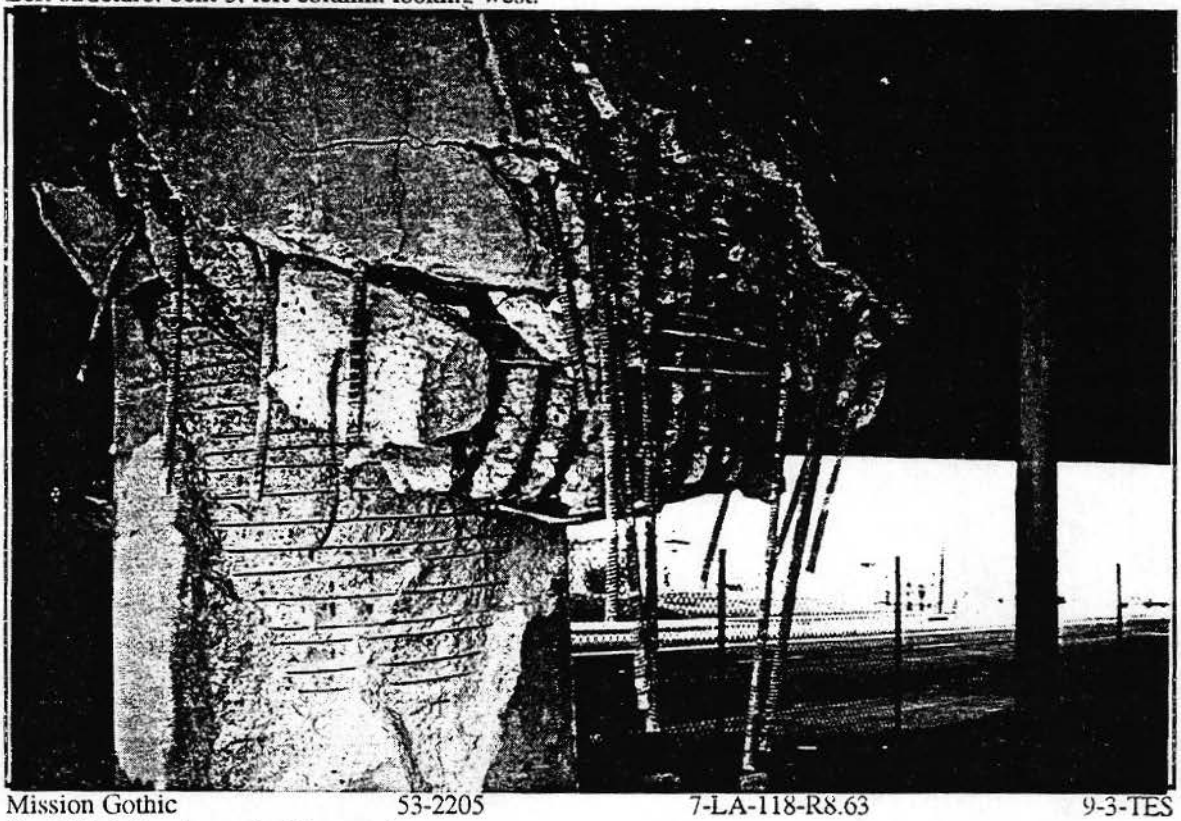


Mission Gothic 53-2205 7-LA-118-R8.63 7-13-TES
Left structure, bent 3, left column, looking west.



Mission Gothic 53-2205 7-LA-118-R8.63 9-3-TES
Bent 2R, left column, looking north.

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Mission Gothic 53-2205 7-LA-118-R8.63 12-23-TES
Bent 2L, right column, looking south.

Mission Gothic 53-2205 7-LA-118-R8.63 2-30-BHM
Closeup of #5 spiral necked down and ruptured in tension.

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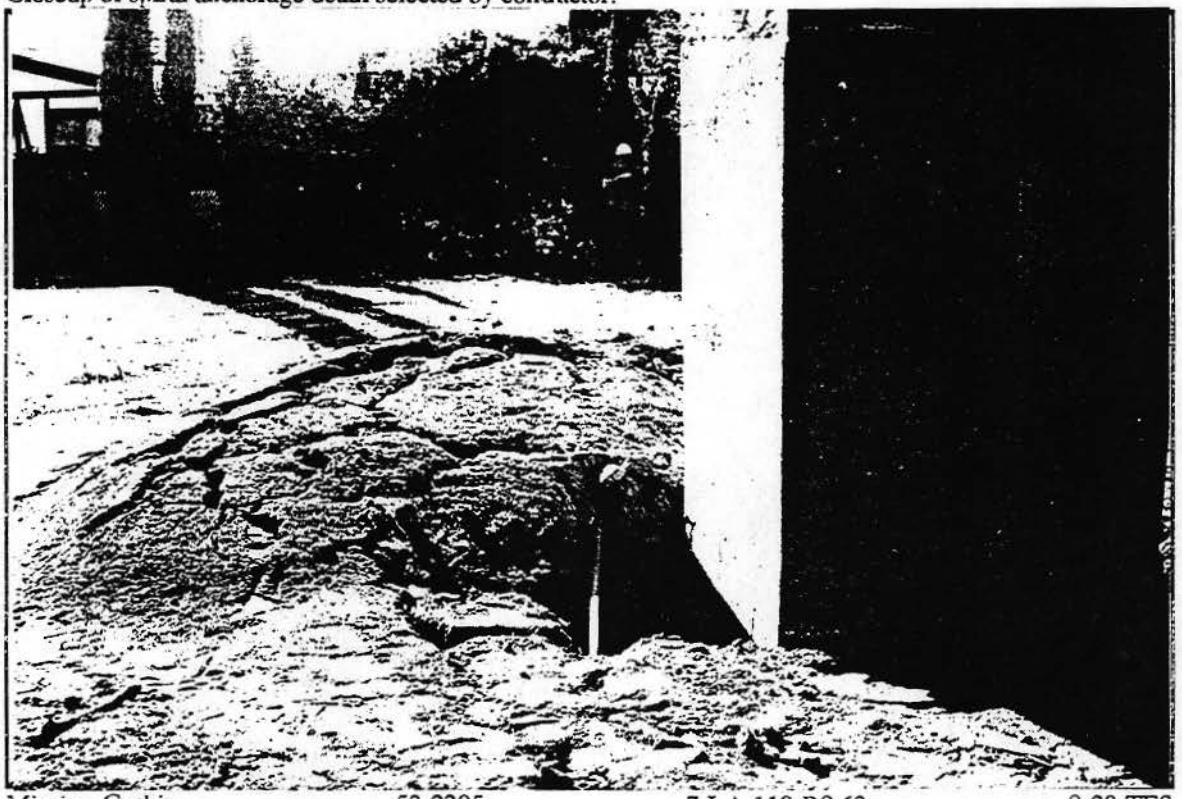
Mission Gothic 53-2205 7-LA-118-R8.63 2-26-BHM
Closeup of spiral anchorage detail selected by contractor.



Mission Gothic 53-2205 7-LA-118-R8.63 8-20-TES
Bent 2R, right column. Heaved soil, looking south.

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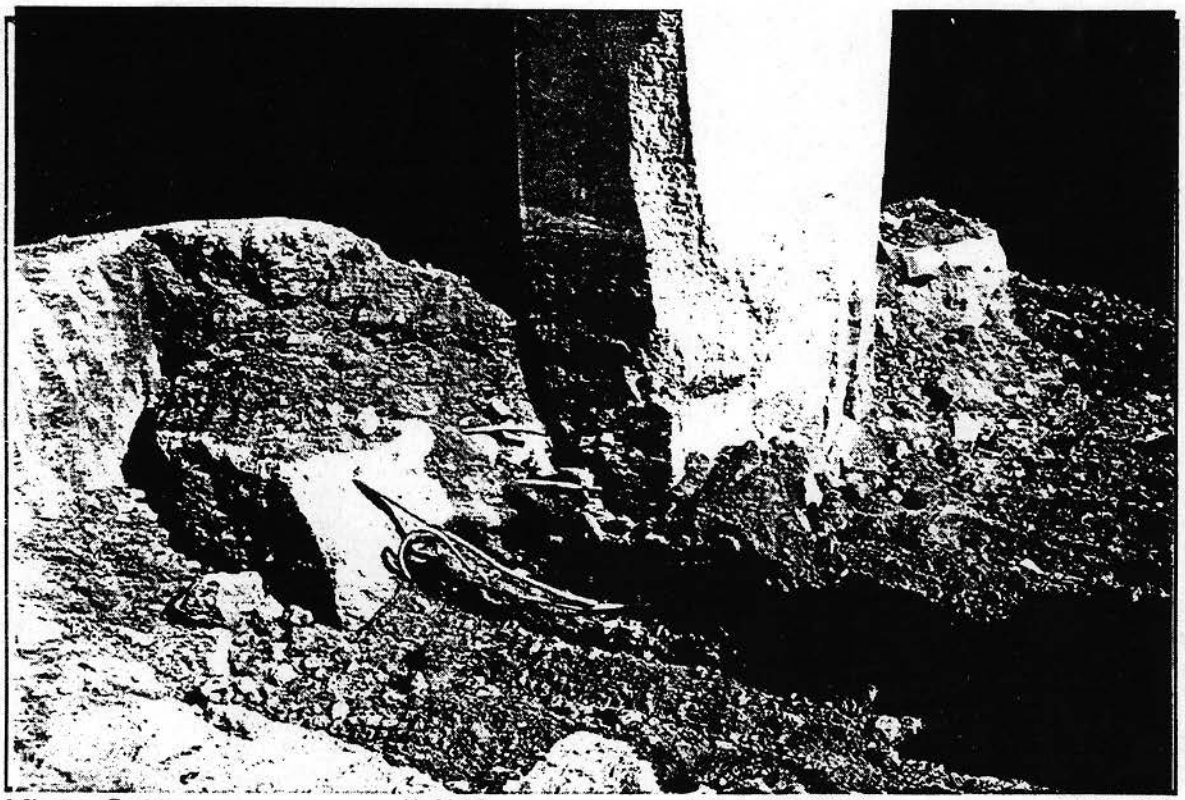
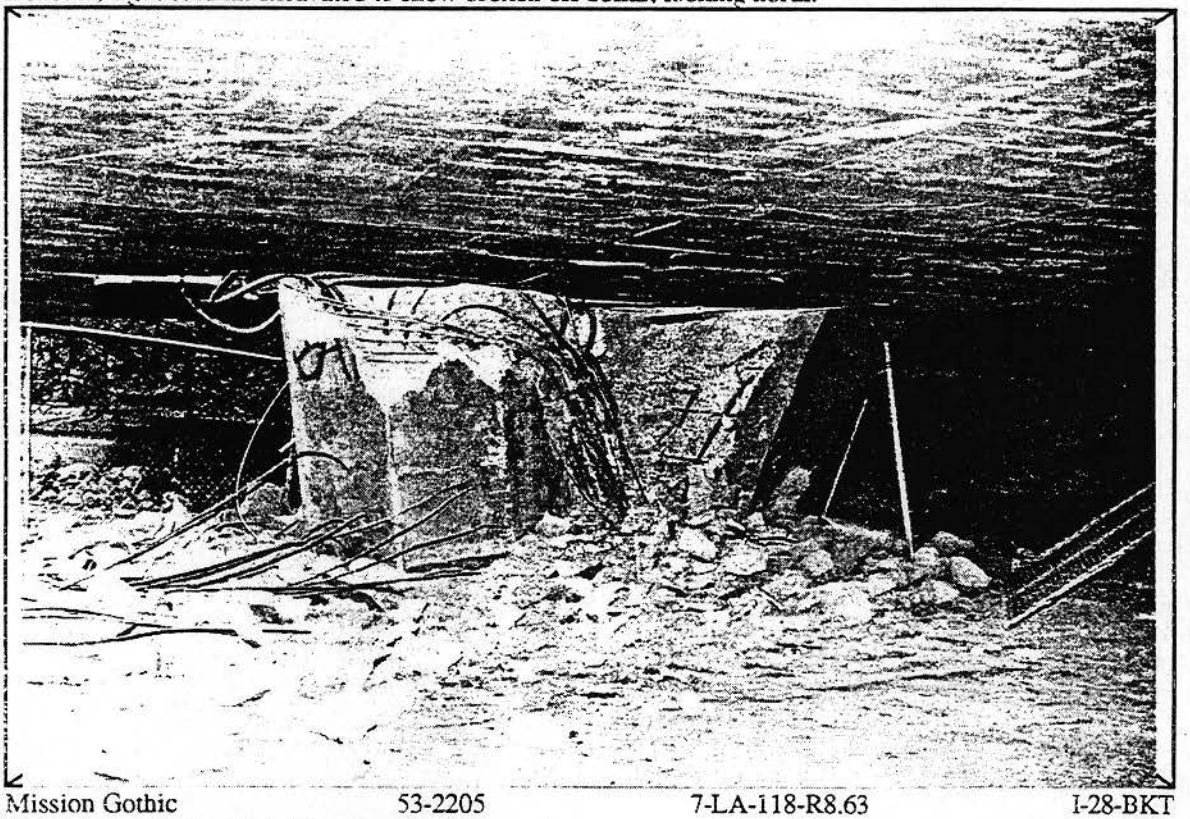


Mission Gothic 53-2205 7-LA-118-R8.63 11-21-TES
Bent 2R, right column excavated to show broken off collar, looking north.



Mission Gothic 53-2205 7-LA-118-R8.63 I-28-BKT
Column 1, bent 3 of right structure, looking south.

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La Cienega-Venice UC 53-1609 07-LA-10-R8.83

Description of Structure

La Cienega-Venice Undercrossing is located on Interstate 10, the Santa Monica freeway. It is two structures separated by a longitudinal joint at the median. These bridges are comprised of 3 frames with a total length of 871 feet. There are seven spans with lengths varying from 50 feet to 116 feet. The left bridge has a constant width of 70 feet. The right bridge width varies from 70 feet to approximately 85 feet. These bridges were designed in 1962 and built in 1964.

The superstructure is a RC box girder with a structure depth of 6'-3". Skews vary from approximately 5° at abutment 1 to 41° at abutment 10. Hinge seat width is approximately 6".

Except for piers 2 and 9 adjacent to the abutments, the bents are 3 or 4 column, 4' diameter round prismatic concrete columns. The column main longitudinal reinforcement has a total of 12 to 48 #11 bars with #4 lapped hoops @ 12. The columns are either fixed or pinned at the base. Pile footings have only a bottom mat of steel. Piers 2 and 9 are concrete pier walls with vertical reinforcement lapped at the top of the pile footing. Curtain walls extend from the piers to the end diaphragm abutments on a single row of piles.

The hinges of these bridges were retrofitted with 1 1/4" diameter H.S. rods in 1978 as part of the Phase I retrofit program.

Description of Damage

Many of the columns from bent 3 to bent 7 lost their confinement steel and their concrete cores disintegrated. The longitudinal column rebar buckled and formed "mushroom" shapes. Both superstructures from Bent 3 to Bent 7 were resting on masonry buildings (mini-storage units). All of the top of columns in Bent 7 of the westbound structure failed except the middle column. In this column, the failure occured at the bottom of column. The bottom of columns, which were designed to be fixed, had continuous or lapped longitudinal rebar. There were no signs of lap splice deterioration or concrete spalls at the bottom of columns. Span 6 of the westbound structure dropped because the cable restrainer at the hinge did not work. Some of the restrainers sheared completely and others pulled out of the hinge.

The collector distributor ramp had minor concrete spalling at bents 3 and 4 and major failure at the south column of bent 5. At this column, the longitudinal bars buckled, and there were very large cracks in the column core. There was no damage at the base of any of the columns. Bent 8 had a large shear crack at the mid-height of the column. The hinges suffered minimal damage.

Six of the footings at various bents of the eastbound and westbound structures were excavated. The top of the footings, the portion of the existing columns below ground, and the piles were exposed. There was no sign of damage or degradation to any of them.

Analysis of Damage

Eastbound and Westbound

It is difficult to state the exact reasons for collapse of bent 3 to bent 7 without a complete analysis of the bents. The following may be a possible scenario of the collapse mechanism based upon a review of the as-built plans and damage observed at the site.

All of the bents on both structures have fixity at the base of the columns (by means of lapped splice or continuous longitudinal rebar) except bent 4 which has a pinned connection at the base of column. These bents have significant lateral strength but lack confining steel.

The collapsed bents on these structures were similar to bent 3 of Fairfax-Washington UC (53-1580). For columns with damage at the top-of-column, the plastic hinges probably started at the top, followed by crushing of the compression concrete and buckling of the longitudinal column bars. The shear flow through these columns increased because the lapped splices at the bottom of the column and the top of footing did not degrade. This increase in shear demand and lack of confinement may ultimately have caused the total disintegration of the column core and, consequently, the collapse of bent 3 to bent 7. This failure may be categorized as combination of flexure and shear failure at the top or bottom of the column within the plastic hinge zone.

It is interesting to note that no damage was observed below ground. It may be due to the fact that the compacted aggregate base, soil, paving asphalt, and concrete curbs moved the point of maximum moment nearer to the ground surface. This theory may be clearly evident for the middle column of bent 4 of the westbound structure, which had 42-#11 bars continuous (no

lap splice allowed in the as-builts) to the bottom of the footing. The column failure (mushroom shape) was above the asphalt paving; no failure was observed below it.

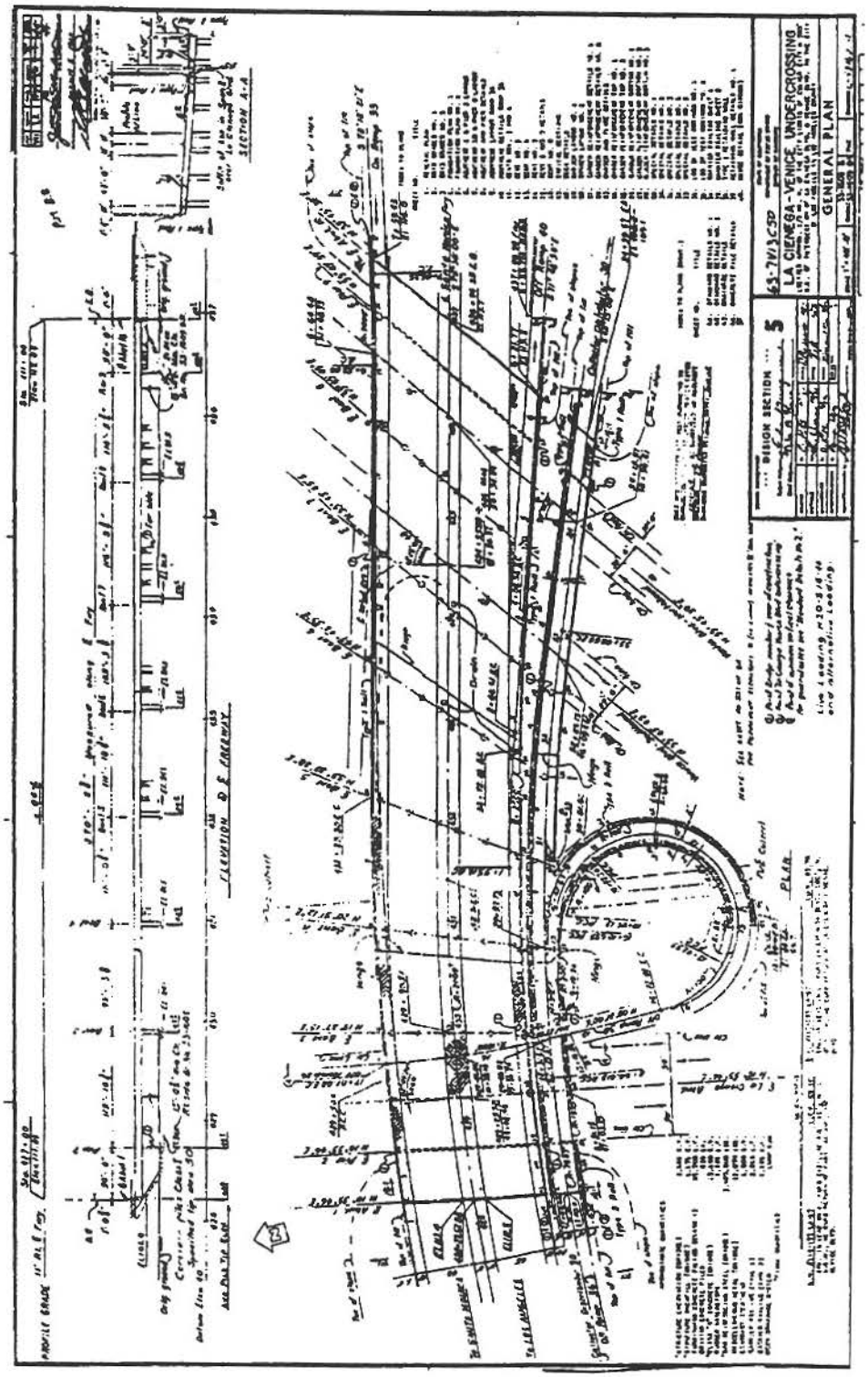
It is difficult to explain why some of the bents had "mushroom shape" failures at the base of the column rather than at the top of column. This may be due to the differences in the relative stiffnesses of the footing influenced by the surrounding environment such as asphalt, curbs, compacted fill, etc.

The restrainer rods in the hinge in span 6 of the eastbound freeway worked well and kept the superstructure together, but on the westbound freeway some restrainers pulled out and others sheared off completely, and spans dropped. The plastic hinging and vertical displacement of columns in bent 7 of the westbound freeway may have caused the collapse of span 6. On the eastbound freeway bent 7 columns did not form plastic hinges and span 6 remained seated.

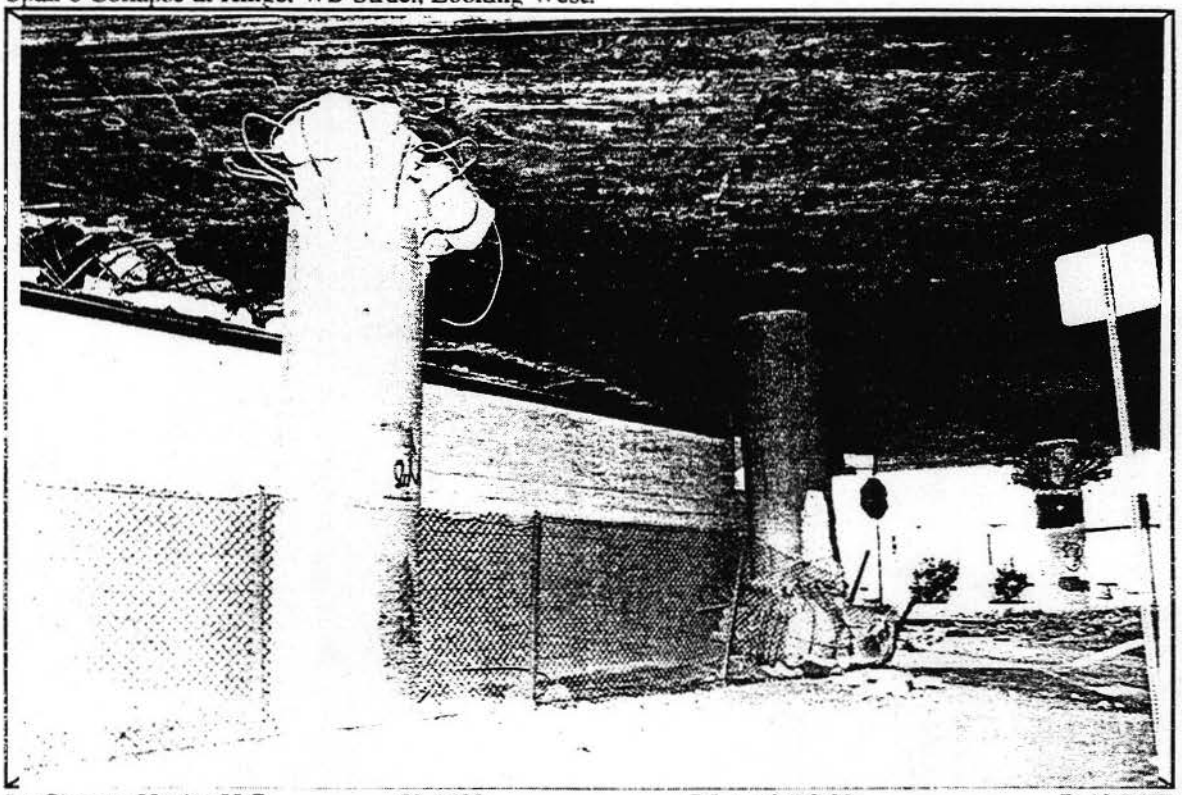
Collector Distributor 30 and Ramp 36

This ramp did not collapse but had some minor damage at bents 3 and 4, and major shear failure at bents 5 and 8. It is interesting to see that this ramp has the same typical details as far as column base fixities, span length, column sizes, and location of hinges, but the amount of main column reinforcement was less where columns did not collapse. The reduced number of longitudinal rebar made columns more flexible and ductile than the columns in the viaduct. This may have reduced the amount of damage in this ramp.

Restrainers worked well in this ramp and kept the superstructure together.


LA CIENEGA - VENICE UNDERCROSSING
GENERAL PLAN
SECTION A-A
ELEVATION OF EXPRESSWAY

La Cienega-Venice U.C. 53-1609 7-LA-10-R8.83 C-31-BKT
Span 6 Collapse at Hinge. WB Struc., Looking West.



La Cienega-Venice U.C. 53-1609 7-LA-10-R8.83 D-10-BKT
Columns 3 & 2, Bent 7 of WB Struc., Looking North.

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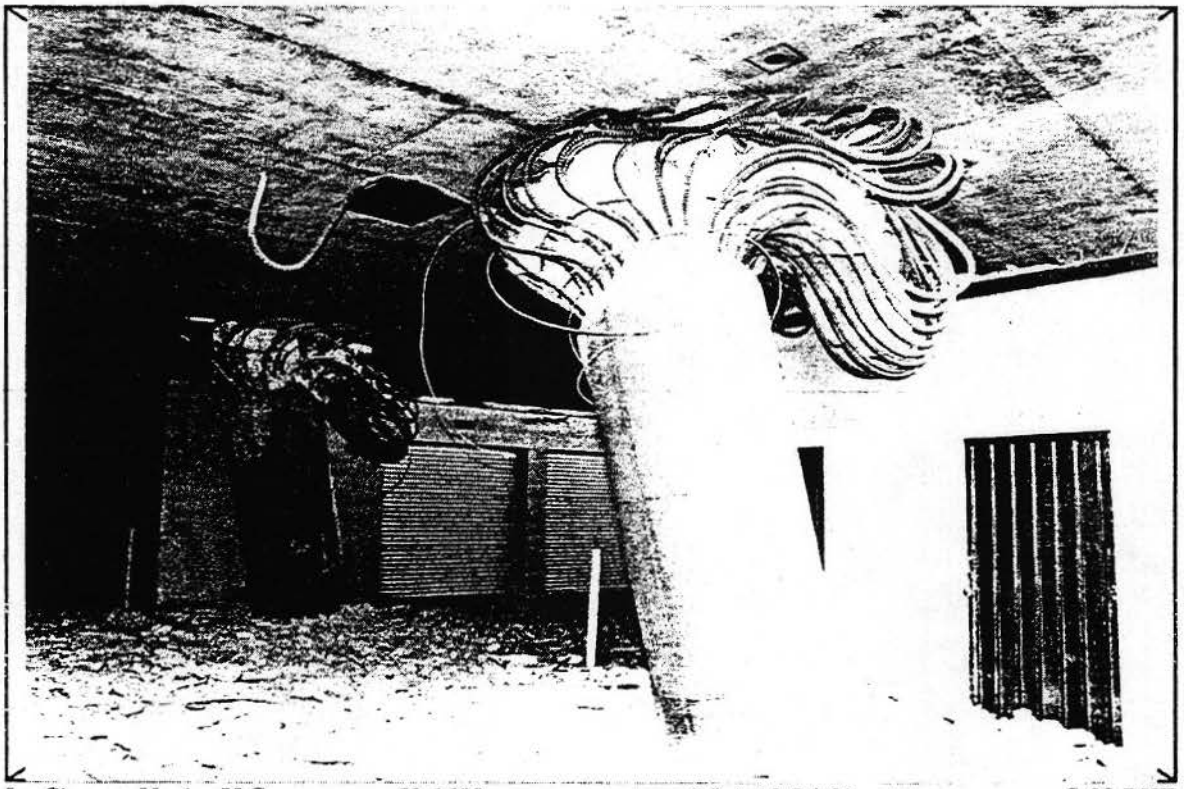
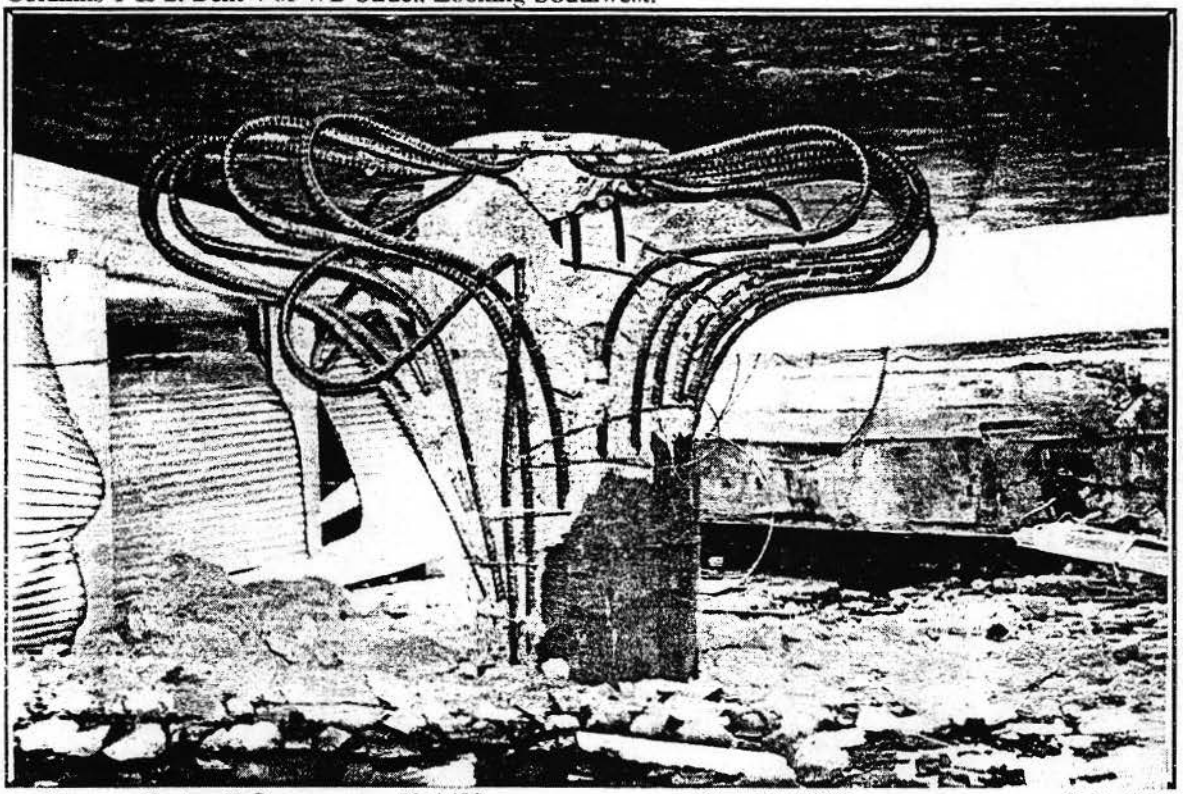


La Cienega-Venice U.C. 53-1609 7-LA-10-R8.83 G-28-BKT
Columns 1 & 2. Bent 4 of WB Struc.. Looking Southwest.



La Cienega-Venice U.C. 53-1609 7-LA-10-R8.83 G-31-BKT
Column 2. Bent 6 of WB Struc.. Looking East.

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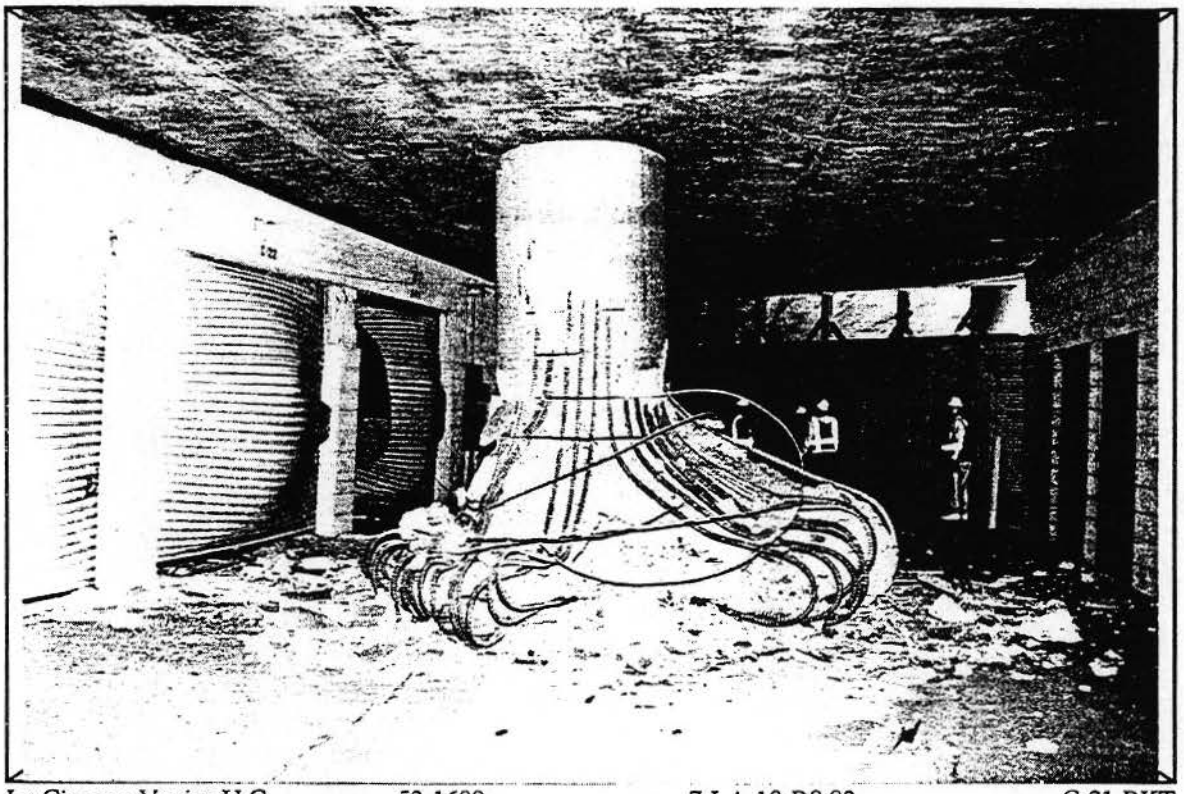
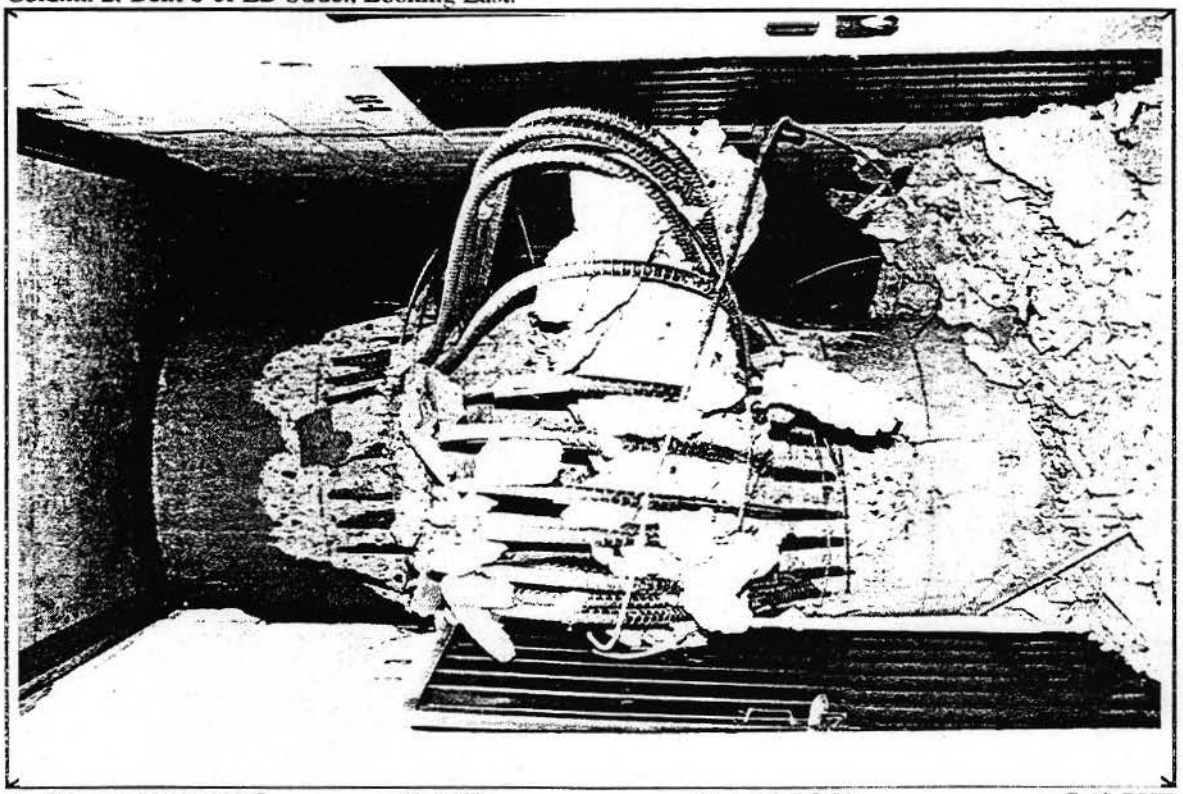


La Cienega-Venice U.C. 53-1609 7-LA-10-R8.83 G-21-BKT
Column 2. Bent 6 of EB Struc., Looking East.



La Cienega-Venice U.C. 53-1609 7-LA-10-R8.83 G-19-BKT
Column 3. Bent 6 of EB Struc.

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La Cienega-Venice U.C. 53-1609 7-LA-10-R8.83 C-36-BKT
Bent 8 of Collector Distributor 30. Looking Southeast.

La Cienega-Venice U.C. 53-1609 7-LA-10-R8.83 E-1-BKT
Column 1. Bent 6 of WB Struc., Looking Southeast.

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MAJOR DAMAGE (NO COLLAPSE)

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Fairfax-Washington UC 53-1580 07-LA-10-R9.31

Description of Structure

Fairfax-Washington Undercrossing is located on Interstate 10, the Santa Monica freeway. It is two structures separated by a floating slab in the median. The bridges are comprised of two frames with a total length of 577 feet measured along the centerline of Route 10. The right bridge has seven spans and the left bridge has eight spans. Both bridges have span lengths which vary from 46 feet to 112 feet. The right bridge has a width which varies from 72 feet to 74 feet. The left bridge width varies from approximately 72 feet to 110 feet. These bridges were designed in 1962 and built in 1964.

The superstructure is a RC box girder with a varying structure depth of 4'-9" to 5'-6". Skews vary from approximately 5° to 45°. The hinge seat width is 6".

The bents adjacent to the abutments are pier walls pinned at the base on pile footings. All other bents are 3 or 4 column; 4' diameter, round, prismatic, concrete columns that are either fixed or pinned at their base. The main longitudinal column reinforcement is a total of 12 to 62 #11 bars with #4 lapped hoops @ 12. Pile footings have only a bottom mat of steel.

The superstructure is supported on bearing assemblies anchored to concrete support blocks at the abutments. The abutments are founded on spread footings.

These bridges were retrofitted with 5 and 7 cable restrainer assemblies at the hinge in 1974.

Description of Damage

All columns of bent 3 in the eastbound structure (three columns) and in the westbound structure (four columns) lost their confinement steel, and their concrete cores disintegrated. All the longitudinal column rebar buckled and formed "mushroom" shapes. The superstructure sagged approximately 10 feet at bent 3 and rested at the hinge in span 3 and pier 2. As a result of the sag in the superstructure, the superstructure lifted off the rocker bearing at Abutment 1 approximately 5 feet. There was a 1 foot gap between the soil and the front face of the abutment footing. It is hard to say if this existed prior to the earthquake or is due to the longitudinal movement of the abutment. The bottoms of the columns at bent 3 were designed

to be fixed, and longitudinal column rebar were lapped at the top of footing. Yet, there were no signs of lap splice deterioration or concrete spalls at the bottom of columns, indicating that the cable restrainers at the hinge in Span 3 worked well because the superstructure did not become unseated. The columns in Bent 4 of the eastbound structure had major shear cracks, and all other columns had some minor spalls or none at all.

Two of the footings at bent 3 of the eastbound structure were excavated following the earthquake. The top of the footing, the portion of the existing column below ground, and the piles were exposed. There was no sign of damage or degradation to any of them.

Analysis of Damage

Eastbound Structure

It is difficult to state the exact reasons for the collapse of bent 3R without a complete analysis of the bents, but the following may be a possible scenario of the collapse mechanism based upon a review of the as-built plans and damage observed at the site.

The first frame consists of a solid pier wall at pier 2, which has one row of dowels connecting the top of the pier wall to the superstructure. Bent 3R has three, 4' diameter columns on pile footings. The transverse displacement demand of frame 1 was resisted by bent 3R columns, and plastic hinges probably started at the top of the columns, followed by crushing of the compression concrete and buckling of the longitudinal column bars. The shear flow through the columns increased because the lap splice at the bottom of the columns did not degrade. The increase in shear demand and lack of confinement may have ultimately caused the total disintegration of the column core and, consequently, the collapse of bent 3R. This collapse may be categorized as a combination of flexure and shear failure within the top plastic hinge zone of the column.

It is interesting to note that no damage was observed below ground. It may be due to the fact that the compacted aggregate base, soil, and asphalt paving could have moved the point of maximum moment near to the ground surface.

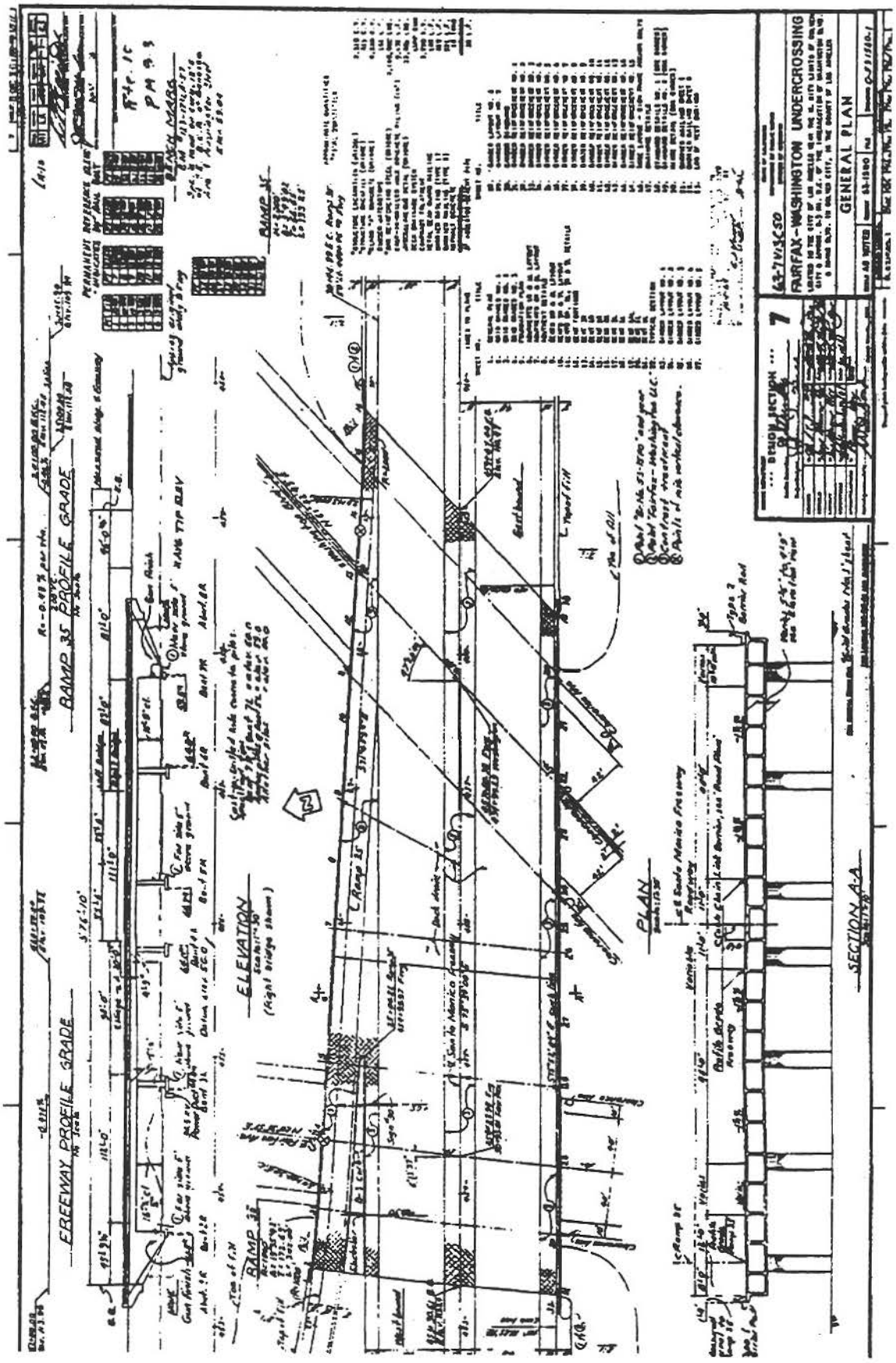
The second frame suffered minor damage from plastic hinging at the top of columns. The reasons for the minor damage here compared to the first frame may have been as follows: the second frame has greater redundancy (additional bents) and the columns are more ductile

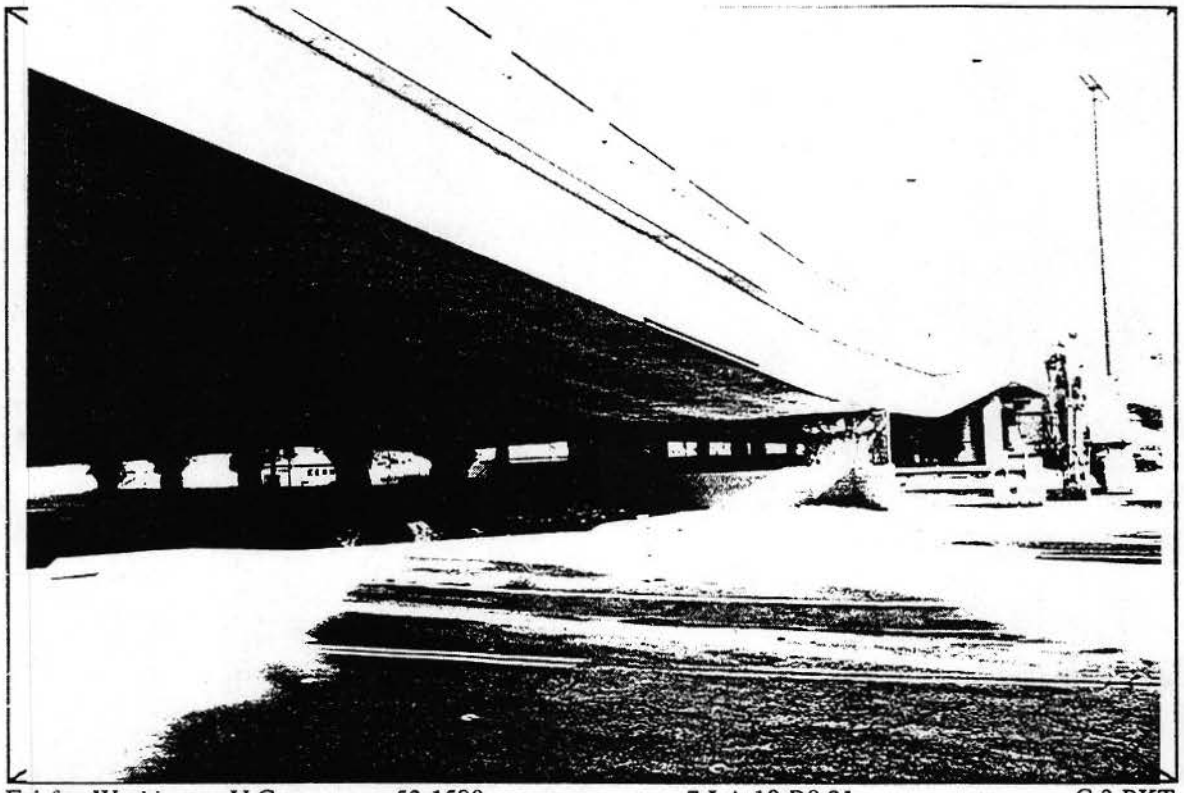
(pinned at base and less longitudinal rebar). The restrainers at the hinge in span 3 worked very well given the fact that the frames were held up and the superstructure did not come off its seat.

Westbound Structure

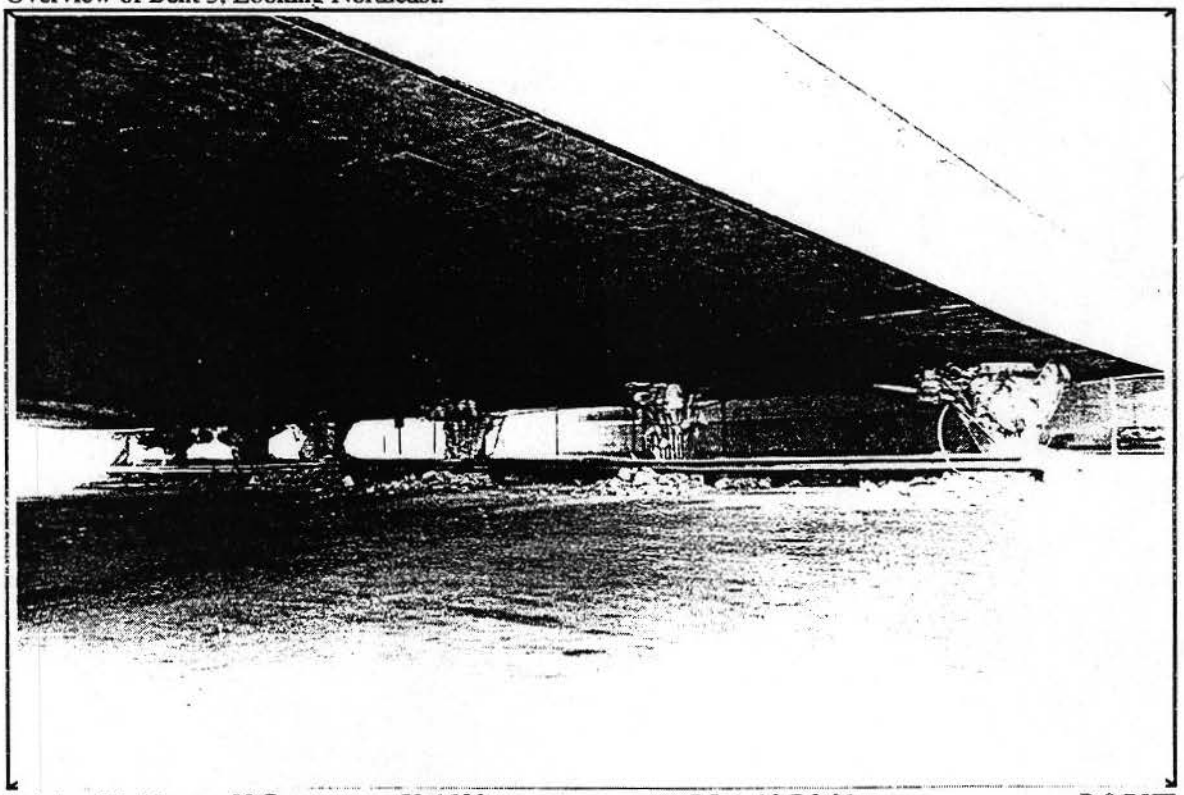
The structural response of the westbound freeway was very similar to the eastbound freeway except bent 4L. Bent 4L has pinned connections at the bottom of the columns and has twice the amount of longitudinal reinforcement in the columns. It developed large shear cracks at the mid-height of the column.

This failure may be categorized as shear failure of the column because the shear cracks developed before the top of column reached its plastic capacity.


FREEWAY PROFILE GRADE
RAMP 35 PROFILE GRADE
ELEVATION
PLAN
SECTION A-A
GENERAL PLAN
FAIRFAX-WASHINGTON UNDERCROSSING



Fairfax-Washington U.C. 53-1580 7-LA-10-R9.31 C-3-BKT
Overview of Bent 3, Looking Northeast.



Fairfax-Washington U.C. 53-1580 7-LA-10-R9.31 B-9-BKT
Bent 3 of WB Struc., Looking Southwest.

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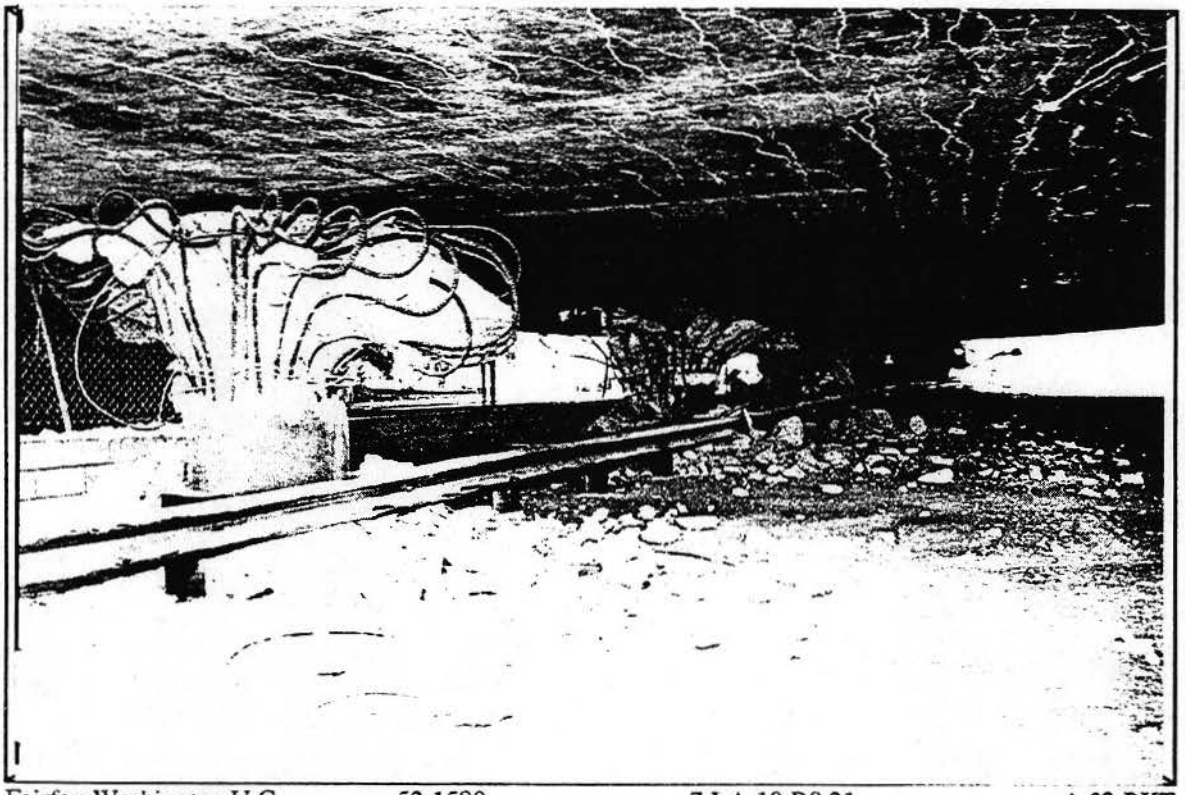
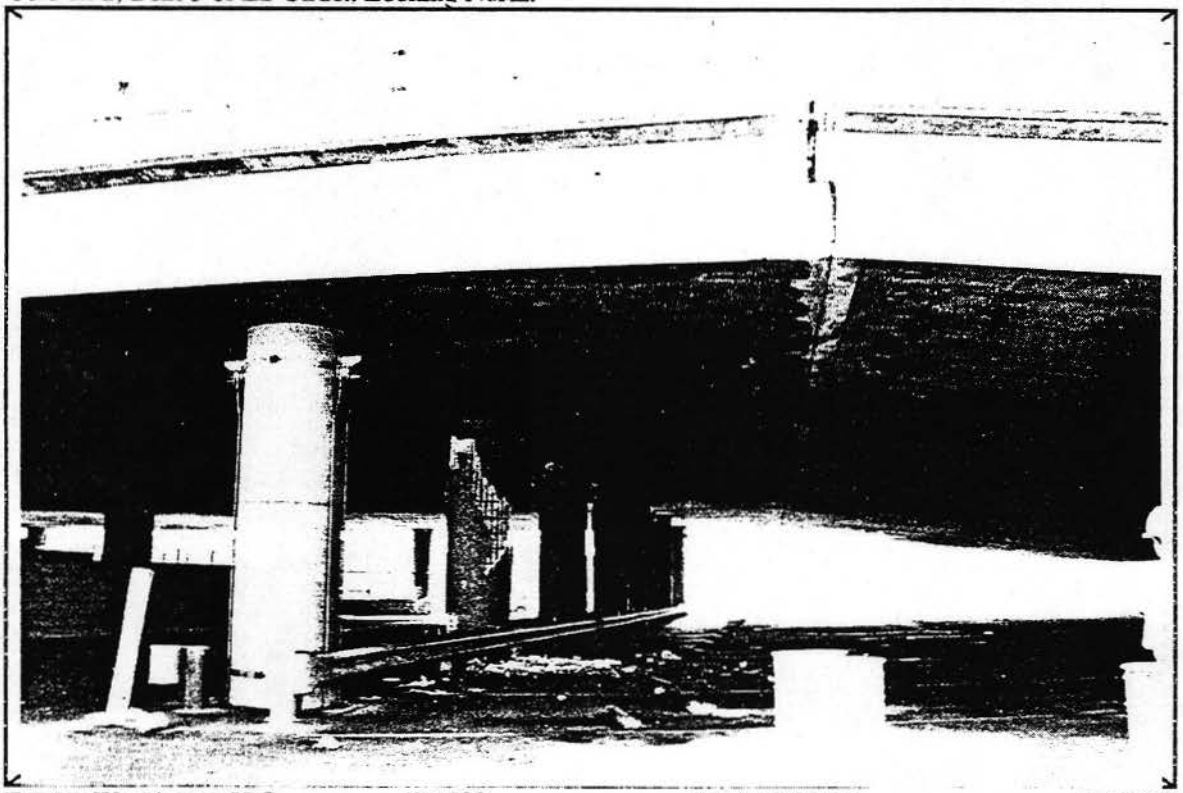


Fairfax-Washington U.C. 53-1580 7-LA-10-R9.31 A-32-BKT
Column 2, Bent 3 of EB Struc., Looking North.



Fairfax-Washington U.C. 53-1580 7-LA-10-R9.31 B-6-BKT
Bent 4 of WB Struc., Looking South.

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Bull Creek Canyon Channel Bridge 53-2206 07-LA-118-R8.84

Description of Structure

Bull Creek Canyon Channel Bridge is located on Route 118. This bridge is approximately 256 feet in length and 200 feet minimum width and varies. The three span structure has a skew that varies over the length of the bridge: 36° at abutment 1, 42° at bent 2, 47° at bent 3 and 47° at abutment 4. The span lengths are 90', 101' and 65'. The middle span crosses over Bull Creek Canyon Channel which is a concrete lined channel. The bridge was designed in 1973 and built in 1976.

The superstructure is a multi-celled CIP P/S box girder with a longitudinal joint near the centerline of Route 118. The structure depth is 4'-0". The superstructure is monolithic with an end-diaphragm type abutment, 8' to 9' tall, that is isolated from its pile footing to accommodate prestress and thermal movement. 16" diameter CIDH piles support the footing.

The bents are multi-column (9 or 10), RC, fixed frame using 4' octagonal prismatic columns and supported by 16" diameter CIDH concrete pile footings. The main column reinforcement is continuous from the bottom of footing into the bent cap. The transverse column reinforcement is #5 spiral @ 3 from 4 feet down from the soffit and 4 feet up from the top of footing, with #5 spiral @ 12 spacing throughout the remaining length of column. At bent 3, the column section changes shape (widens out to form the channel wall) in the area of the concrete channel wall, and then continues the typical prismatic section below the channel wall down to the top of the footing. Bent 2 has prismatic columns full height.

Description of Damage

This structure suffered major damage. There was no evidence of cracking or spalling at the abutments with the exception of minor shear cracks near the shear keys. The structure appeared to have rotated clockwise. At abutment 4, there was some soil heaving at the right bridge.

The right bridge had 2 of the 5 columns at bent 2 fail near the top of the column. This failure occurred at the transition of the spiral steel from a 3 inch pitch to a 12 inch pitch. This was approximately one column diameter down from the soffit. Also at bent 2, there were large

soffit cracks near the bent cap. The cracks seemed to propagate between the weep holes in the soffit.

At bent 3, all the columns failed at the top of the culvert wall at the ground line. At this location, the spiral spacing was at 12 inches. The top of the culvert wall was approximately 8 feet above the top of the footing.

At bent 2, the left bridge did not suffer as much damage as did the right bridge. At bent 2, the columns did not fail but were beginning to form cracks at the top. There were no large cracks observed in the soffit near the bent cap.

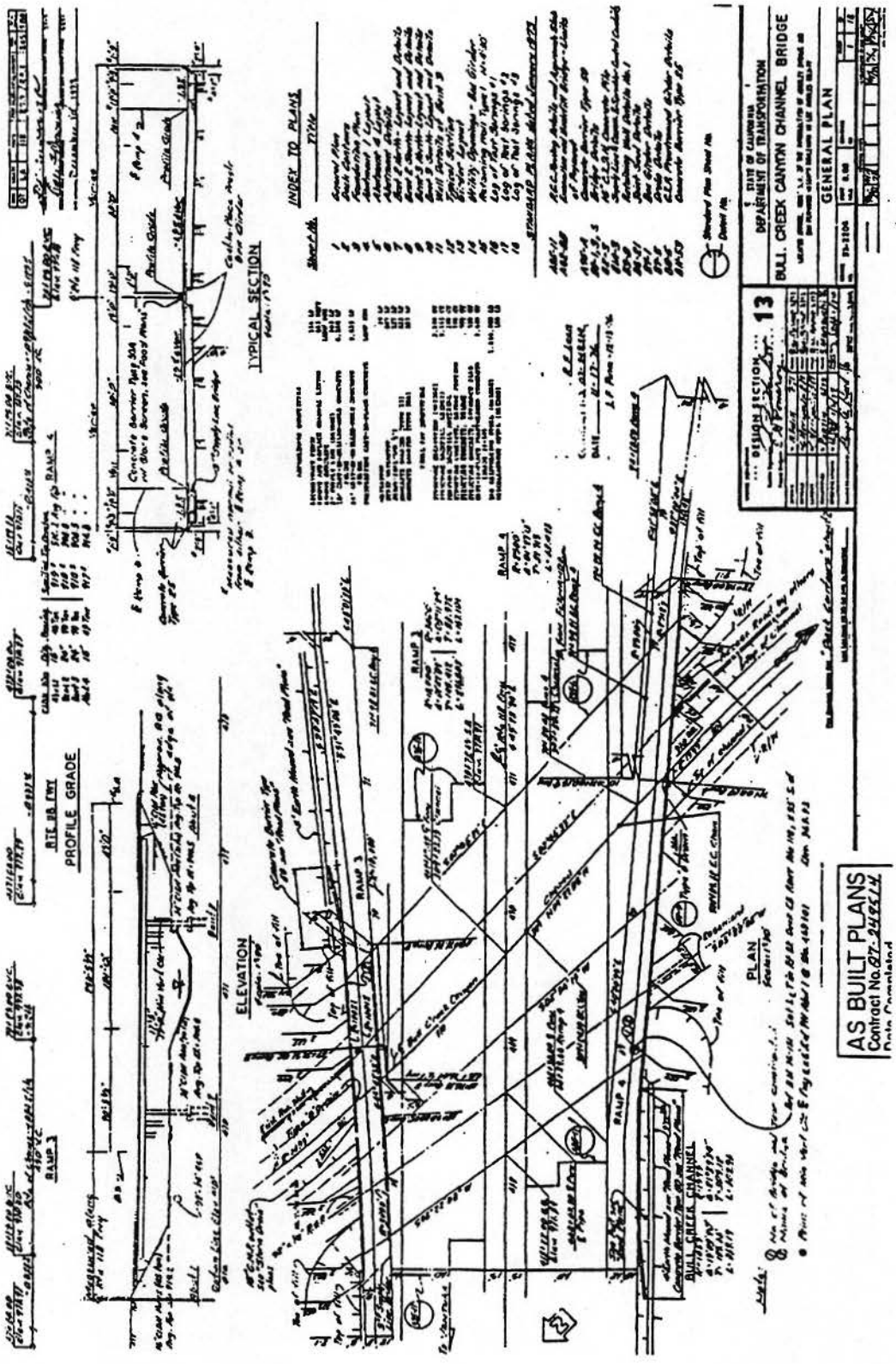
At bent 3, the columns failed identically to the ones in the right bridge with the failure occurring at the top of the culvert wall.

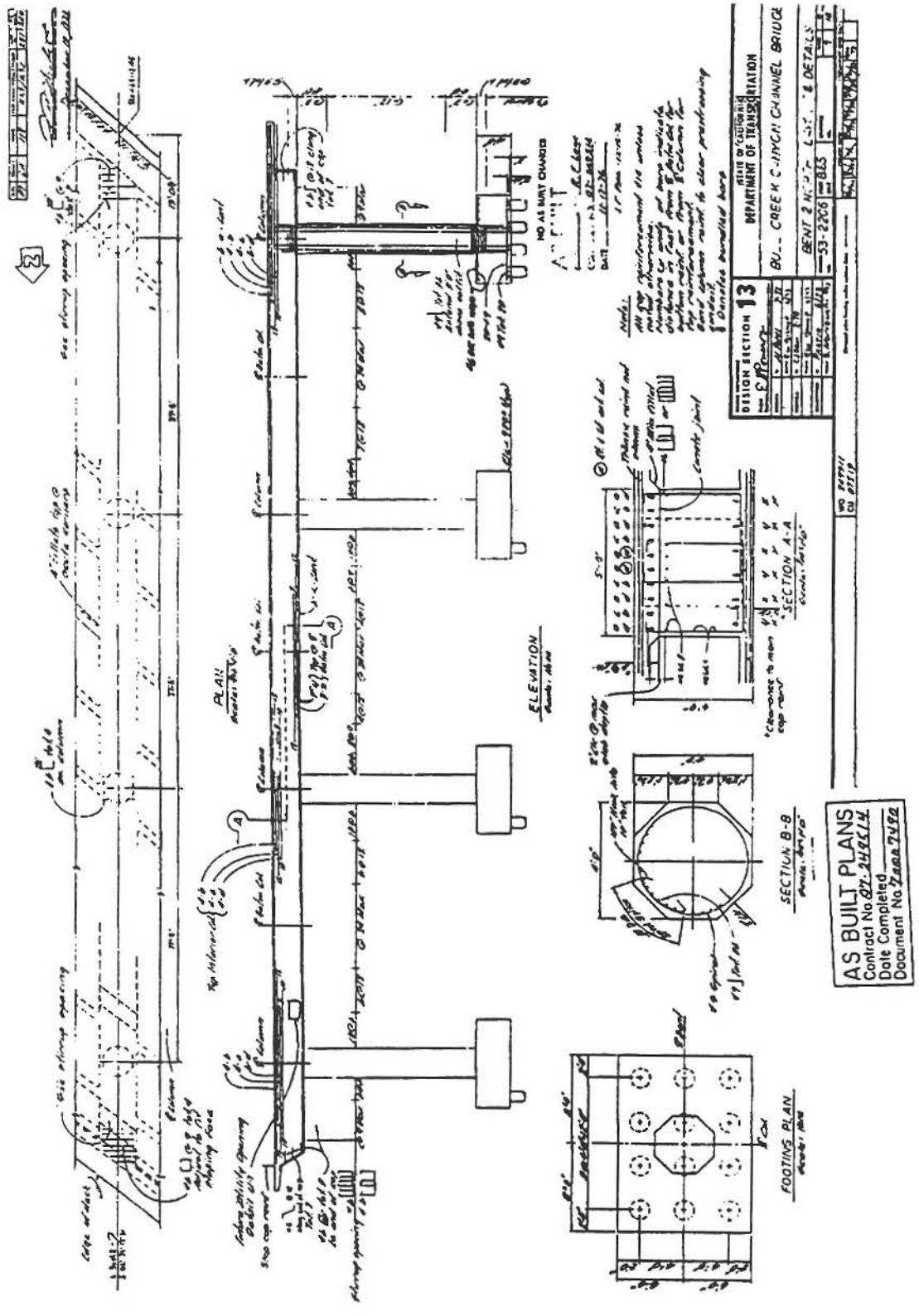
Analysis of Damage

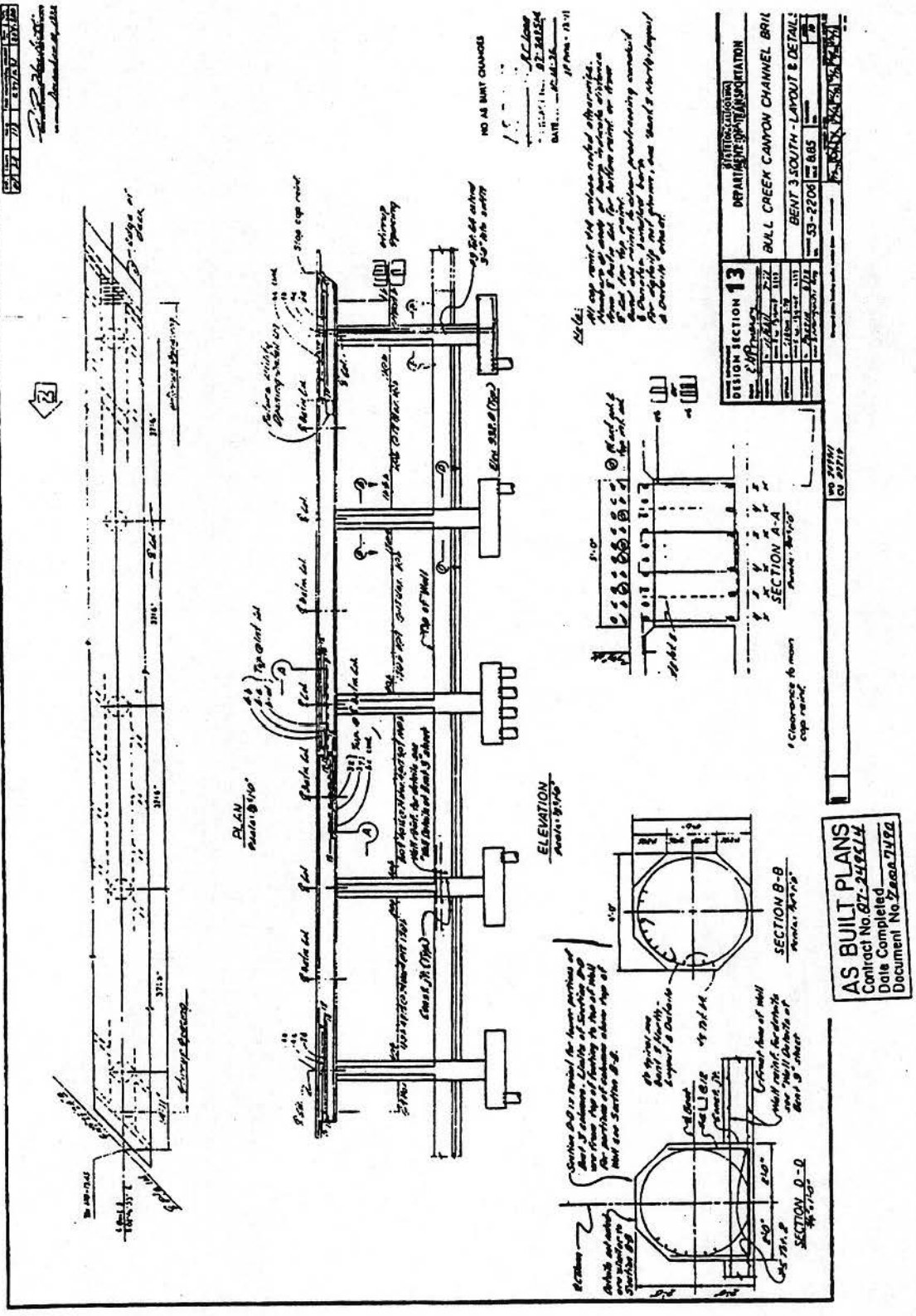
The cause of the major damage at Bull Creek Canyon Channel Bridge was the detailing of the structural channel wall in a manner which made it integral with the columns of bent 3.

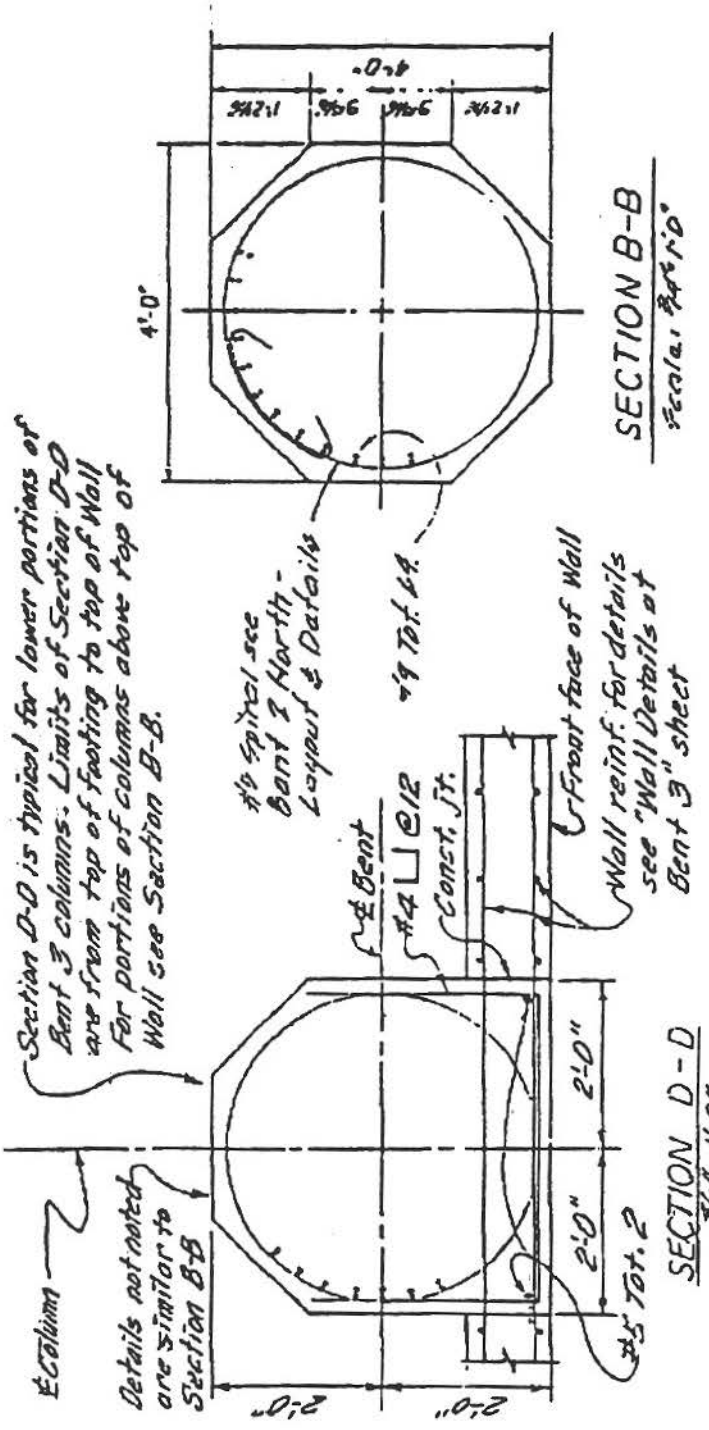
The bridge appears to have failed in a transverse mode. The channel wall effectively acted as a grade beam providing fixity at the intersections of the wall and the columns. When the strong motion forced the structure to sway in the transverse direction, the effectively shorter and thus relatively stiffer columns of bent 3 attracted most of the earthquake generated load. The column reinforcing details near the channel wall were such that the columns failed in shear.

It is believed the damage at the tops of two of the columns in bent 2 was of a secondary nature and occurred after the columns of bent 3 had already failed.

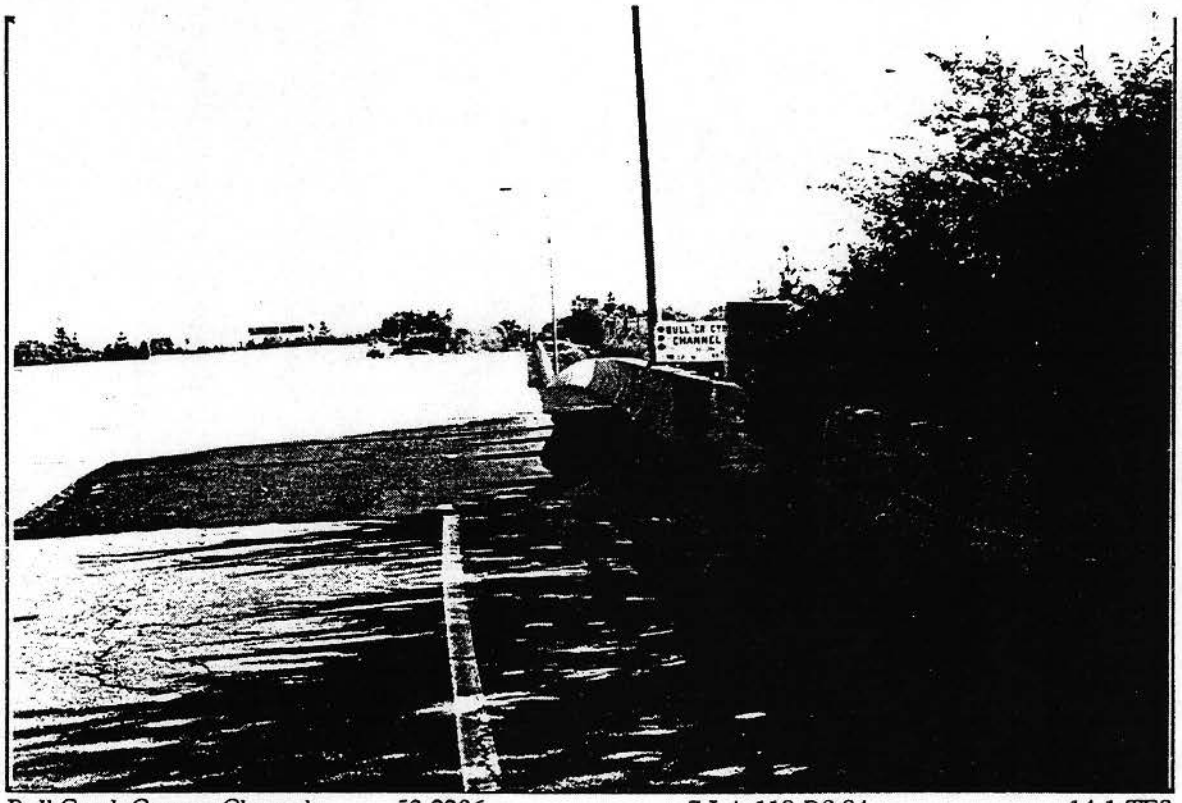

PROFILE GRADE
ELEVATION
TYPICAL SECTION
INDEX TO PLANS
PLAN
GENERAL PLAN
BULL CREEK CANYON CHANNEL BRIDGE
DEPARTMENT OF TRANSPORTATION
AS BUILT PLANS


AS BUILT PLANS
Contract No. 07-249514
Date Completed
Document No. 2000-71572

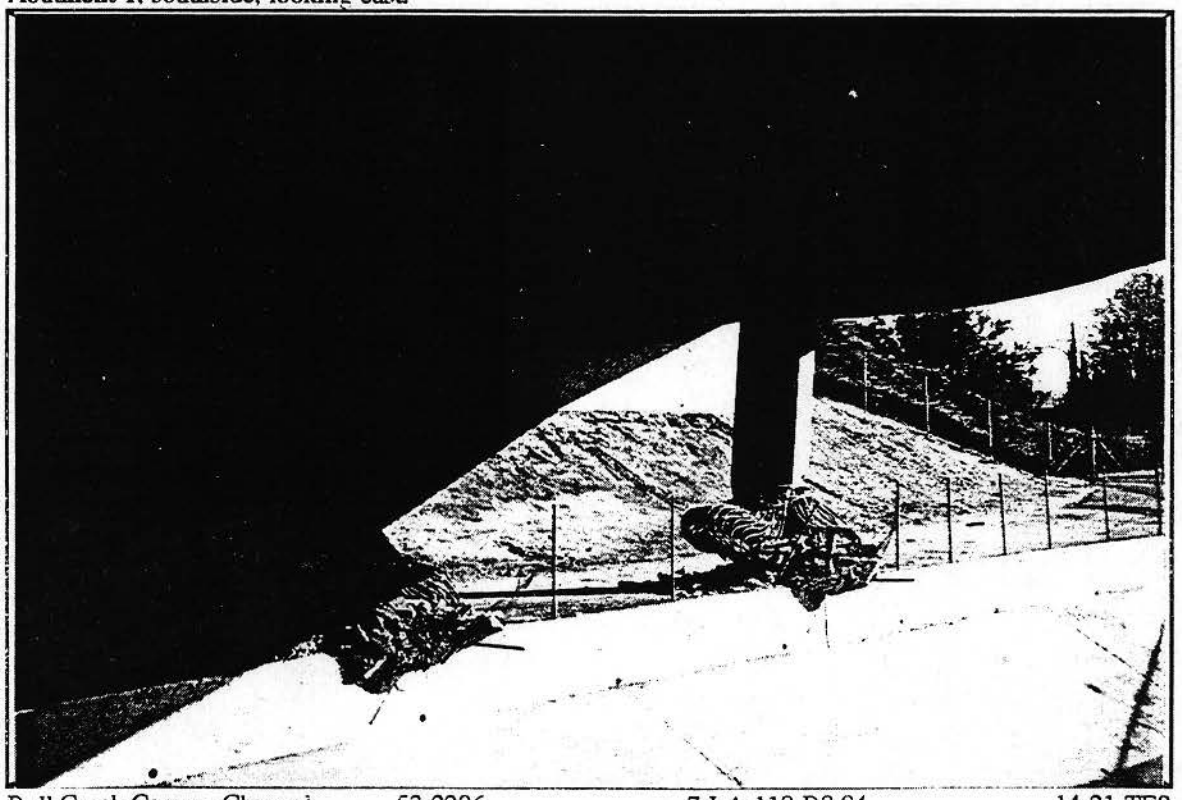

PLAN
ELEVATION
SECTION A-A
SECTION B-B
SECTION C-C
SECTION D-D
DESIGN SECTION 13
BULL CREEK CANYON CHANNEL BRI
BENT 3 SOUTH - LAYOUT & DETAIL
AS BUILT PLANS
Contract No. 07-249514
Date Completed
Document No. 2aaa7454a



Enlarged detail showing channel wall framing into column.



Bull Creek Canyon Channel 53-2206 7-LA-118-R8.84 14-1-TES
Abutment 1, southside, looking east.



Bull Creek Canyon Channel 53-2206 7-LA-118-R8.84 14-21-TES
Bent 3 southern columns.

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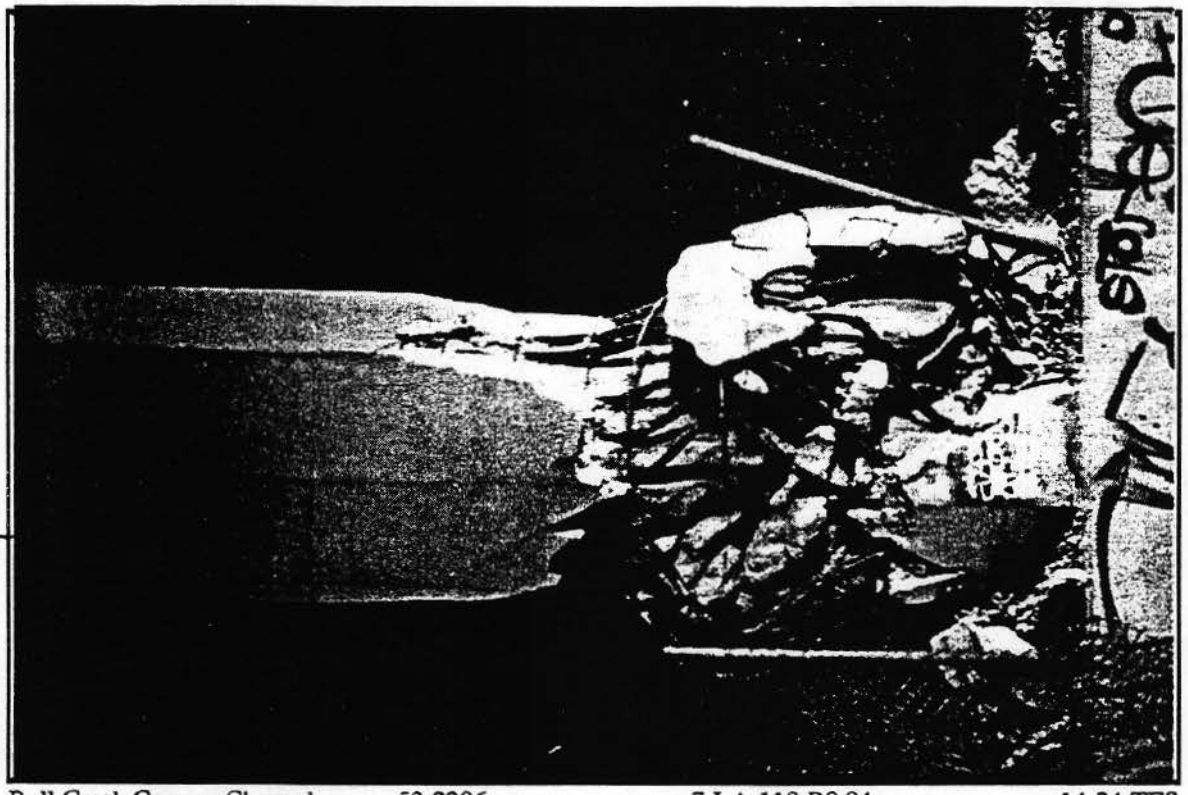
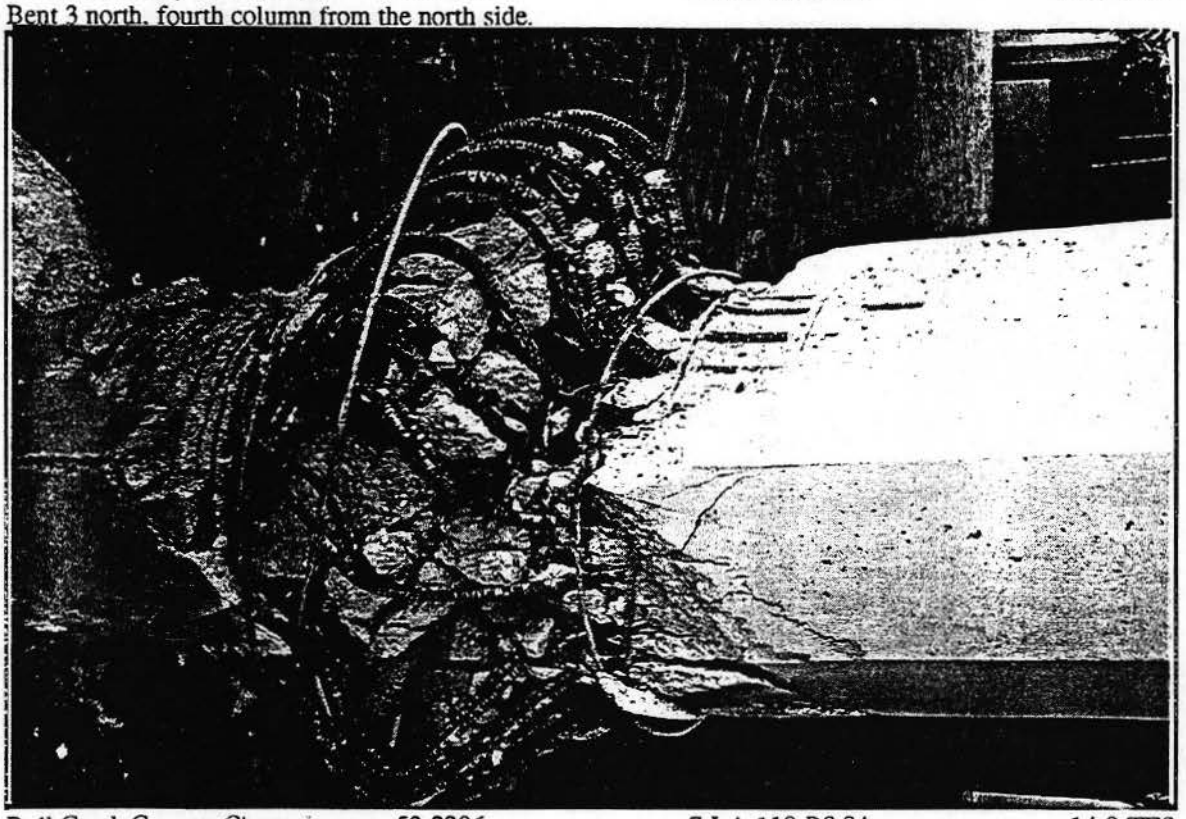


Bull Creek Canyon Channel 53-2206 7-LA-118-R8.84 14-24-TES
Bent 3 north, fourth column from the north side.



Bull Creek Canyon Channel 53-2206 7-LA-118-R8.84 14-9-TES
Bent 2 south side, looking east. Second column to the north.

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Route 14/5 Separation & OH 53-1960G 07-LA-14/5-R24.77/R45.52

Description of Structure

Route 14/5 Separation & Overhead connects I-5 northbound to Route 14 northbound. This bridge is comprised of three frames with a total length of 1136 feet. There are eight spans which range in length from 112 feet to 194 feet. This bridge was under construction in 1971 and suffered damage in the San Fernando Earthquake. At the time of the San Fernando Earthquake all columns had been constructed. The superstructure was complete from abutment 1 to the hinge in span 5. Final construction of this bridge was completed in 1974.

The superstructure consists of alternating RC and CIP P/S box girder frames with a structure depth of 7'-0". Hinge seat width is 14", as called for in the standard plans.

The bents consist of single 12' x 4' to 12' x 6' octagonal columns that flare to a 26 foot width at the soffit and extend into the ground as a pier shaft. The main longitudinal reinforcement consists of 20 to 32 #18 bars that follow the flare and extend into the bent cap. Lateral column reinforcement is #5 @ 12.

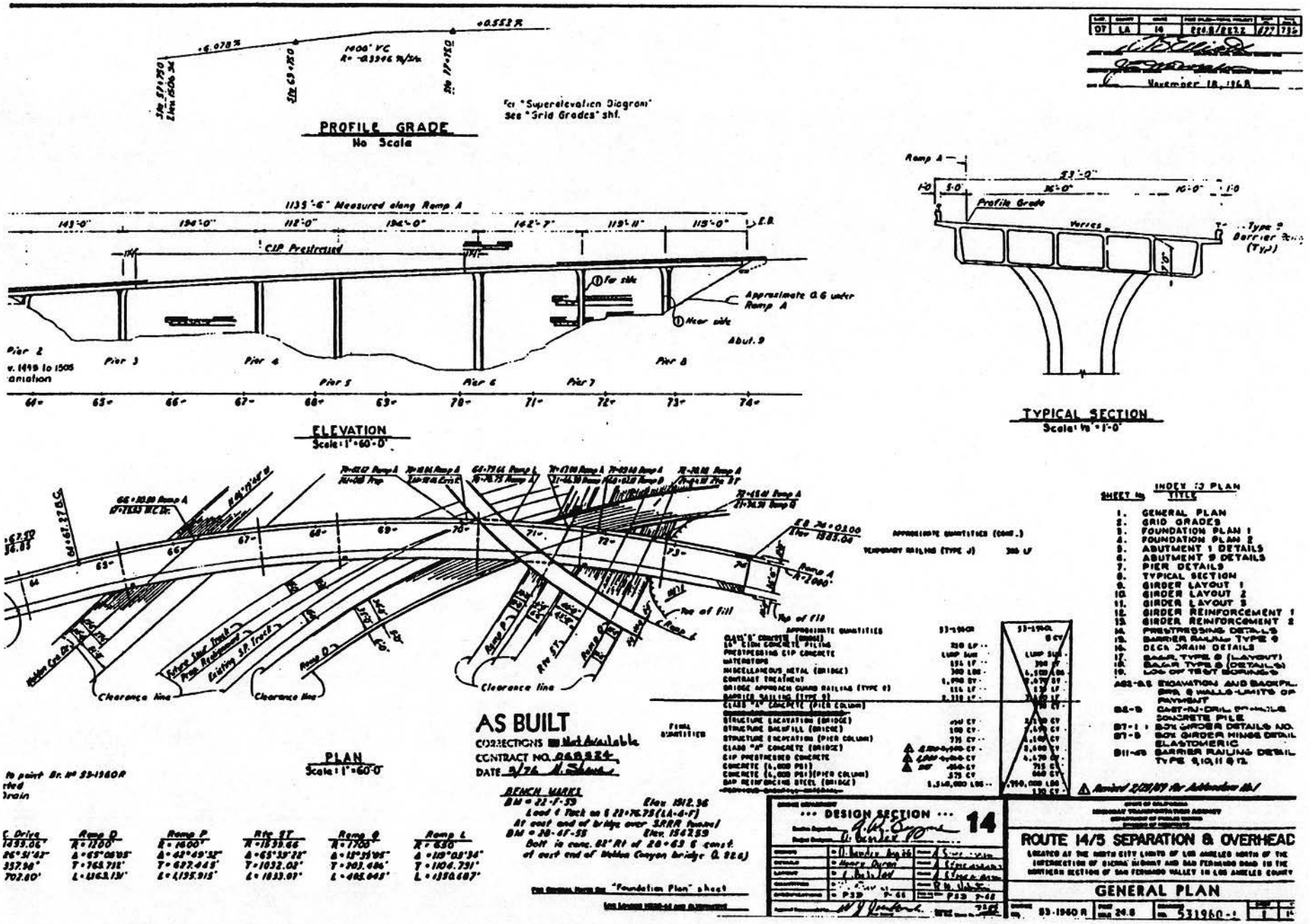
Abutment 1 is an end-diaphragm type on a pile foundation and abutment 9 is a seat type on a spread footing. The two hinges of this bridge were retrofitted with cable restrainers as part of the damage restoration contracts.

Description of Damage

The hinges suffered major damage, all of the restrainers failed, and the diaphragm in the left exterior bay in hinge 2 failed completely. At the time of inspection, all of the restrainers were missing their nuts. There was compression banging evident at each of the hinges with spalling and cracking in the concrete at the barrier rail, overhang and superstructure. Hinge 2, which had the taller columns adjacent to it, had the most damage. Little damage was seen at the abutments.

Analysis of Damage

The diaphragms at the exterior bays suffered the most damage. This damage could be attributed to the exterior diaphragms having had 2 restrainer units each. The restrainers were designed with the cables grouted in the pipes, which left little room for elongation of the cables Having one of the exterior bay diaphragms cracked indicates that the connector moved radially, with the outside part of the hinge opening and the inside part of the hinge compressing.


PROFILE GRADE
No Scale
ELEVATION
Scale: 1"=60'-0"
TYPICAL SECTION
Scale: 1/2"=1'-0"
PLAN
Scale: 1"=60'-0"
AS BUILT
CORRECTIONS Not Available
CONTRACT NO. 08S524
DATE 5/76
DESIGN SECTION
14
ROUTE 14/5 SEPARATION & OVERHEAD
GENERAL PLAN
INDEX TO PLAN
1. GENERAL PLAN
2. GRID GRADES
3. FOUNDATION PLAN 1
4. FOUNDATION PLAN 2
5. ABUTMENT 1 DETAILS
6. ABUTMENT 9 DETAILS
7. PIER DETAILS
8. TYPICAL SECTION
9. GIRDER LAYOUT 1
10. GIRDER LAYOUT 2
11. GIRDER LAYOUT 3
12. GIRDER REINFORCEMENT 1
13. GIRDER REINFORCEMENT 2
14. PRESTRESSING DETAILS
15. BARRIER RAILING TYPE 9
16. DECK DRAIN DETAILS
17. BARRIER TYPE 9 (LAYOUT)
18. BARRIER TYPE 9 (DETAILS)
19. LOW CUT TEST BOUNDS
BENCH MARKS
BM = 22-F-59 Elev 1912.36
BM = 28-AF-58 Elev 1562.59

South Connector Overcrossing 53-1963F 07-LA-14/5-R24.82/R45.69

Description of Structure

The South Connector Overcrossing connects southbound Interstate 5 to northbound Route 14. This bridge is comprised of five frames with a total length of 1349 feet. There are nine spans which range in length from 100 feet to 191 feet. This bridge was under construction in 1971 and was damaged in the San Fernando Earthquake. The bridge was designed in 1968 and built in 1972.

The superstructure consists of alternating CIP P/S and RC box girder frames with a structure depth of 7'-0". The hinge seat width is 14".

The bents consist of single 10' x 4' to 10' x 6' octagonal columns that extend into the ground as a pier shaft. The main longitudinal column reinforcement consists of 40 to 52 #18 bars. The lateral reinforcement consists of #4 stirrups @ 12.

The abutments are end-diaphragm type on piles. The four hinges of this bridge were retrofitted with cable restrainers as part of the damage restoration contracts.

Description of Damage

This bridge had major hinge damage with some spans tenuously supported on their hinge seats. The long span at hinge 3 near bent 6 has only approximately 3" bearing on the hinge seat. There was compression banging evident at each of the hinges with spalling and cracking in the concrete at the barrier rail, overhang and superstructure. Hinge 2 near bent 5 has shear cracks at the end of the long span. Abutment 1, which was adjacent to a tall column, has considerable damage consisting of large cracks, broken concrete and buckling of the vertical steel at its front face. The joint at abutment 1 opened approximately 3". Abutment 10, which is adjacent to a very short column, showed no signs of damage and had minimal movement. Movement of the columns at ground level was typically less than 1/2".

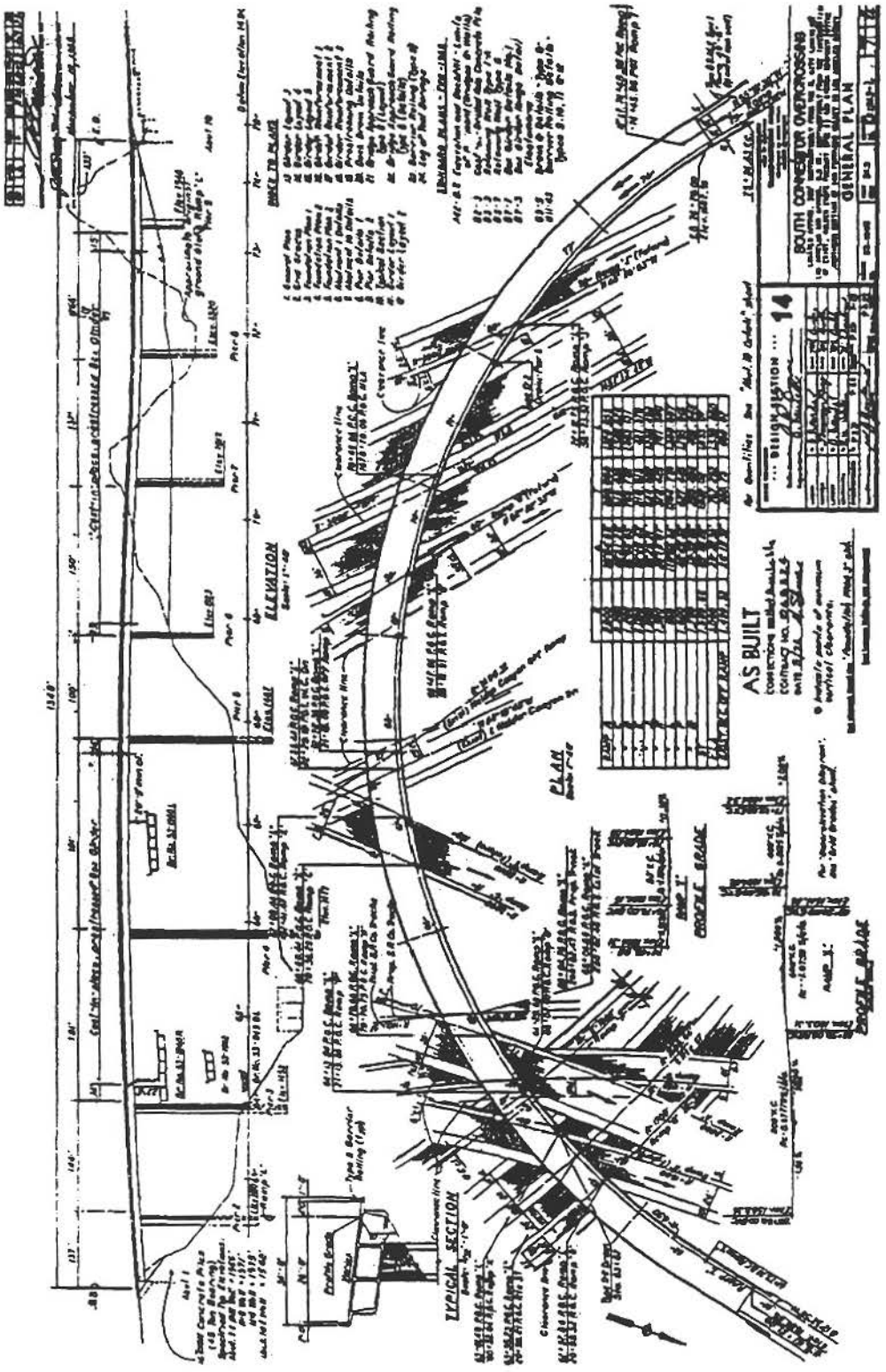
Analysis of Damage

Movement at the superstructure level caused heavy damage at the hinges. No bolsters were included when the cable restrainers were added as part of the damage restoration contract after the 1971 San Fernando Earthquake. This led to heavy damage to the hinge diaphragms as reported by Structures Maintenance; however, the hinge restrainers worked sufficiently to prevent the superstructure from unseating.

The tall columns (140 feet maximum clear height) were very flexible and were not highly excited during the earthquake. Therefore, the column movement at the ground level was found to be less than a half of an inch.

Abutment 1, an end-diaphragm abutment, was damaged due to its stiffness relative to the tall, flexible columns in frame 1. The superstructure tried to pull away from the abutment which led to the cracking at the front face of the abutment.

Bent 9, with only 7 feet of clear height, was not damaged despite its short height. It was protected by the stiff end-diaphragm of abutment 10. Bent 9 was the only column in the frame; some of the differential movement between the other columns was taken up in the hinge.


AS BUILT
ELEVATION
PLAN
LONGITUDINAL SECTION
GENERAL PLAN

MODERATE DAMAGE

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Southwest Connector OC 53-2329G 07-LA-118/5-R11.40/39.31

Description of Structure

Southwest Connector Overcrossing is located in the city of Los Angeles at the intersection of Interstate 5 and Route 118 in Los Angeles county. The bridge is approximately 1667 feet in length and 54 feet wide. It was designed in 1974 and built in 1976.

The superstructure is a CIP P/S box girder from abutment 1 to the hinge in span 2; a RC box girder from the hinge in span 2 to the hinge in span 4; a CIP P/S box girder from the hinge in span 4 to the hinge in span 6; a RC box girder from the hinge in span 6 to abutment 11. It has vertical restrainers (total of 5 per hinge) and Type A restrainers (total of 4 per hinge; 9 cables, 25 feet in length per restrainer). The hinge seats are 24". The structure depth is 8'-0". The bridge alignment is a 1150 foot radius curve. The last span sits on elastomeric bearing pads at abutment 11.

The bents are RC fixed frame with a single octagonal column and are radial to the bridge. The columns have a one-way flare from an 8' octagon to a 8' x 18' rectangle over a transition length of 14'. The main longitudinal reinforcement forms the flare. The transverse reinforcement consists of #4 spiral @ 3 1/2 in the octagonal section and #4 @ 12 ties in the flared section. All bents except 8 and 10 are 96" CIDH pile shaft foundation. Transverse reinforcement is #4 spiral @ 3 1/2 for the first 10 feet and then changes to #4 spiral @ 12. Bents 8 and 10 are on spread footings. Footings have top and bottom mats of steel but no shear reinforcement.

Abutment 1 is a diaphragm type on pile foundation. Abutment 11 is a seat type on pile foundation. Abutment piles are 70 ton steel HP 10 x 57 piles. Abutments are slightly skewed.

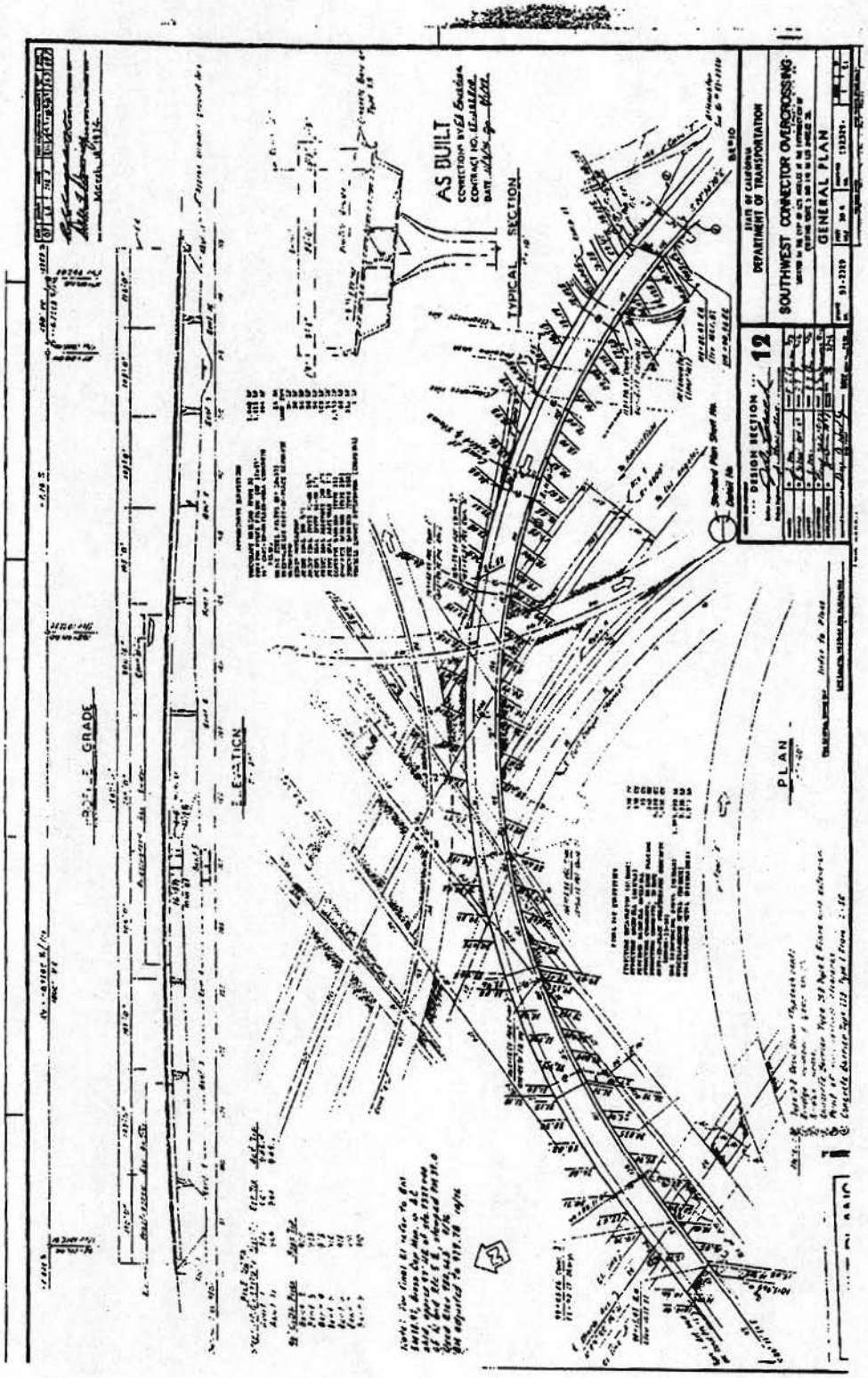
Description of Damage

This bridge suffered moderate damage. At abutment 1, the bridge and/or approach slab has separated 6 inches in the longitudinal direction and approximately 5 1/2 inches in the transverse direction. There is some very minor spalling at this abutment. Bent 2 has some significant shear cracking. This crack appears to have propagated on both sides of the column. The remainder of the bents showed no damage. All of the hinges on this structure have minor

damage, including transverse and longitudinal displacements, coupled with vertical offsets. Abutment 11 suffered minor damage as did abutment 1. The separation between abutment 1 and the approach slab was not as severe, showing only 3 inches of transverse displacement.

Analysis of Damage

The abutment damage was only minor and typical. Bent 2 was the only bent that experienced any damage. The column at bent 2 is a relatively short column in comparison to the other columns on this bridge and is the only column supporting frame 1. The spans adjacent to bent 2 are somewhat long and, therefore, this column was subjected to large forces as indicated by the movement at abutment 1 and the damage to bent 2. With the movement at abutment 1 and the crack patterns in the column at bent 2, it appears that the column also experienced some torsional forces.


AS BUILT
TYPICAL SECTION
DEPARTMENT OF TRANSPORTATION
SOUTHWEST CONNECTOR OVERCROSSING
GENERAL PLAN
PLAN
ELEVATION
GRADE

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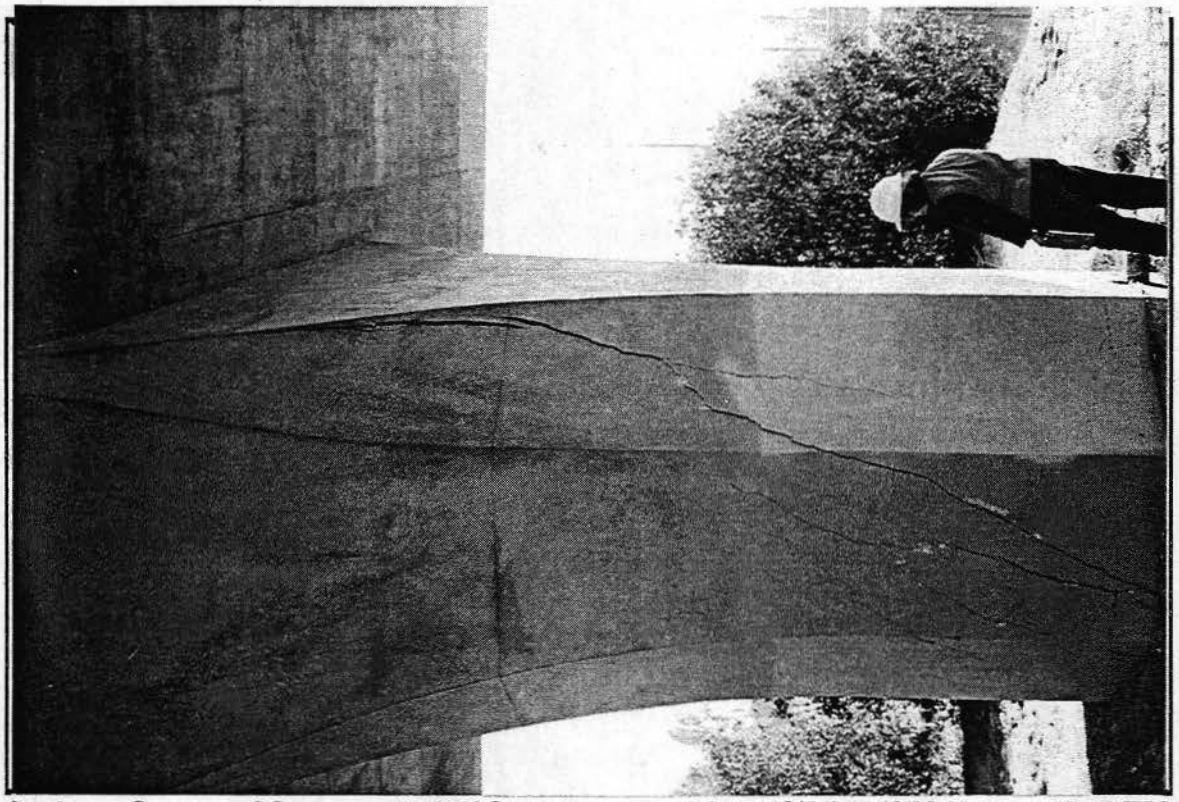
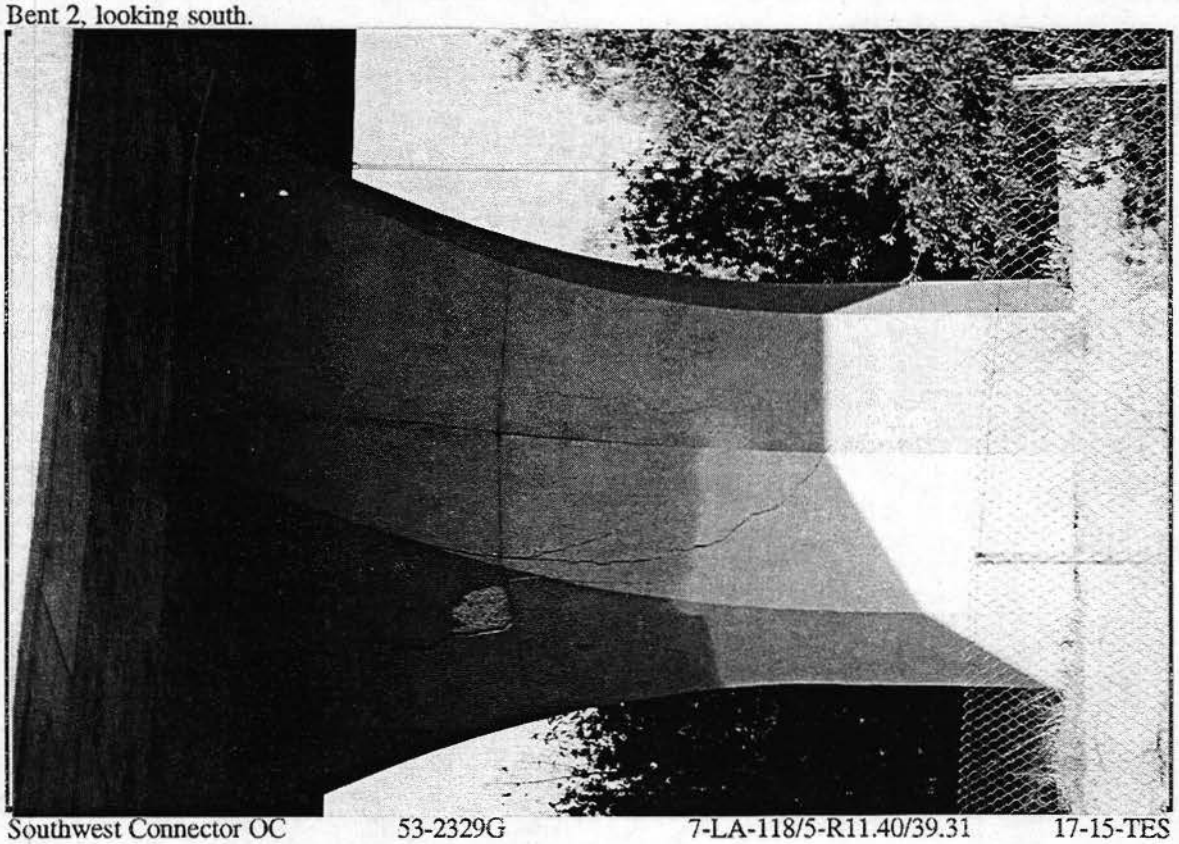


Southwest Connector OC 53-2329G 7-LA-118/5-R11.40/39.31 17-15-TES
Bent 2, looking south.



Southwest Connector OC 53-2329G 7-LA-118/5-R11.40/39.31 17-15-TES
Bent 2. looking north.

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Route 101/170/134 Separation 53-1336R 07-LA-101-11.7/R14.6/.01

Description of Structure

Route 101/170/134 Separation is located in the city of Los Angeles and crosses Tujunga Avenue and the Hollywood Freeway. The bridge is approximately 705 feet in length and 76 feet wide. It was designed in 1957 and built in 1959.

The superstructure is a RC box girder with a curved alignment. The structure depth is 5'-9" in spans 1, 2 and 3; varies from 4'-6" to 5'-9" in span 4; and then a constant 4'-6" in spans 5, 6, 7 and 8. The skew varies from 64° at abutment 1 to 0° at abutment 9 and is not radial to the bridge. The superstructure sits on pedestals of the bearing assembly at the abutments. Hinges are in spans 2 and 4.

The bents are RC fixed frame using 2'-6" x 4' rectangular columns fixed at the top and pinned at the bottom. Bent 2 has 6 columns. Bents 3, 4 and 5 have 5 columns. Bents 6, 7 and 8 have 4 columns. Transverse reinforcement consists of #4 @ 12. All columns are on driven concrete pile footings. The bents are not aligned radial to the bridge.

Abutment 1 is a seat-type with the backwall placed directly on the footing (no stem). Abutment 9 is a high cantilever-type with Type 2 retaining walls on either side. Both abutments are on pile footing foundations.

This bridge was retrofitted in 1973. Restrainer units were installed at the hinges (total four per hinge) through the hinge diaphragms only. Concrete bolsters 9" thick were placed full width of bays. This work was done under a Phase I contract.

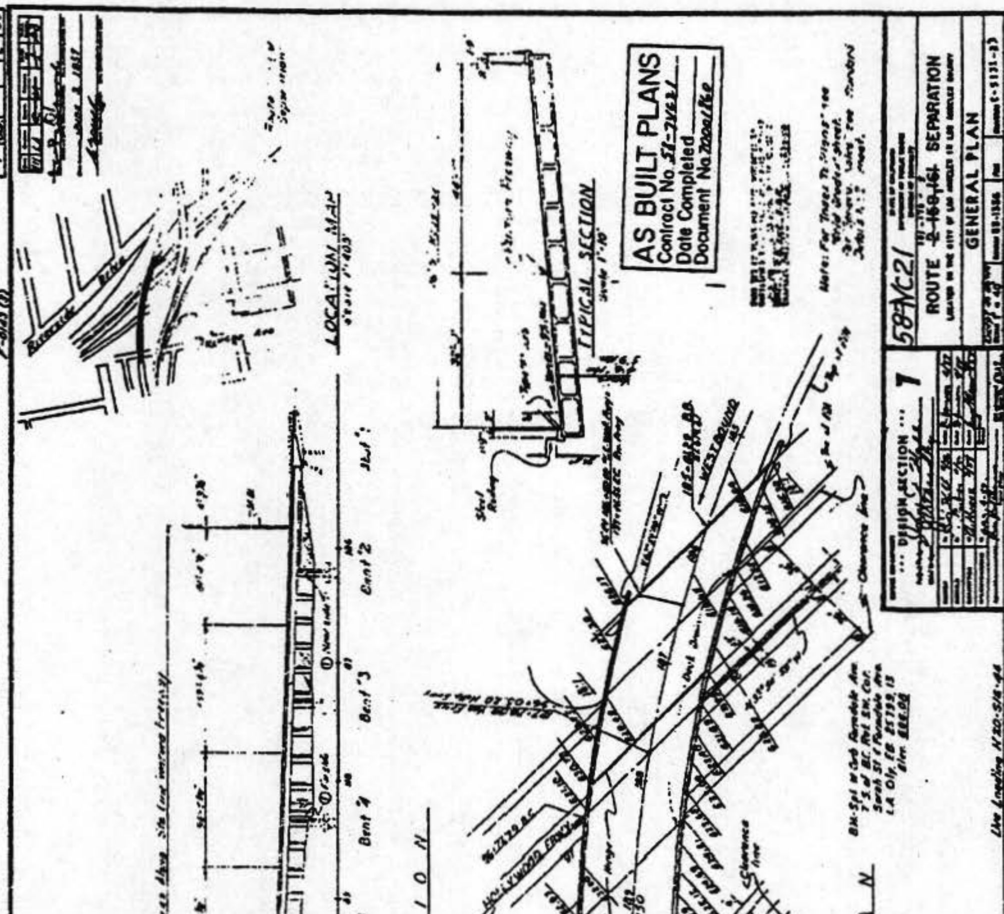
Description of Damage

There was minor spalling at the top of many of the columns due to plastic hinging of the column. However, the two southern columns of bent 5 had heavy damage with major spalled concrete at the top of columns. Some of the longitudinal column rebar had buckled, but the concrete core appeared undamaged.

The rocker bearings in abutment 9 had failed and the superstructure needed to be shored. Also, the return wall at abutment 9 was crushed due to longitudinal superstructure banging. Some of the return wall reinforcing was exposed.

Analysis of Damage

This structure experienced both transverse and longitudinal displacements. The transverse response may have caused most of the columns to have some minor spalling of the concrete cover and may have formed the plastic hinges at the tops of some of the columns. The longitudinal response caused the rocker bearings to fail and damaged the abutment return wall.


AS BUILT PLANS
Date Completed
ELEVATION
PLAN
LOCATION MAP
TYPICAL SECTION
SEPARATION
GENERAL PLAN

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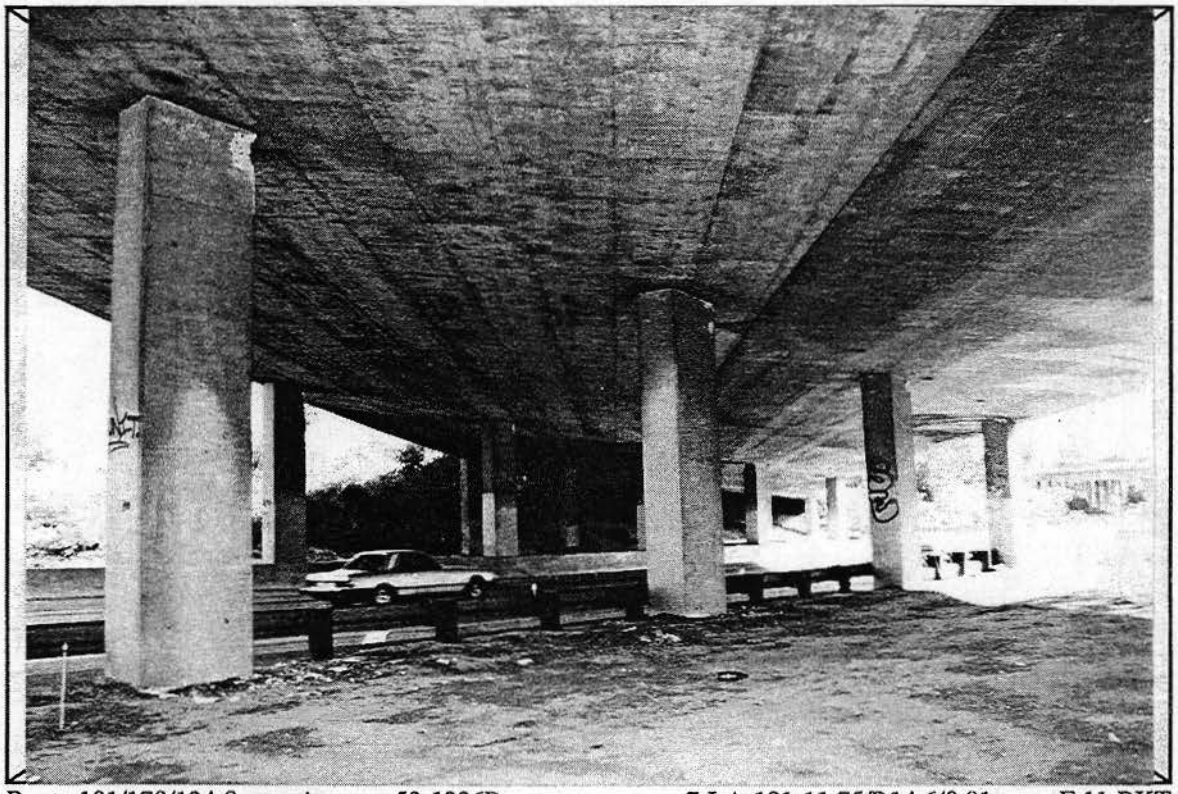
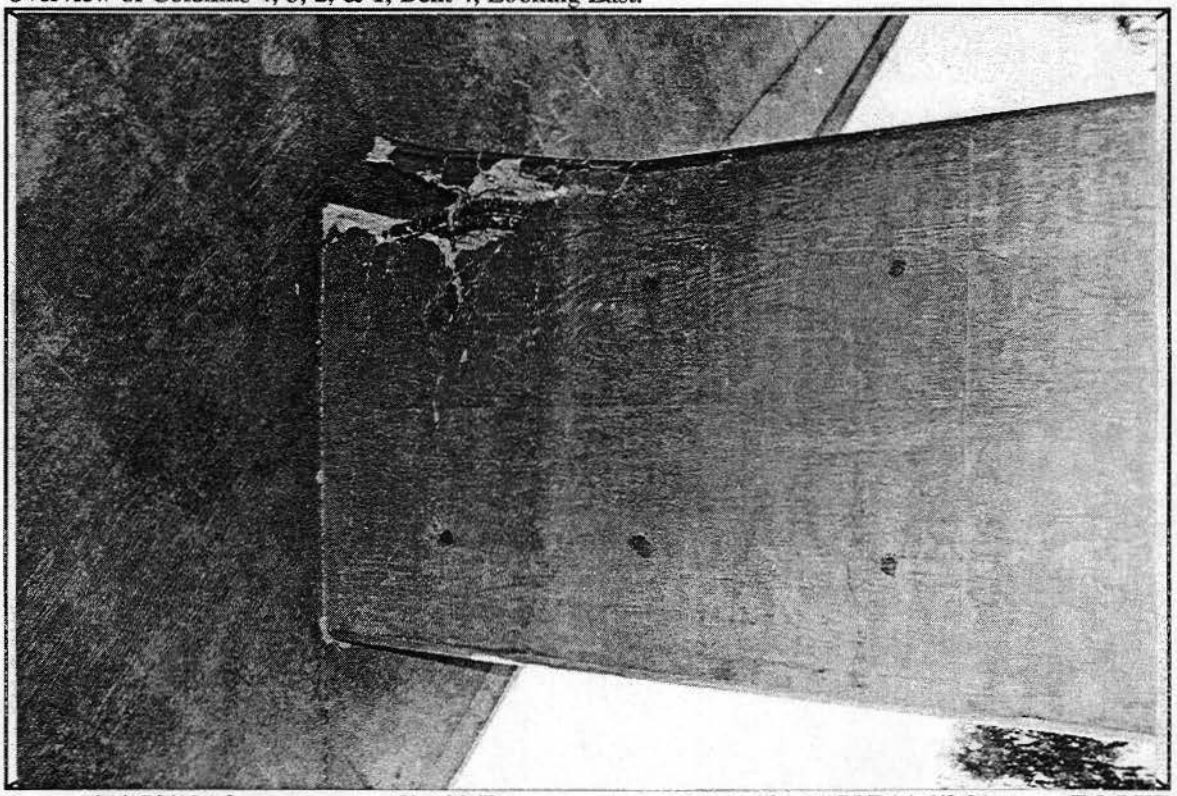


Route 101/170/134 Separation 53-1336R 7-LA-101-11.75/R14.6/0.01 F-11-BKT
Overview of Columns 4, 3, 2, & 1, Bent 4, Looking East.



Route 101/170/134 Separation 53-1336R 7-LA-101-11.75/R14.6/0.01 F-2-BKT
Column 1, Bent 5, Looking Southwest.

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MINOR DAMAGE

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Balboa Blvd. Overcrossing 53-2395 07-LA-118-R7.80

Description of Structure

Balboa Blvd. Overcrossing is located on Route 118 near Devonshire Street in the city of Los Angeles. It is approximately 283 feet in length and 117 feet wide. It was designed in 1973 and built in 1976.

The superstructure is a CIP P/S box girder with a structure depth of 6'-0". Skew is negligible. The superstructure rests on elastomeric bearing pads at the abutments.

Bent 3 is a multi-column RC fixed frame. The columns are 5' diameter octagons with a one-way flare. The flared section is a 5' x 13' rectangle with a 12 foot transition length. The main longitudinal reinforcement (core) extends into the bent cap as does the transverse reinforcement, #5 spiral @ 3. The flared section is formed with #5 bars and tied with #4 @ 12. The columns are pinned at the footing and are on a spread footing foundation. The footings have a top and bottom mat of steel.

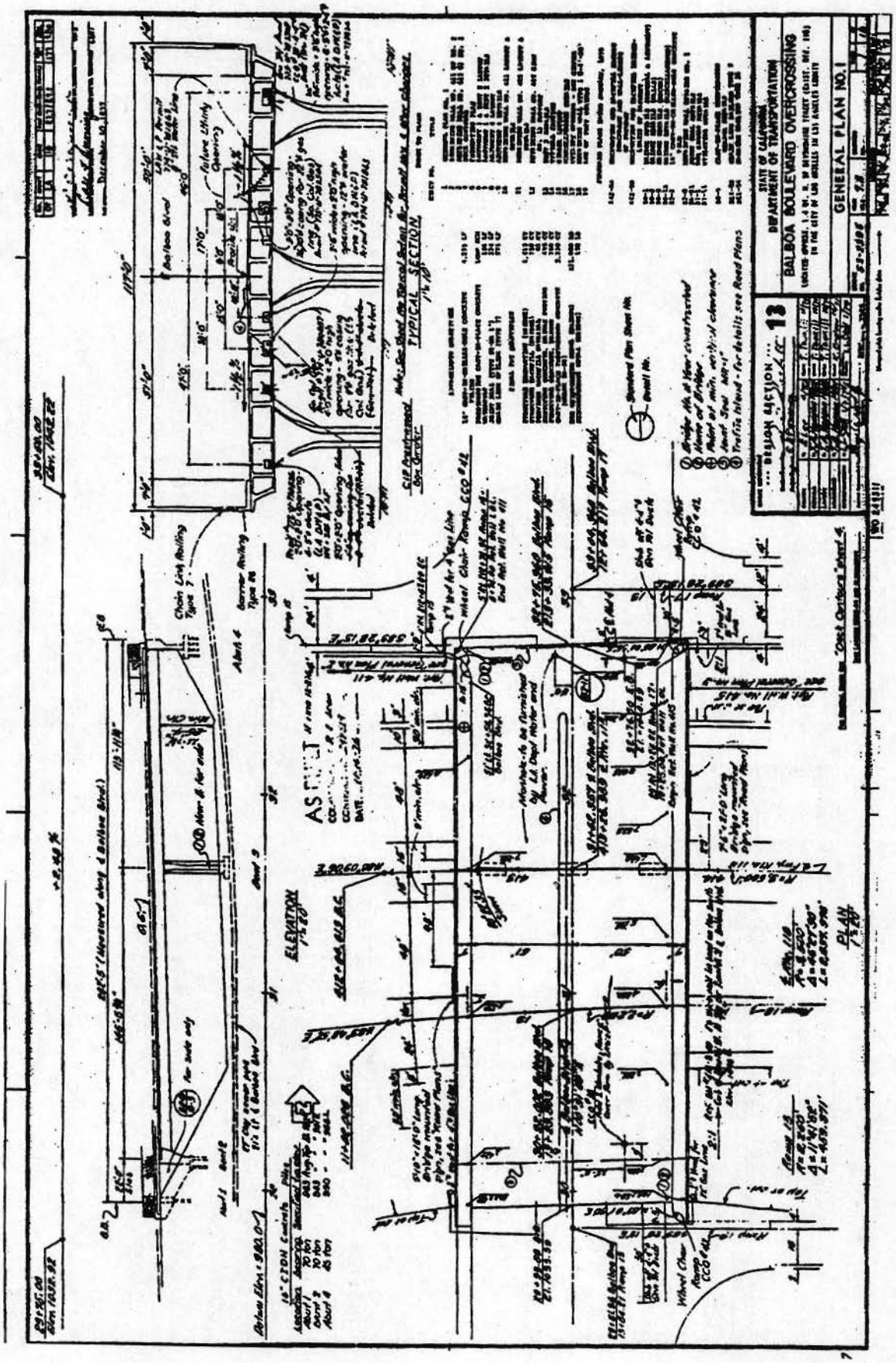
Abutment 1/bent 2 is a bin-type abutment on a pile footing with a 22 foot long reinforced concrete slab span. Abutment 4 is a high cantilever-type abutment on a pile footing. The footing has a top and bottom mat of steel and 16" diameter, concrete piles. The abutments have cantilevered wingwalls with piles under the ends of the wingwall connected by a grade beam.

Description of Damage

This bridge suffered minor damage at bent 3. There was minor cracking at the soffit/column connection. The structure backfill at abutment 1 was undermined due to a ruptured water line. The piles of the footing at bent 2 are exposed about 4 feet, whereas the piles at abutment 1 are exposed about 10 feet to 12 feet. The corner details of bent 2 were damaged. This appears minor but warrants attention. The pile/footing connection at bent 2 showed a small (1/16" to 1/8") circumferential crack at the top of piles. Abutment 4 suffered only minor damage. Some spalling at the face of the abutment was noted and an 18 inch section of barrier had fallen. Also, there is an apparent longitudinal movement of about 1 inch to the south.

Analysis of Damage

Very little of the damage at the structure was due to the earthquake except for a small amount of spalling at the top of the columns and at the bin abutment. The undermining at the bin type abutment was solely due to the broken water line.


BALBOA BOULEVARD OVERCROSSING
GENERAL PLAN NO.1
ELEVATION
PLAN
TYPICAL SECTION

Rinaldi Street Undercrossing 53-1506 07-LA-405-47.75

Description of Structure

Rinaldi Street Undercrossing is located on Interstate 405. The bridge is approximately 175 feet in length, 116.7 feet wide with a main simple span 105.5 feet long. It was designed in 1961 and built in 1963.

The superstructure consists of a 15 cell R/C Box Girder with a 14° skew, seated on a bin-type abutment. The structure depth is 6'-0".

The abutment foundations are on piles. 16" diameter CIDH concrete piles were used at all footing locations. Abutment 1 end diaphragm sits on elastomeric pads while abutment 2 end diaphragm is keyed into the abutment seat.

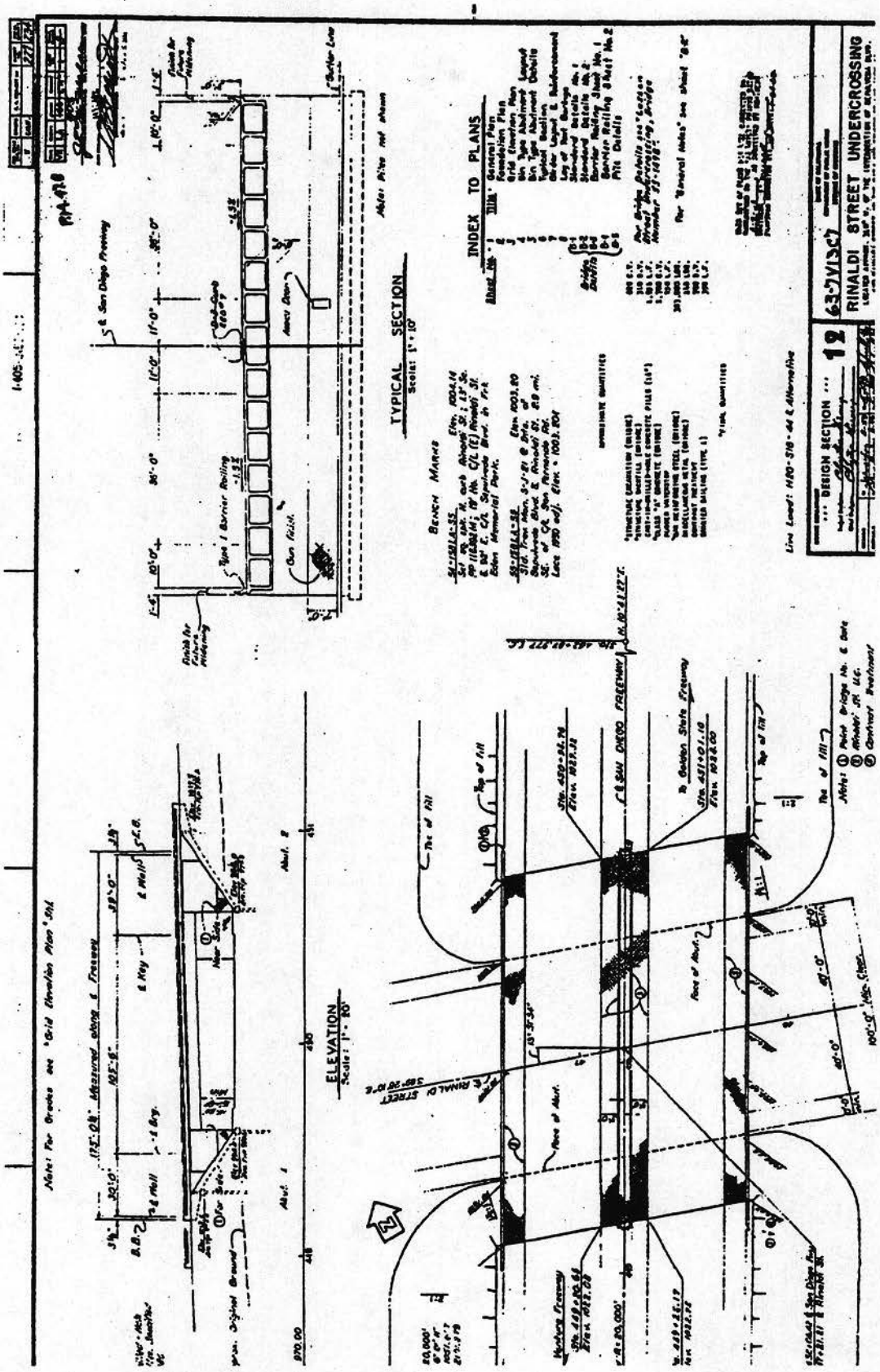
The bridge had been repaired in 1973 due to earthquake damage.

Description of Damage

The north abutment backwall had been damaged. There were flexural tension cracks in the backwall of the abutment and concrete spalling where the girders framed into the backwall and along the length of the backwall. The footings also had damage.

Analysis of Damage

The girders spanning the bin had cycled a longitudinal moment into the backwall, working it back and forth to form a flexural tension crack into the abutment backwall. This movement spalled off a compression region at the back and bottom of the backwall surface. There are signs of transverse motions of the bin girders doing more damage.


INDEX TO PLANS
TYPICAL SECTION
ELEVATION
RINALDI STREET UNDERCROSSING
DESIGN SECTION ... 12
63-0V1SC7

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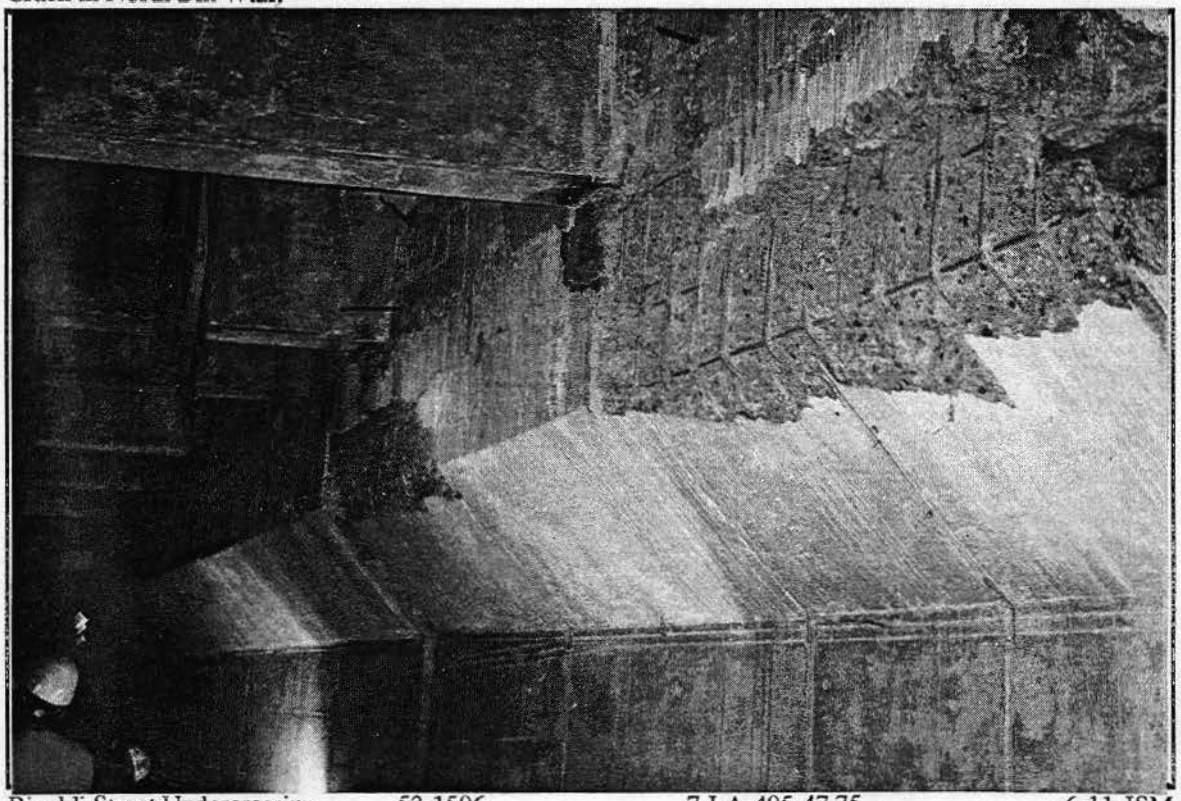
Rinaldi Street Undercrossing 53-1506 7-LA-405-47.75 6-5-JSM
Crack in North Bin Wall.



Rinaldi Street Undercrossing 53-1506 7-LA-405-47.75 6-11-JSM
Flexural Tension Cracks in Backwall.

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Ruffner Avenue OC 53-2396 07-LA-118-R8.05

Description of Structure

Ruffner Avenue Overcrossing is on Route 118. It is a 337 foot, two span bridge with 165 foot and 172 foot spans. The bridge width is 56 feet. It was designed in 1973 and built in 1976.

The superstructure is a CIP P/S box girder with superstructure depth of 6'-6". The skew is 21°.

The bents are comprised of two columns and the columns have a one-way flare. #14 main column bars form the core, with #8 bars forming the flare. The transverse reinforcement is #5 spiral @ 3 1/2. The columns are fixed-fixed at the ends with spread footings. The spread footings have top and bottom mat of steel but no shear reinforcement.

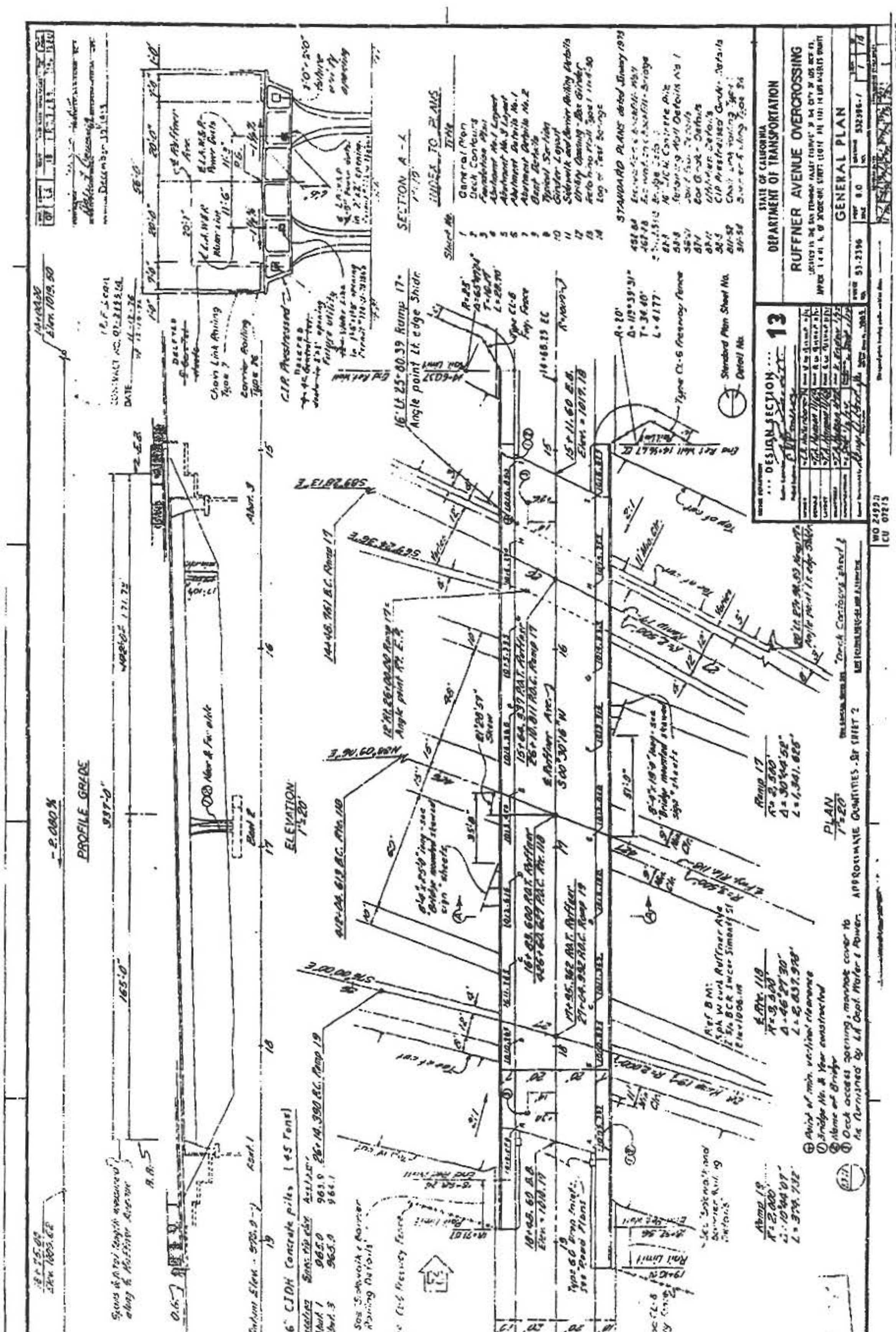
The abutments are seat type using elastomeric pads and internal shear keys. The wingwalls are also on piles. The piles are 16" diameter CIDH concrete piles at all locations.

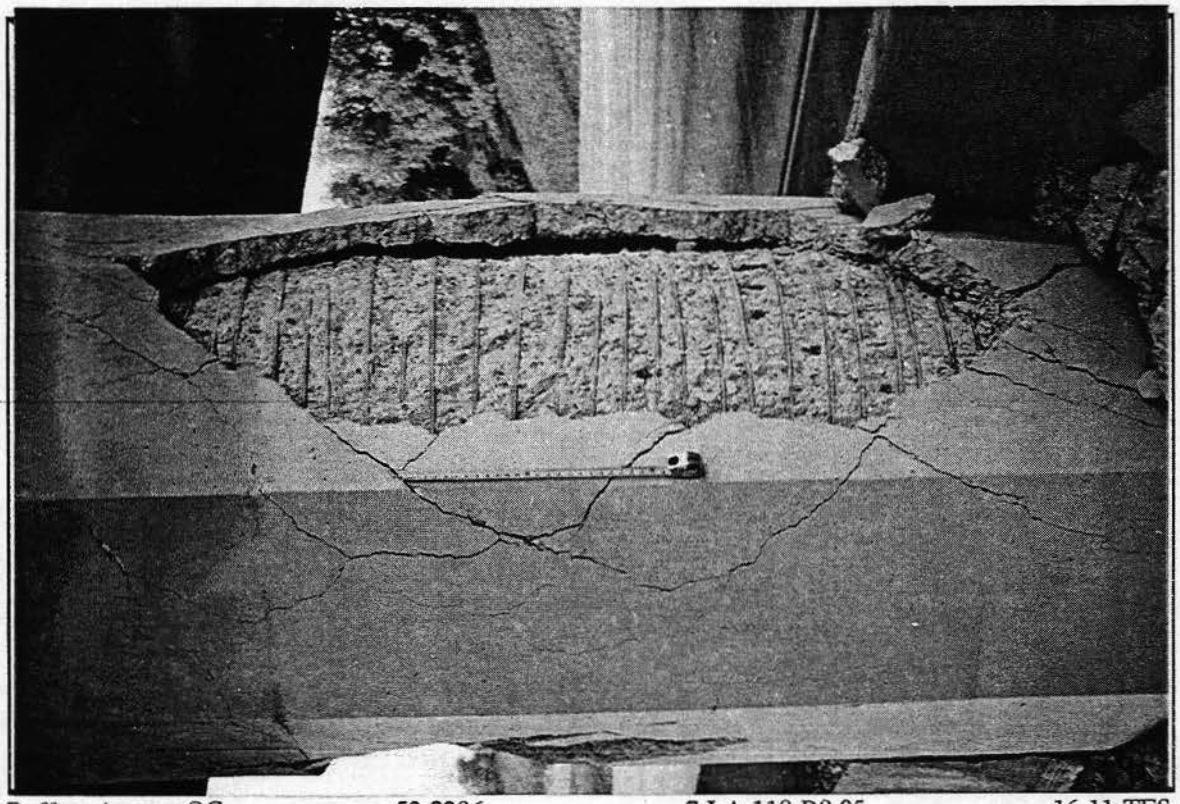
Description of Damage

This bridge only experienced minor damage. At first glance, the columns at bent 2 appear much worse due to the significant spalling of the cover. However, a closer look reveals that the core is intact with hairline cracks propagating longitudinally with the main column reinforcement. The majority of the cracking is at the base of the column flares. The abutments show signs of movement and show only minor shear cracking on the east side of abutment 1 at the shear key. The west side shear key of abutment 1 did not sustain any damage. There is only minor spalling of concrete at abutment 3. The approach slab settled back approximately 2 inches at abutment 1.

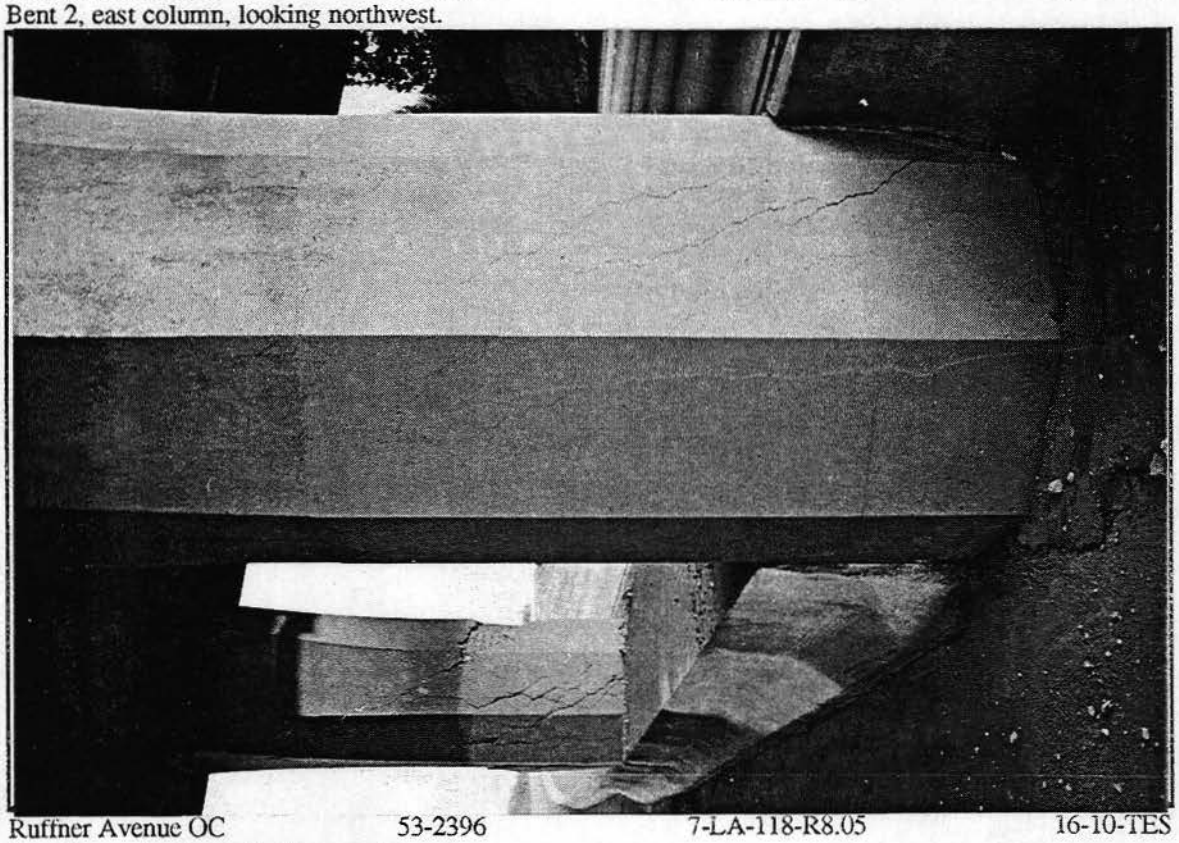
Analysis of Damage

Although the column had massive spalling, the core of the column remained intact. This type of behavior can be expected to happen with only minor repair of the bridge necessary.


STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
RUFFNER AVENUE OVERCROSSING
GENERAL PLAN
PROFILE GRADE
ELEVATION
PLAN
SECTION A-A
INDEX TO PLANS
DESIGN SECTION
13



Ruffner Avenue OC 53-2396 7-LA-118-R8.05 16-11-TES
Bent 2, east column, looking northwest.



Ruffner Avenue OC 53-2396 7-LA-118-R8.05 16-10-TES
Bent 2, west column, looking east.

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South Connector OC 53-1917F 07-LA-2-R18.72

Description of Structure

South Connector Overcrossing is located at the intersection of Eagledale Avenue and Colorado Blvd. on Route 2 in the city of Los Angeles. It is approximately 1432 feet in length and 34 feet wide. It was designed in 1973 and built in 1976.

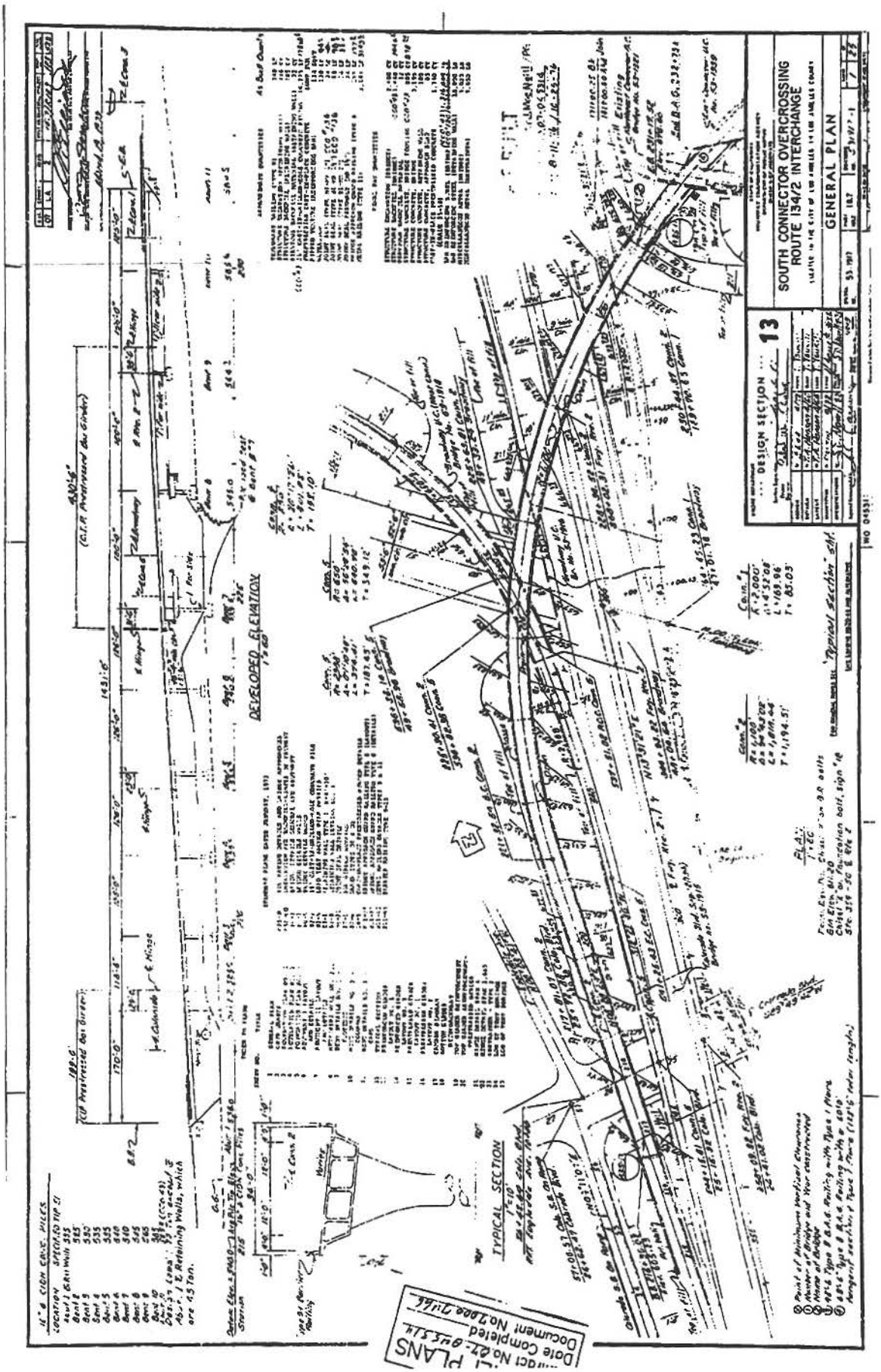
The superstructure is a CIP P/S box girder from abutment 1 to the hinge in span 2, and from the hinge in span 6 to the hinge in span 9. It is a RC box girder in all remaining spans. There is also a hinge in span 4. The structure depth is 7'-0" and rests on elastomeric bearing pads at abutment 1. The hinge in span 4 (the RC section) has a 14" seat. It also has equalizing bolts, total of 2 in each exterior bay. All other hinges have 18" seats and the same equalizing bolt detail. All hinges have vertical restrainers and Type A restrainers, 10 cables per restrainer unit. The cable lengths vary from 30' to 46'.

The bents are RC, single-column fixed frame. The column is 8' in diameter with a one-way flare. The flared section is 8' x 19' oblong with a 14' transition length. All columns are fixed-fixed connections to the footings on pile foundation. The main longitudinal reinforcement extends into the footings and bent caps and the transverse reinforcement is #5 spiral @ 3 1/2. The flared section is formed with #11 bars into the cap and tied with #5 @ 12. The footings have a top and bottom mat of steel and 16" diameter concrete piles.

Abutment 1 is a high cantilever seat-type on a pile footing foundation. The footing has a top and bottom mat of steel and 16" diameter concrete piles. Abutment 11 is a end diaphragm-type on a pile footing foundation. The footing has a bottom mat of steel only and 16" concrete piles.

Description of Damage

This structure has been retrofitted with restrainers at the hinges and steel casings at the columns. There is no abutment damage and no visible column damage. The abutment suffered only very minor damage. There was approximately 1 inch of longitudinal movement and minor cracking at the abutment.


SOUTH CONNECTOR OVERCROSSING
ROUTE 134/2 INTERCHANGE
GENERAL PLAN
DESIGN SECTION 13
DEVELOPED ELEVATION
TYPICAL SECTION
PLANS
Date Completed
Document No.
Contract No.

Northeast Connector OC 53-1921F 07-LA-2-R18.81

Description of Structure

Northeast Connector Overcrossing is located in the city of Los Angeles on Route 2. It is approximately 748 feet in length and 34 feet wide. It was designed in 1969 and built in 1971.

The superstructure is a CIP P/S box girder except for the span of RC box girder superstructure between the two hinges in span 3. The alignment has an 875 foot radius curve. The structure depth is 7'-0". The end span sits on 25" x 12" T.F.E. fluorocarbon resin sheets bonded to a fabric pad at abutment 6. The hinges have 14" seats.

The bents are RC single column fixed frame. The columns are 6' in diameter with one-way flares. The flared section is 6' x 14' oblong with a 12' to 14' transition length. The columns' main longitudinal reinforcement extends into the bent caps and footings. Bent 4 only has concentric longitudinal reinforcement. The flared section has additional bars which form the flare. The transverse reinforcement is #5 spiral @ 5 in the column and #5 ties @ 10 in the flared section. The footing has a 2 foot pedestal into which the spiral reinforcement extends. The pedestal also has a top mat of steel and stirrups around the perimeter that extend through to the footing. The footing has a bottom mat of steel only and 3' diameter CIDH concrete piles. Bent 3 footing is a combined footing that is shared with bent 2 of Route 134/2 Separation (53-1919). As a result, the footing is at a skew from the centerline of bent 3. The two columns from 53-1919 are pinned into the footing and the bridge itself is separated from bent 3 column by a Type A joint seal. The piles are 3' diameter 200 ton CIDH.

Abutment 1 is diaphragm-type on pile footing foundation. The piles are driven Class I concrete piles. Abutment 6 is a cantilever seat-type also on pile footing foundation.

This bridge was retrofitted by contract change order in May, 1973 after the San Fernando Earthquake while the bridge was still under construction. Restrainer units were installed in the hinge (total 2, total 7 cable assemblies per restrainer unit) through hinge diaphragms only. This work was done under a Phase I retrofit contract.

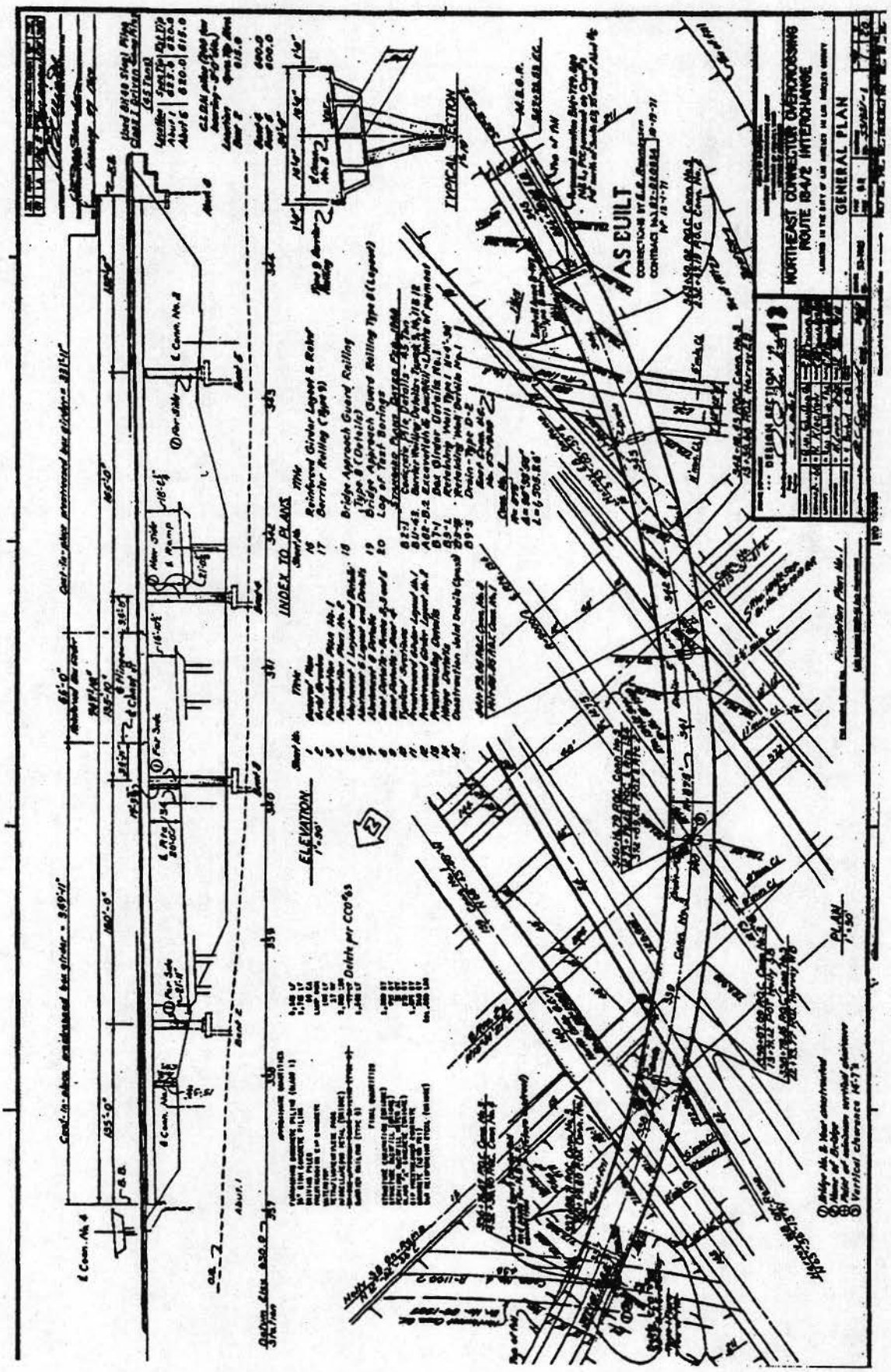
It also had a Phase II retrofit completed in 1991 which included additional work at the hinges, steel casings around the columns (full height at bents 2,4, & 5, and partial height at bent 3), and footing retrofits at bents 2,4, & 5 using tie-downs.

Description of Damage

This bridge only experienced minor abutment damage. The internal shear key at abutment 6 shows a 1/4 inch diagonal crack. The columns did not suffer any damage.

Analysis of Damage

This bridge performed well , backing up our current retrofit standards.


AS BUILT
NORTHEAST CONNECTOR OVERCROSSING
ROUTE 134/2 INTERCHANGE
GENERAL PLAN
INDEX TO PLANS
ELEVATION
PLAN
TYPICAL SECTION

Pacoima Wash Bridge 53-1128 07-LA-5-39.19

Description of Structure

Pacoima Wash Bridge is located on Interstate 5. This 3 span bridge is approximately 175 feet in length, 174 feet wide with a skew of 29°. The bridge was designed in 1959 and built in 1963.

The superstructure is a multi-celled, RC box girder. The structure depth is 5'-3" and is keyed into a short strutted abutment. There is a longitudinal joint at the centerline of bridge.

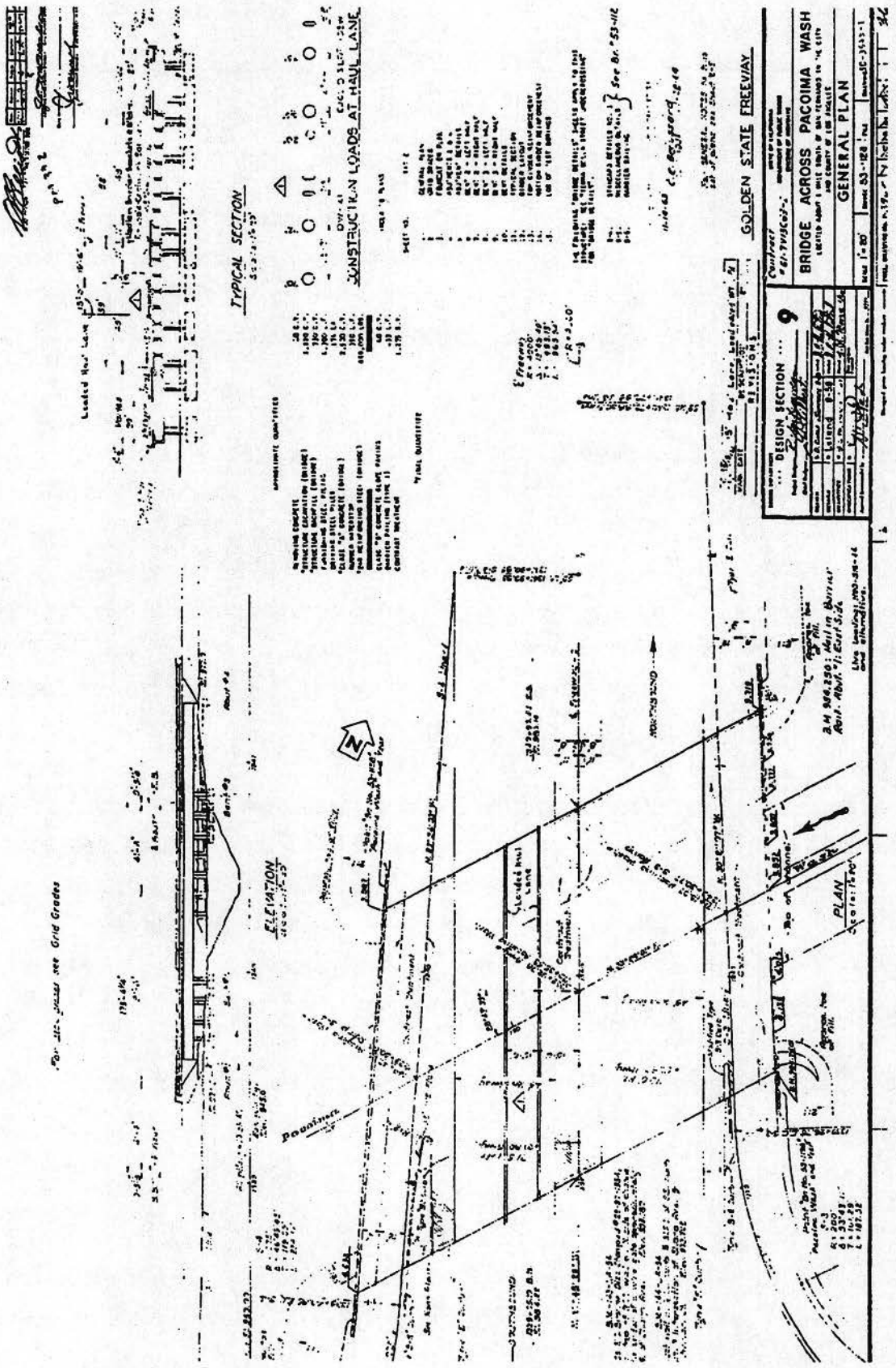
The bents are multi-column RC fixed frame using 2' x 3' rectangular columns fixed at the top and pinned at the footing. Transverse reinforcement in the column is #4 @ 12. The columns are supported by a narrow (3'-0") footing with a single row of steel piles. Six sets of column pairs share a common footing also on steel piles. The footings do not have a top mat of reinforcement.

Description of Damage

The abutments sustained minor damage. The columns suffered moderate damage, showing the initial stages of shear failure. This structure was shored up for traffic.

Analysis of Damage

These columns are very short and poorly confined (#4 @12"), introducing the probability of shear failure when subjected to large forces.


TYPICAL SECTION
CONSTRUCTION LOADS AT HAUL LANE
ELEVATION
PLAN
GOLDEN STATE FREEWAY
DESIGN SECTION
BRIDGE ACROSS PACOIMA WASH
GENERAL PLAN

West Sylmar OH 53-1984RL 07-LA-5-R44.87

Description of Structure

West Sylmar Overhead is located in the city of Los Angeles near the intersection of Balboa Blvd. and San Fernando Road on Interstate 5. There are two separate bridges, right and left. The right bridge is approximately 543 feet in length and 90 feet wide. The left bridge is approximately 551 feet in length and also 90 feet wide. It was designed in 1968 and built in 1971.

The superstructure of the left bridge is a RC box girder resting on elastomeric bearing pads at the abutments. The structure depth is 7'-0". The superstructure of the right bridge is a RC box girder in spans 1,2, and 5. It is CIP P/S box girder in spans 3 and 4. There are hinges in spans 3 and 4, with 19" seats. It rests on elastomeric bearing pads at the abutments. The structure depth is 6'-0". Both bridges have a closure pour in the middle and are on a 3000 foot radius curved alignment. Skews are not radial to the bridge. The left bridge has skews that vary from very large at abutment 1 and bents 2 and 3 to moderate the remainder of the bridge. The right bridge has very large skews throughout.

The bents are multi-column, RC fixed frame. The columns are 4' octagons, and there are 6 columns at each bent. All columns are pinned at the footings; the exception is at bent 4R where the columns are fixed at the footings. All columns extend the main longitudinal bars into the bent cap. All columns have transverse reinforcement of #4 @ 12 ties with a 1'-6" lap. All footings have a bottom mat of steel. Bents 2 left and right, and bent 5 right have spread footing foundations; all others have 65 ton driven steel pipe piles.

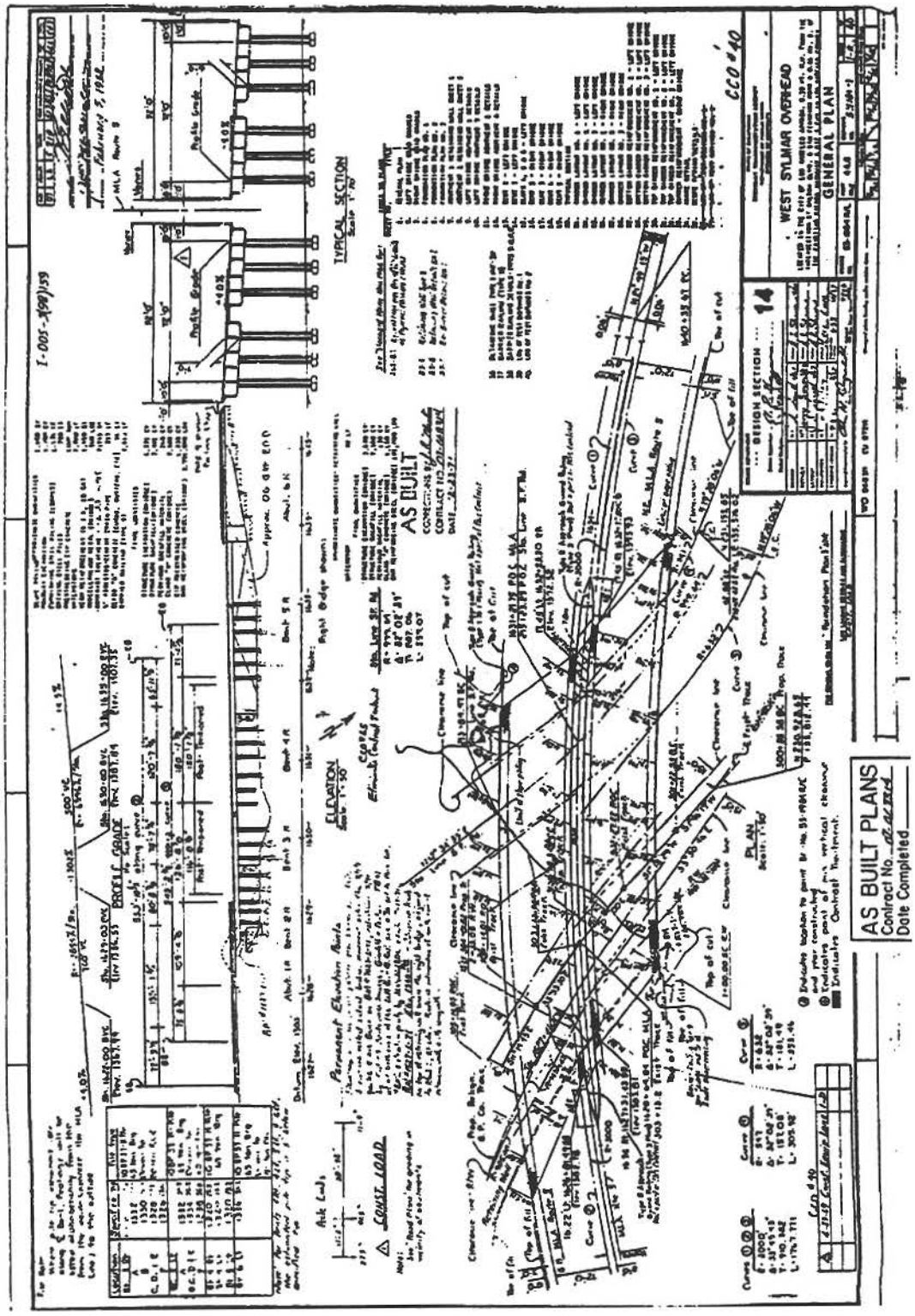
The abutments for both bridges are high cantilever seat-type on spread footing with a shear key.

Description of Damage

The exterior shear keys at the abutments failed. The hinges appeared to suffer some banging and differential movement. Existing patches spalled off at the columns. Most of the damage at these structures can be classified as minor damage.

Analysis of Damage

The damage encountered at these structures was similar to the damage from the 1971 San Fernando Earthquake. The patches which spalled off the columns were from the repair work from the 1971 Earthquake. Overall, the structure performed well.


AS BUILT PLANS
Contract No. 07-087804
Date Completed
AS BUILT
WEST SYLMAR OVERHEAD
GENERAL PLAN
TYPICAL SECTION
ELEVATION
PLAN
COUNTY LOAD

Southeast Connector OC 53-2327F 07-LA-5-39.30

Description of Structure

The Southeast Connector Overcrossing is located at the intersection of Routes 5 and 118 in the city of Los Angeles. The bridge is approximately 1672 feet in length and 42 feet wide. It was designed in 1974 and built in 1976.

The superstructure consists of alternating RC and CIP P/S box girder frames. The hinges have 24 inch seats with Type A restrainers (total 8 per hinge; 8 cables 22 feet long per restrainer) and also vertical restrainers. The structure depth is 7'-0".

The bents are single column, RC, fixed frame. The column has a one-way flare with a transition length of 12 feet. The main longitudinal reinforcement forms the flare. The transverse reinforcement is #4 spiral @ 3 1/2 in the column and #4 ties @ 3 1/2 ties in the flared section. Bents 2, 3, 4, 5, 9, 10, and 11 have octagonal columns flaring to a 6' x 14' rectangular section. Bents 3, 9, 10, and 11 are on a 6' diameter pile shaft with longitudinal bars from the column continuing into the shaft. The shaft transverse reinforcement is #4 spiral @ 3 1/2 for the first 10 feet and #4 spiral @ 12 thereafter. Bents 2, 4 and 5 are on spread footings with top and bottom mats of steel. Bents 6, 7, 8 and 12 are on 8' diameter pile shafts. The reinforcement is similar to the 6' diameter pile shafts.

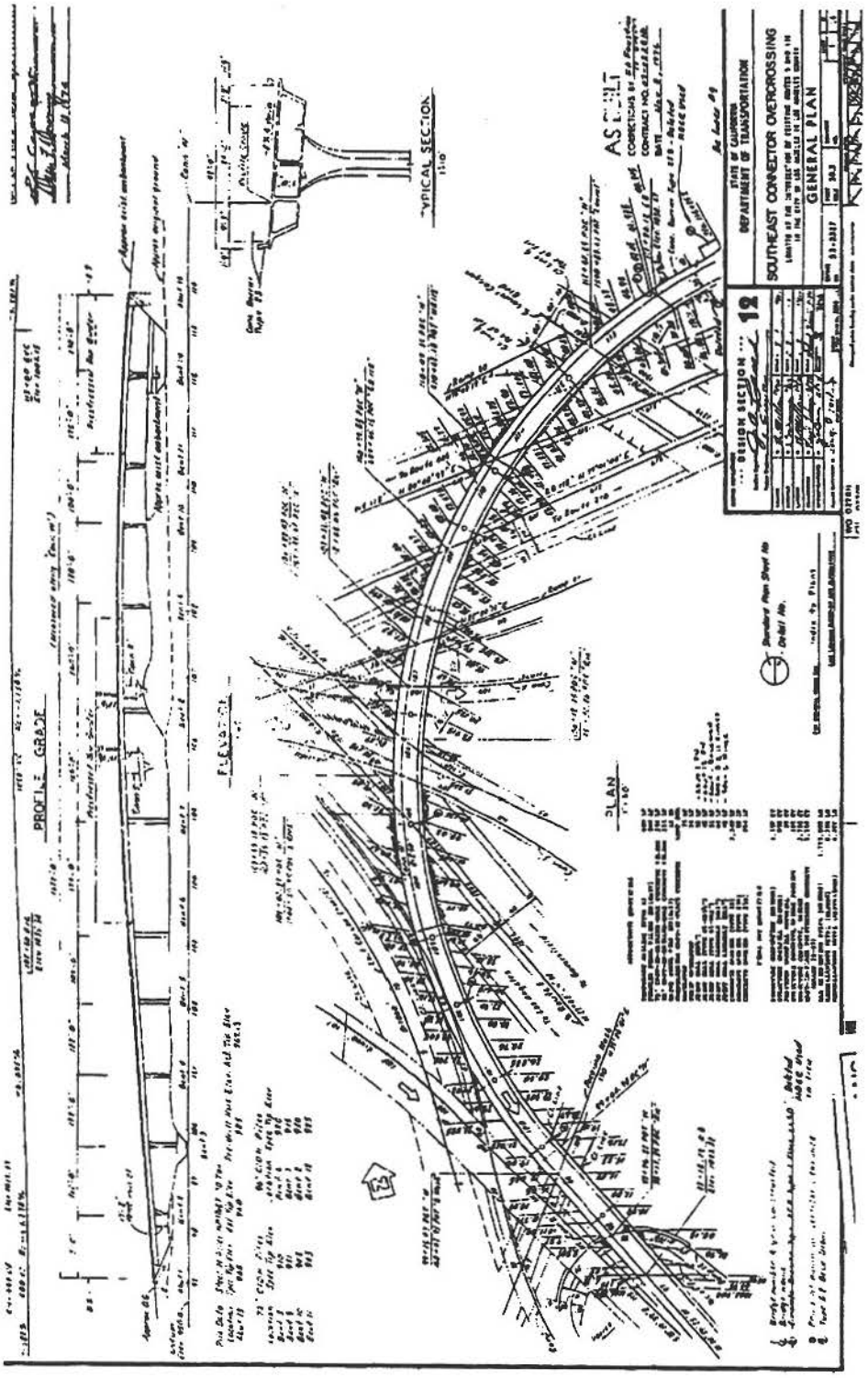
Abutment 1 is a seat-type on spread footing with a moderate skew. Abutment 13 is a diaphragm-type on pile footing foundation. The piles are driven steel pipe piles (HP 10 x 57). Both abutment footings have top and bottom mat steel.

Description of Damage

This bridge had minor damage. Abutment 13 displaced longitudinally 7 inches and transversely 1 inch. Abutment 1 lost a portion of the barrier rail. There was no damage at the columns but the hinges were closed tight, indicating that there was some movement.

Analysis of Damage

The bridge performed well.


PROFILE GRADE
TYPICAL SECTION
PLAN
SOUTHEAST CONNECTOR OVERCROSSING
GENERAL PLAN
DEPARTMENT OF TRANSPORTATION
AS BUILT

Centinela-Pico UC 53-1603 07-LA-10-R4.24

Description of Structure

Centinela-Pico Undercrossing is located in the city of Santa Monica, with a portion extending into the city of Los Angeles on Interstate 10. The bridge is approximately 567 feet in length and varying width to approximately 168 feet. It was designed in 1963 and built in 1965. It was retrofitted in 1974 with hinge restrainer cables.

The superstructure is a RC box girder with a structure depth of 5'-6". There is a 1 inch longitudinal expansion joint in the middle of the bridge in the top slab and 1" open joint in the bottom slab below it, effectively making it a left and right bridge. The bridge has a tangent alignment for the first 345' with large, varying skews. These skews also reverse direction from one bent to the next. The last 222' is on a 2000 foot radius curve with large skews not radial to the bridge. There are hinges in span 3 near bent 4 and span 6 on the right side of the expansion joint only. The hinge seats are 6" and have skews of 55° (NE) and 36° (NW) respectively.

The bents vary in type and geometry. Pier 2 is a RC pier wall the full width of the bridge. It is 1'-3" thick and pinned at the base. The footing has a top and bottom mat of steel and a single row of Class II driven PCC piles. The skew is 55° (NE). Bents 3 and 4 are multi-column RC fixed frame for the full width of the bridge. The columns are 3' in diameter, pinned at the bottom, and fixed at the top. The main longitudinal reinforcement extends into the bent cap. The transverse reinforcement is #5 @ 12 ties. The skew for bents 3 and 4 is also 55° (NE). The footings have a bottom mat of steel only and Class II driven PCC piles. Bents 5R and 6R are on the right side of the expansion joint. The columns and footings have similar details as bents 3 and 4. The skews are 39° (SW) and 0° respectively. Bent 5L is on the left side of the expansion joint and does not coincide with bent 5R. The columns and footings have similar details to bents 3 and 4. It changes skew greatly from bent 4, turning almost perpendicular to it, and actually joining it. Bent 5L skew is 26° (NW). Bent 7 is along the entire width of the bridge at a 34° (NW) skew, also turning perpendicular to bent 4 with similar details. Pier 8 is similar to pier 2 except that it is 1'-6" thick and has a 34° (SE) skew.

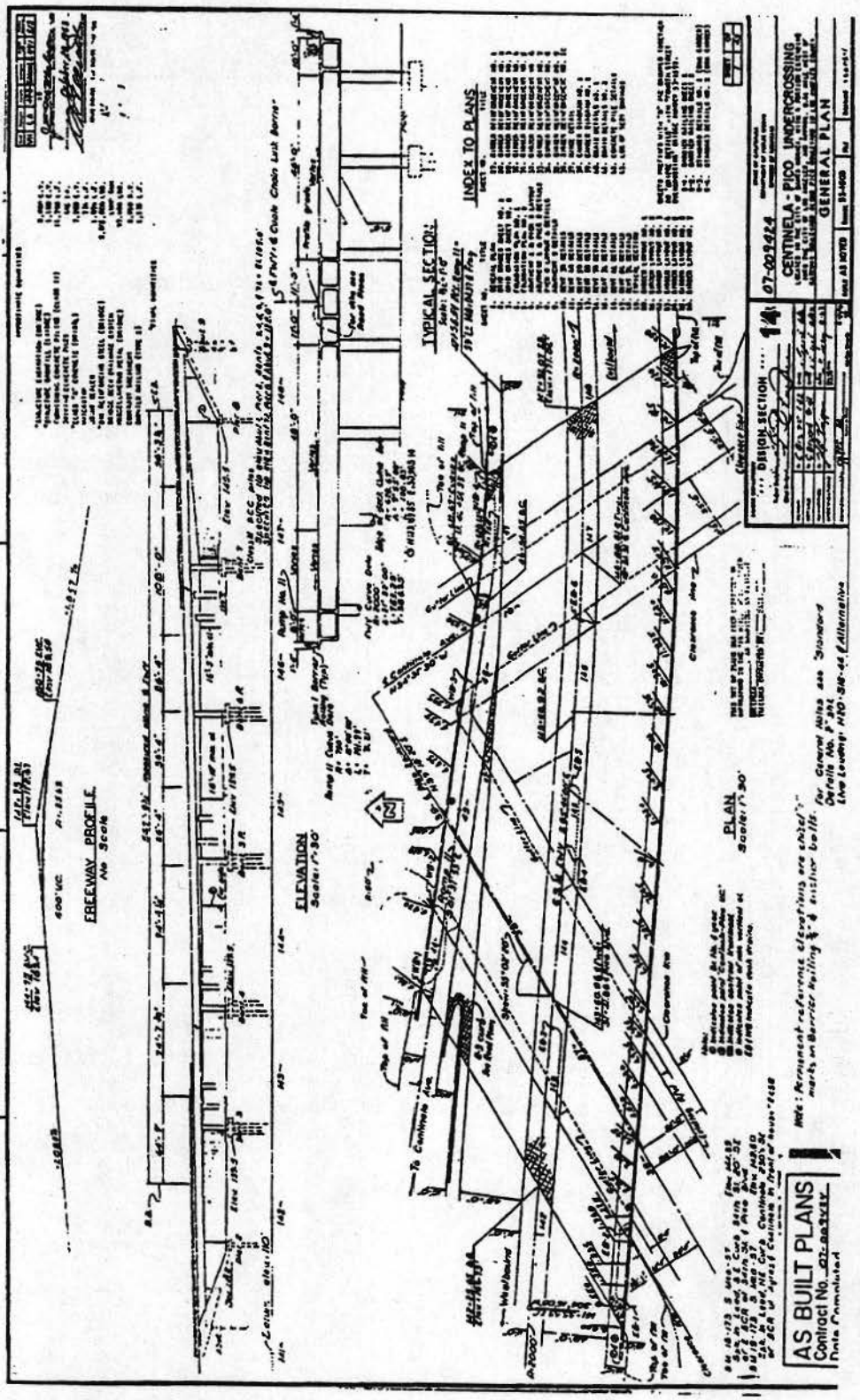
Abutment 1 is a diaphragm type on a pile (single row) foundation. Piles are Class II PCC driven. The abutment skew is 55° (NE). Abutment 9 is a short seat type on a pile footing. The footing has top and bottom mat steel and Class II PCC driven piles.

Description of Damage

There was minor spalling at the top of many of the columns. Also, the approach slabs at both ends of the structure had settled approximately six inches.

Analysis of Damage

The bridge performed well despite its highly skewed arrangement of bents.


AS BUILT PLANS
FREEWAY PROFILE
ELEVATION
PLAN
TYPICAL SECTION
INDEX TO PLANS
GENERAL PLAN
CENTINELA - PICO UNDERCROSSING

National Blvd. OC 53-1615 07-LA-10-R6.31

Description of Structure

National Blvd. Overcrossing is located near the intersection of Overland Avenue and National Blvd. on Interstate 10 in Los Angeles county. The bridge is approximately 410 feet in length and 80 feet wide. It was designed in 1961, built in 1963, and retrofit with hinge restrainer cables in 1974.

The superstructure is a CIP P/S box girder carrying a multitude of utilities. The skew is 57°. The structure end diaphragms rest on seats of bin type abutments with expansion bearing assemblies. The structure depth is 6'-2".

The bent consists of four, 4 foot diameter columns in a RC frame. The columns are on a spread footing foundation. The columns have a raised hinge key (normal to centerline of roadway) at the top and pinned at the bottom. The footings have a bottom mat of steel but no top mat or shear reinforcement.

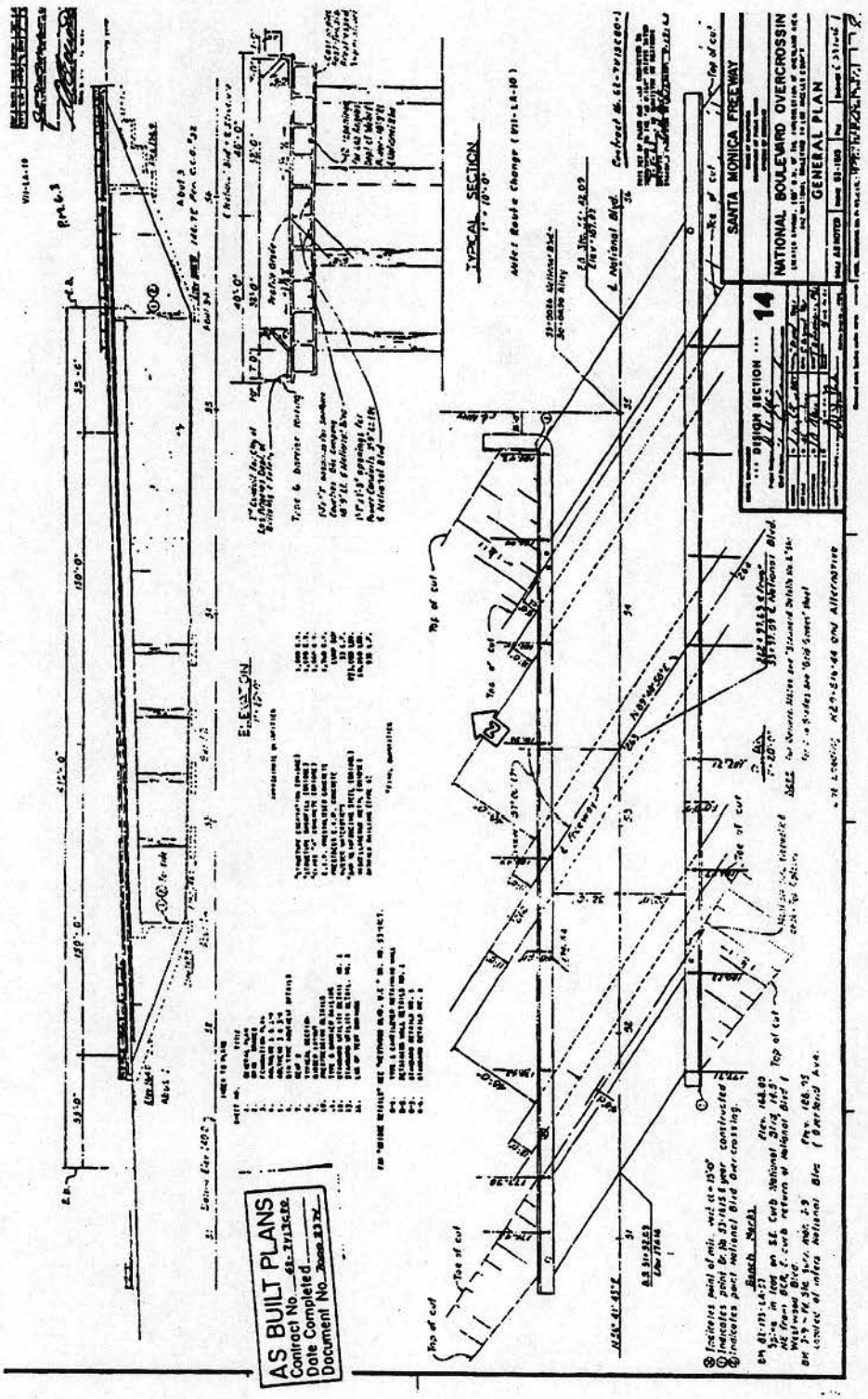
The abutments are bin type with a 55 foot long RC T-beam span with a 5' structure depth.

Description of Damage

Both abutment curtain walls adjacent to the acute corners of the superstructure were heavily damaged. Many rocker bearing keeper bolts had sheared off and were found below the seats at both abutments. At the top of all the columns, there was some spalling at their connection to the bottom of the bent cap. This spalling indicates that the superstructure may have rotated during the earthquake.

Analysis of Damage

This structure performed very well. The transverse movement of the bridge may have caused the shearing off of the rocker bearing bolt and damage to the acute corner curtain wall which was on a 57° skew.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Contract No 07-271524
Date Completed
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TYPICAL SECTION
ELEVATION
SANTA MONICA FREEWAY
NATIONAL BOULEVARD OVERCROSSIN
GENERAL PLAN
14

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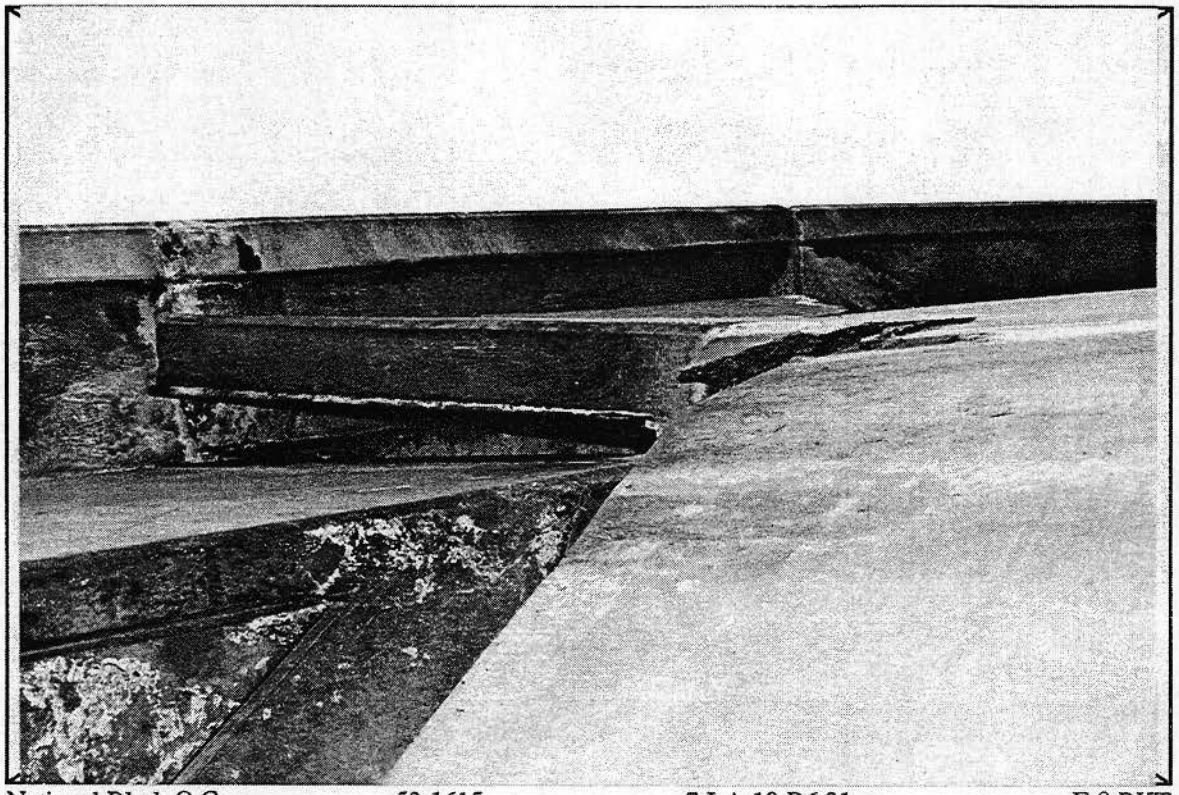
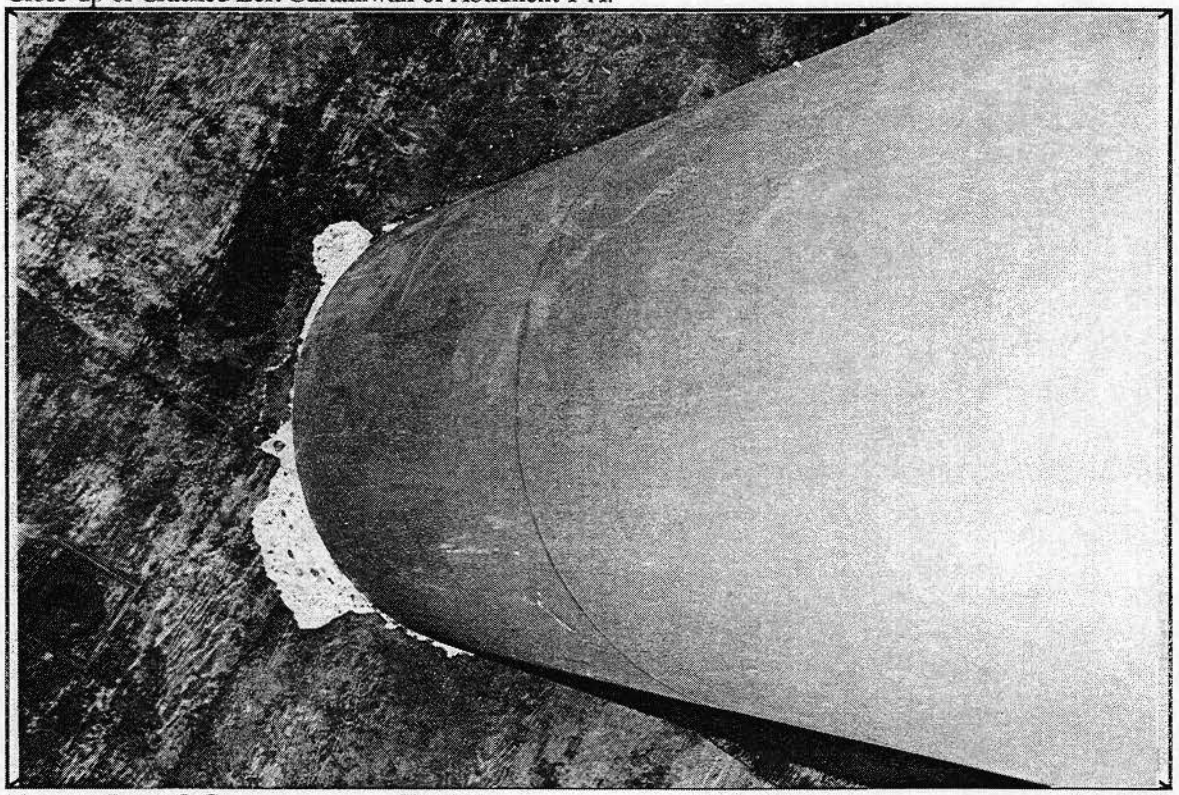


National Blvd. O.C. 53-1615 7-LA-10-R6.31 E-8-BKT
Close-up of Cracked Left Curtainwall of Abutment 1-A.



National Blvd. O.C. 53-1615 7-LA-10-R6.31 E-6-BKT
Spalling of bentcap at top of column 4, bent 2.

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Southeast Connector OC 53-1637F 07-LA-10/405-R5.65/29.35

Description of Structure

Southeast Connector Overcrossing is located in the city of Los Angeles portion of the Santa Monica-San Diego freeway interchange on Interstate 10. It is approximately 2864 feet in length and 34 feet wide. It was designed in 1962 and built in 1964.

The superstructure is a RC box girder in all spans except 4, 5, 6, 15, 16, and 17, where it is CIP P/S box girder. The alignment for the first 2500 feet is a 1088 foot radius curve. The centerline of the bents along the curved alignment is radial to the bridge. Abutment 1 wall and face have a skew of 35°. The remainder of the bridge (approximately 350 feet) is on a tangent alignment. The bents have 0° skew. The wall and face of abutment 24 have a skew of 12°. The structure depth is 7'-0" typical. There are hinges in spans 10 and 20 with 6" seats.

The bents are single, 6 foot diameter columns on a pile footing foundation. All columns have main longitudinal reinforcement and transverse reinforcement extending into the bent cap. All bents except 4, 8, 9, 10, and 13 have lapped splices at the footing pedestals (main bars stop at pedestal). Bents 4, 8, 9, 10, and 13 have no lapped splices, and main longitudinal bars extend through the pedestal into the footing. All bents except 4, 8, 9, 10, and 13 have transverse reinforcement consisting of #4 spiral @ 12; bents 4, 8, 9, 10, and 13 have #4 spiral @ 3 1/2. These bents also have longitudinal bars added as you move down the column. Bents 4, 7, 15 and 18 have a drop cap bent with the superstructure resting as end diaphragms on elastomeric bearing pads on either side of the centerline of the bent. The bent width (seat) is 6'-0". There is 1/2" expansion joint material for the height of the cap. The footings have a bottom mat of steel only on CIDH concrete piles.

The abutments are bin type with a RC T-beam span. Abutment 1 has a 50 foot span with a 4'-6" structure depth, and abutment 24 has a 30 foot span with a 3'-0" structure depth. Both are on pile footing foundations with CIDH concrete piles. The footings have a bottom mat of steel only.

This structure was retrofitted in 1990. The hinges were retrofitted with cable restrainers extending from the hinges to the bent caps, and concrete bolsters full width of bays. A total of 4 cable restrainers were placed at the first hinge and 3 at the second hinge.

Fully grouted, 3/8" column shells were placed on bents 3, 5, 6, 7, 11, 14, 15, 16, 17, 18, 19, 20, 21, and 22 for the full column height. Footing retrofits were done on all bents. A top mat of steel and shear reinforcement were added and the footing enlarged from 3'-6" to 5'-6" deep and 3' added to entire existing perimeter. 16" diameter 70 ton CIDH concrete piles were used in new perimeter section.

Description of Damage

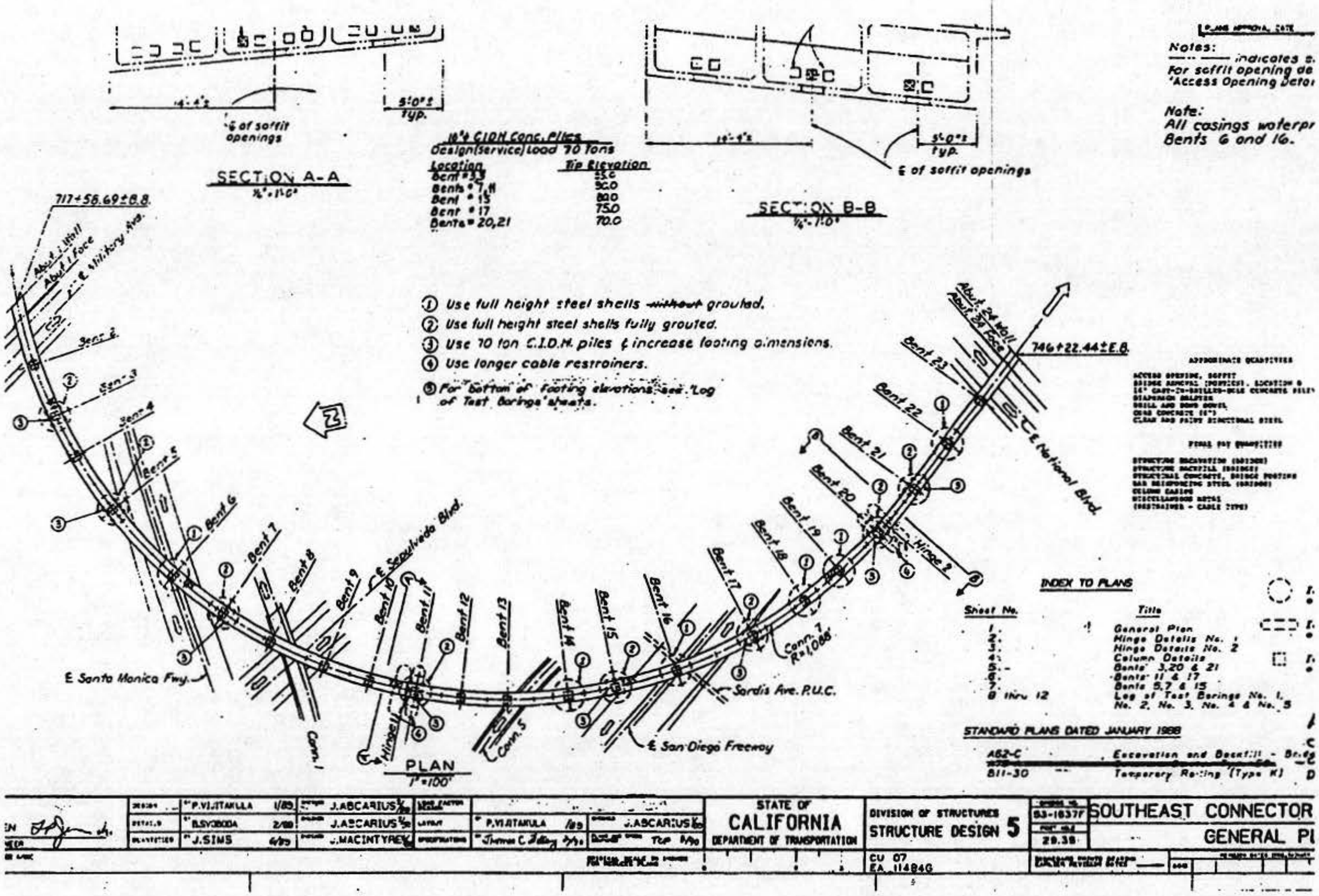
During the earthquake, the joint seals at all the hinges were in the process of being replaced. The joints were recently saw-cut; therefore, it is hard to tell how much the structure displaced longitudinally. There is evidence of longitudinal displacements at the steel railing joints in the vicinity of the hinges. At the superstructure joint at bent 7, there was evidence of superstructure banging. At this joint, there was some spalling in the deck. Also, looking from the deck, long propagating cracks were seen in the east diaphragm at this joint. There were significant cracks in the south barrier railing at this joint. Also, looking from ground level, cracks were seen on the south face of the same diaphragm. The first hinge from the west abutment had moved approximate 3 inches in the transverse direction but there were no signs of damage to any of the columns nearby.

Analysis of Damage

This structure experienced some transverse and longitudinal displacements. The longitudinal response caused the banging of the superstructure at the centerline of bent 7 (also centerline of hinge) which produced cracks at the hinge diaphragm.

There was also some vertical settlement of 1/2" at the same hinge (bent 7) which may be due to crushing some of the bearing pad from a vertical ground acceleration at this bent.

The transverse response caused the 3" offset between the abutment wall and the edge of deck. There was no other visible damage to the structure and it was in very good shape.


Notes:
For soffit opening de
"Access Opening Detai
Note:
All casings waterpr
Bents 6 and 16.
SECTION A-A
SECTION B-B
16"Ø CIDH Conc. Piles
Design(Service) Load 70 Tons
Location
Tip Elevation
717+58.69±B.B.
746+22.44±E.B.
① Use full height steel shells without grouted.
② Use full height steel shells fully grouted.
③ Use 70 ton C.I.D.H. piles & increase footing dimensions.
④ Use longer cable restrainers.
⑤ For bottom of footing elevations see "Log of Test Borings" sheets.
℄ Santa Monica Fwy.
℄ Sepulveda Blvd.
℄ San Diego Freeway
Sardis Ave. P.U.C.
℄ National Blvd.
PLAN
1" = 100'
INDEX TO PLANS
Sheet No.
Title
General Plan
Hinge Details No. 1
Hinge Details No. 2
Column Details
8 thru 12
STANDARD PLANS DATED JANUARY 1988
A62-C
B11-30
Excavation and Backfill
Temporary Railing (Type K)
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF STRUCTURES
STRUCTURE DESIGN 5
53-1637F
SOUTHEAST CONNECTOR
GENERAL PL

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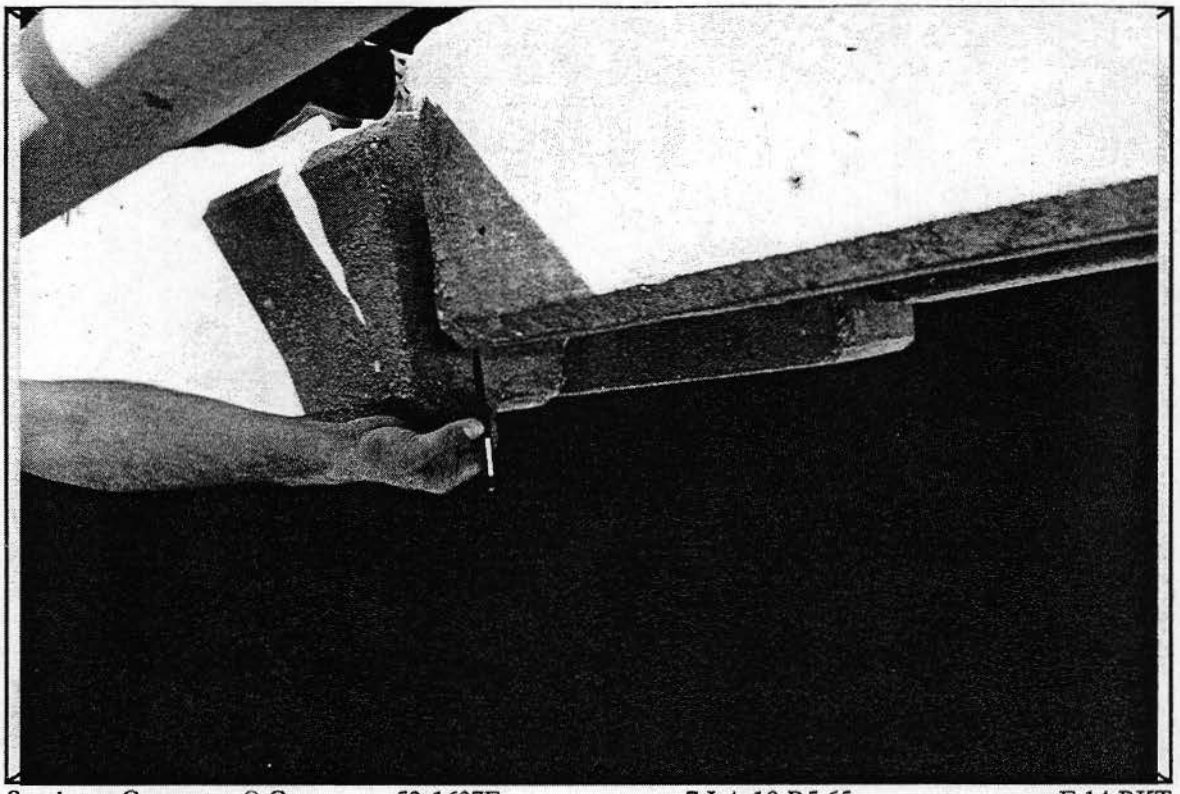
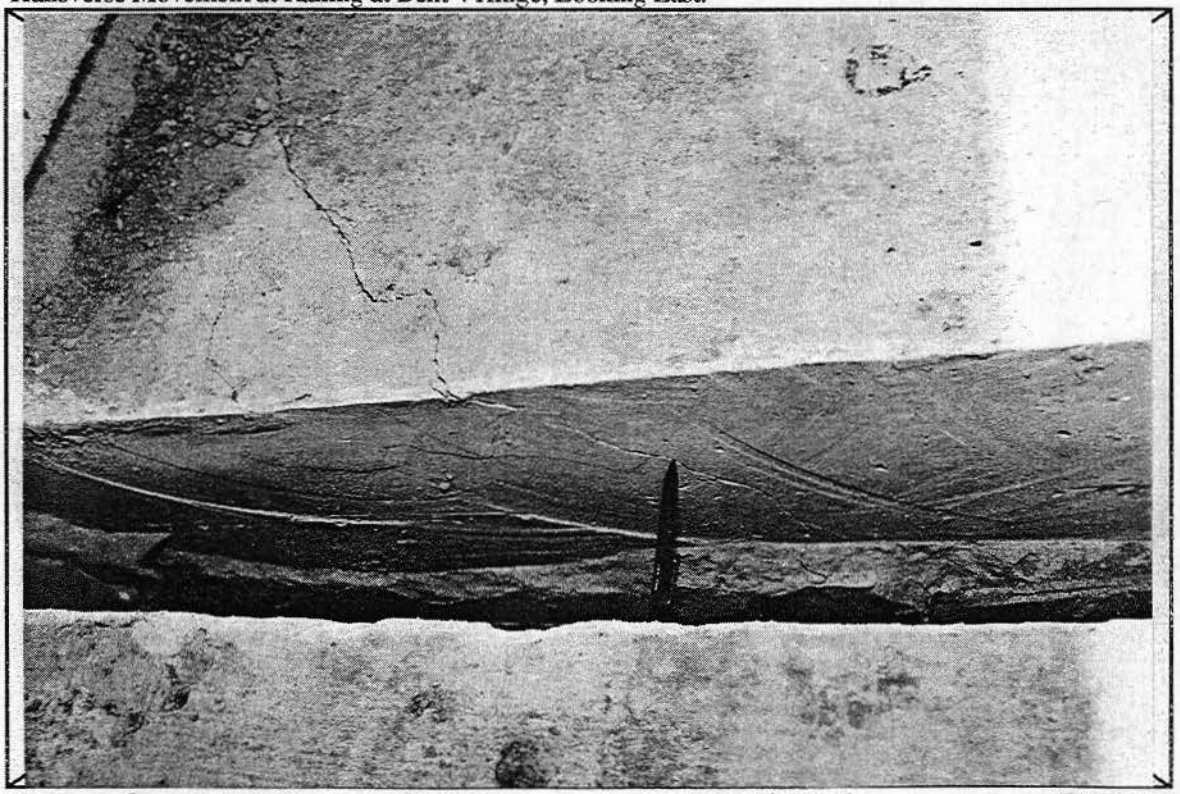


Southeast Connector O.C. 53-1637F 7-LA-10-R5.65 E-14-BKT
Transverse Movement at Railing at Bent 4 Hinge, Looking East.



Southeast Connector O.C. 53-1637F 7-LA-10-R5.65 E-17-BKT
Cracks in Diaphragm (Span 7 Side) at Bent 7 Hinge, Looking West.

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Truck Connector Overcrossing 53-1962F 07-LA-14/5-R24.81/C45.74

Description of Structure

The Truck Connector Overcrossing connects southbound Interstate 14 to southbound Route 5. This bridge is comprised of 4 frames with a total length of 1532 feet. There are nine spans which range in length from 59 feet to 136 feet. The bridge was designed in 1968. This bridge was under construction in 1971 during the San Fernando Earthquake.

All spans are conventionally reinforced box girders with a structure depth of 7'-0". The hinge seat width is 14". The three hinges of this bridge were retrofitted with cable restrainers as part of the damage restoration contracts following the 1971 San Fernando Earthquake.

The bents consist of single 4' x 10' octagonal columns that extend into the ground as pier shafts. The main longitudinal column reinforcement ranges from #11's total 46 to #18's total 36. The lateral stirrups are #4 @ 12.

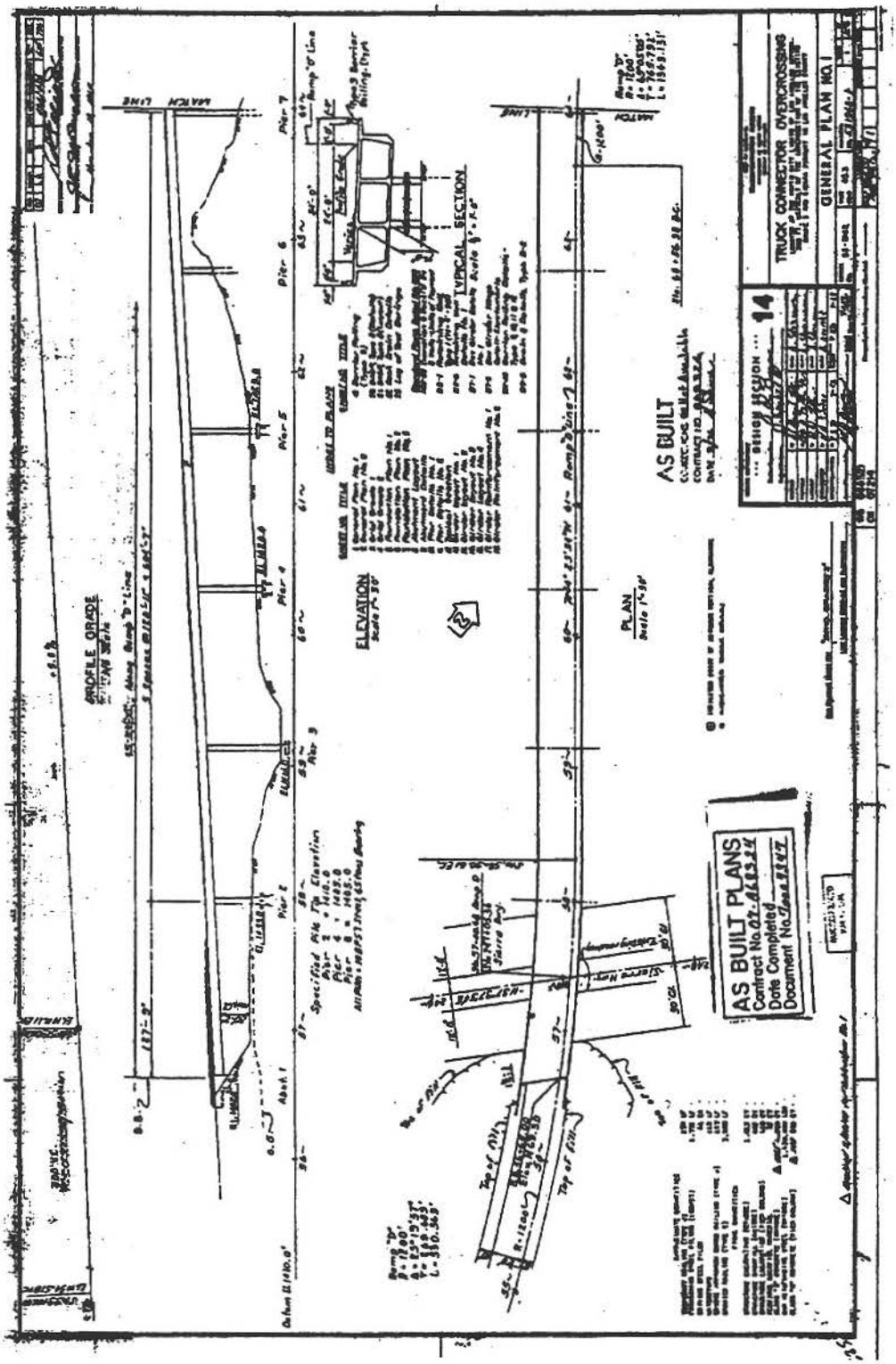
The abutments are end diaphragm-type on spread footings.

Description of Damage

This structure had only minor damage. The exterior shear keys at the abutment had very minor cracks. At the hinges, there was approximately 1 inch of movement with some banging, which was indicated by spalling of the concrete barriers.

Analysis of Damage

This structure performed well. This structure had the advantage of having end diaphragm type abutments near its shorter columns. Also, this structure did not have the large disparity in the heights of the columns as seen in the other connectors in the interchange.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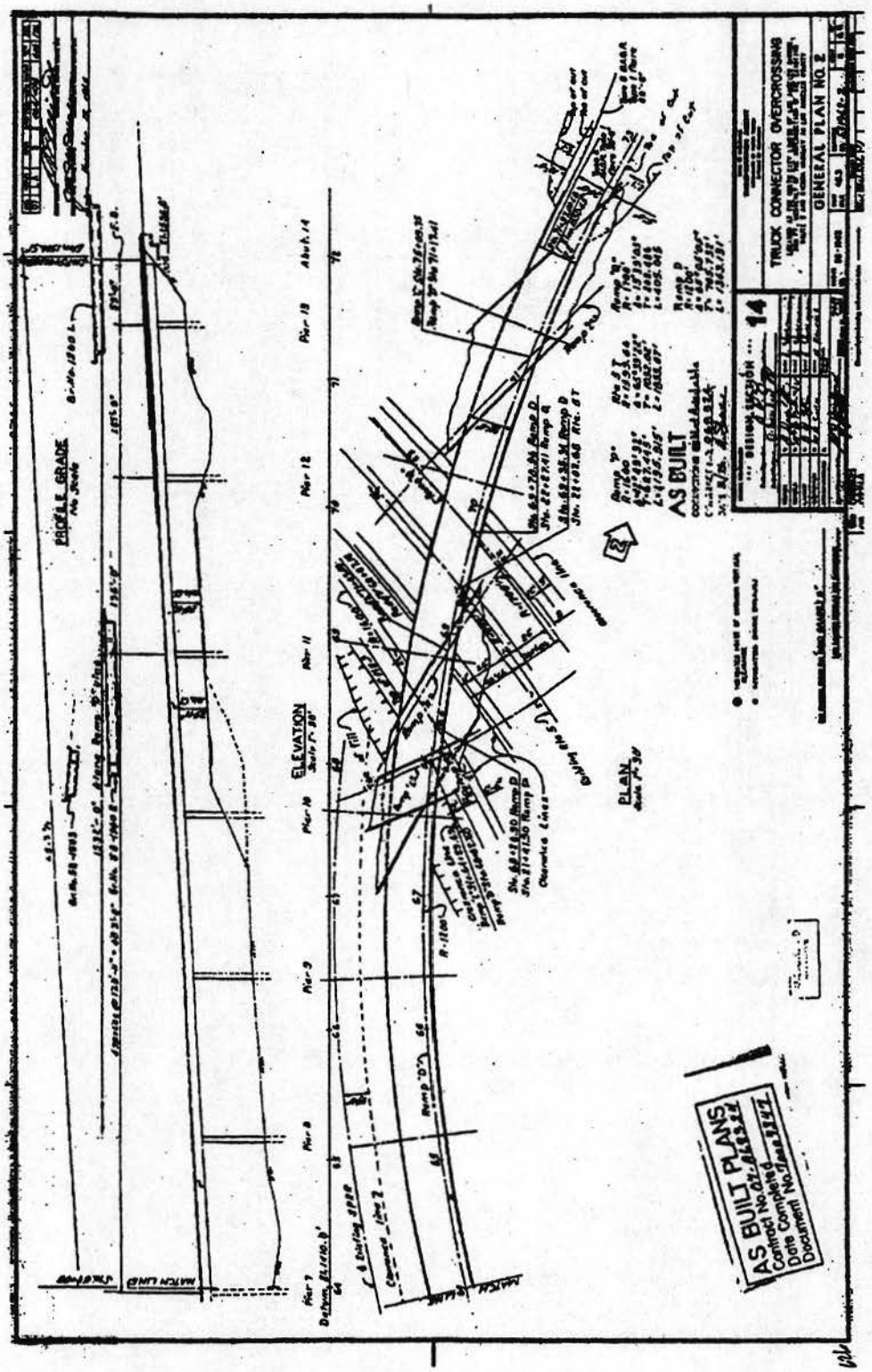
GENERAL PLAN NO.1
TRUCK CONNECTOR OVERCROSSING
PROFILE GRADE
ELEVATION
PLAN
TYPICAL SECTION


PROFILE GRADE
ELEVATION
PLAN
AS BUILT
TRUCK CONNECTOR OVERCROSSING
GENERAL PLAN NO. 2
AS BUILT PLANS
Contract No.
Date Completed
Document No.

Wendy Drive OC 52-0266 07-Ven-101-7.89

Description of Structure

Wendy Drive Overcrossing is located on Route 101 in Ventura County and is the only bridge investigated outside of Los Angeles County. The bridge is approximately 288 feet in length, 80 feet wide and has two spans 156.5 feet and 131.5 feet. It was designed in 1966 and built in 1967.

The superstructure consists of welded plate girders, composite for live load with a reinforced concrete top slab. The girders are continuous over bent 2. The skew is 12°. The structure depth is 7'-6". The steel girders sit on concrete pedestals with bolted down elastomeric pads at the abutments and sit on bolted down elastomeric pads at the bent . The girders have intermediate cross framing and lateral bracing.

The bent is a R/C fixed frame with four 3' x 4' rectangular columns on spread footings. The column reinforcing is lap spliced to the footing and has #4 @ 12 transverse reinforcement. The spread footings only have a bottom mat of steel, no top mat or shear reinforcement.

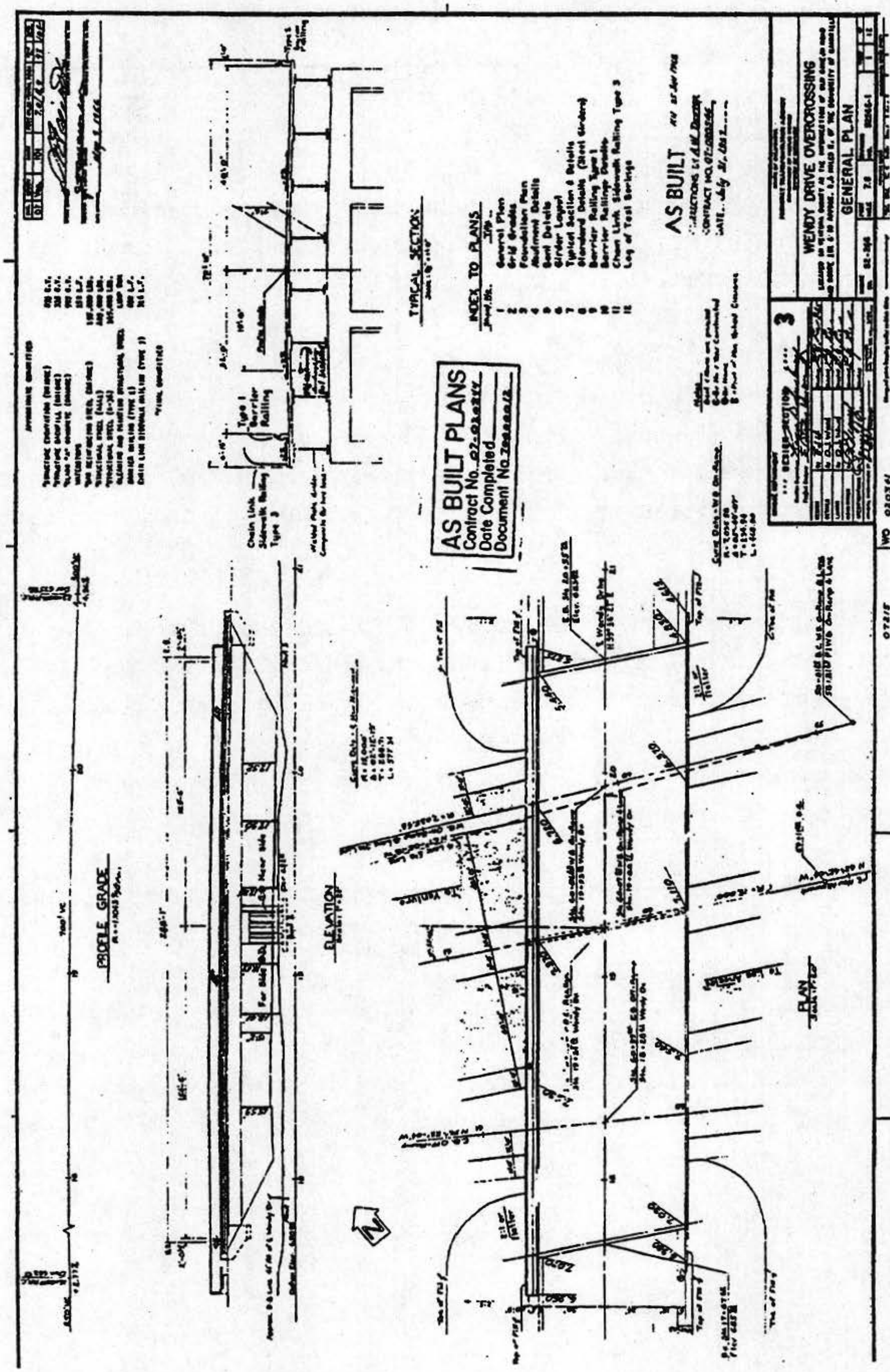
The abutments also have a spread footing foundation.

Description of Damage

There was minor spalling of a concrete deck fillet near bent 2.

Analysis of Damage

This structure performed well.


PROFILE GRADE
ELEVATION
PLAN
TYPICAL SECTION
INDEX TO PLANS
AS BUILT PLANS
AS BUILT
WENDY DRIVE OVERCROSSING
GENERAL PLAN

Las Virgenes Road OC 53-1442 07-LA-101-31.05

Description of Structure

Las Virgenes Road Overcrossing is located on Route 101. It is a four span bridge approximately 228 feet in length and 101 feet wide with a skew of 42°. The bridge was designed in 1961, built in 1962, and widened in 1975.

The superstructure is welded steel plate girders simply supported at spans 1 and 4, and continuous over bent 3 for spans 2 and 3. The RC top slab is made composite with girders using shear studs. The structure depth is 5'-0". There is a longitudinal joint between the original bridge and the main widening. The girders tie into a concrete end diaphragm at the abutments and have steel intermediate diaphragms and end diaphragms along the length of the bridge.

The bents are multi-column, RC, fixed frame with 3' x 4' and 3' x 5' rectangular columns. The columns are fixed at the base as well as at the top. The column transverse steel is #5 @ 6 in the plastic hinge zones and #5 @ 12 in the middle length of the column. The main column reinforcement runs continuous into conventional pile cap footings with main reinforcement only in the bottom of the footing. The footings have 45 ton, driven concrete piles. The bent cap holds the steel girders with either fixed bearings and/or expansion rocker bearings.

The abutments are end diaphragm-type on a single row of concrete piles alternating vertical and battered.

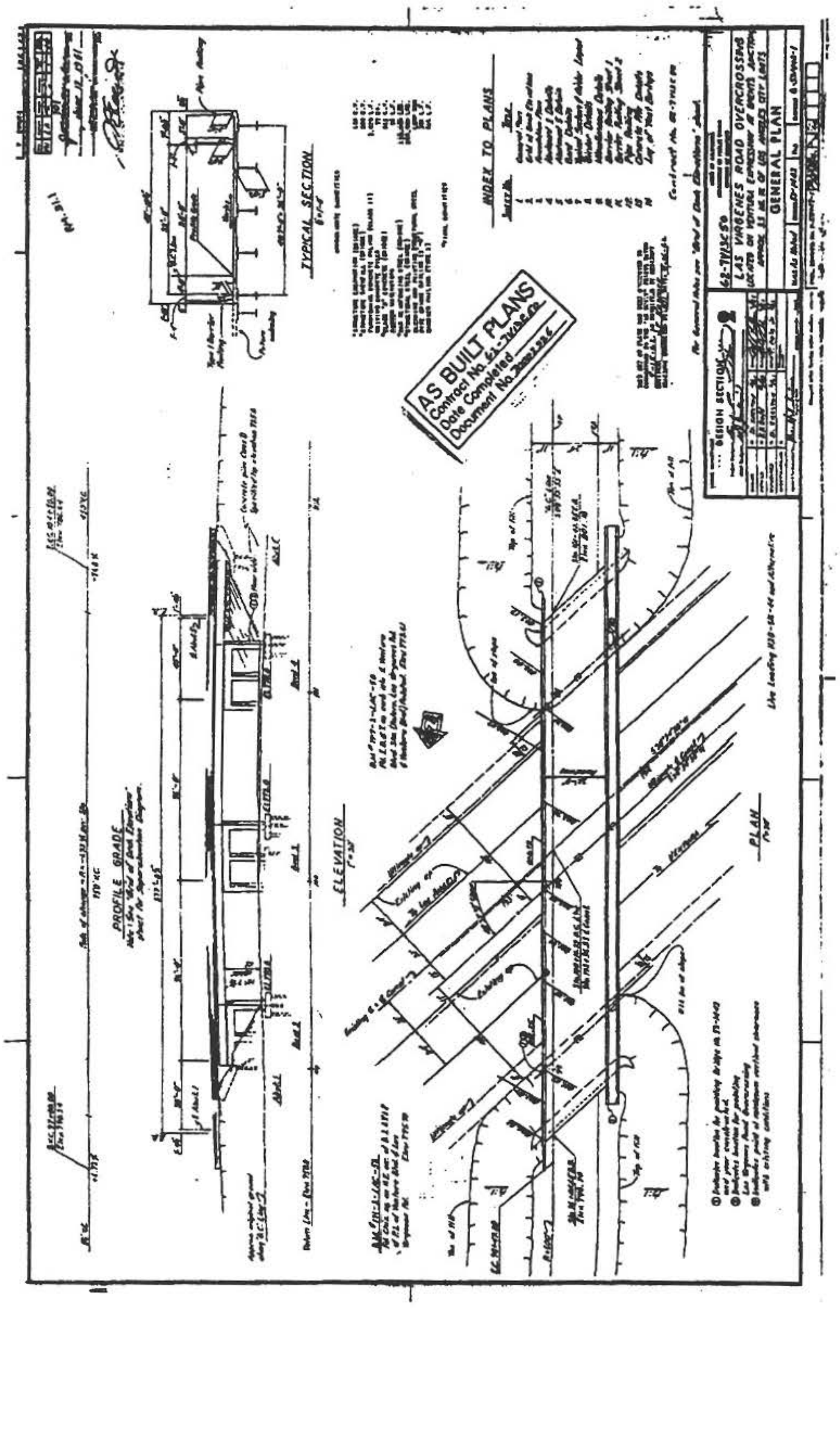
This bridge was retrofitted with cable anchors for longitudinal movement and keeper units for transverse movement in 1984. Four cable anchors were placed in span 2 near bent 2 and span 3 near bent 4. Eight cable anchors were placed either side of bent 3. Five keeper units were placed near Bents 2 and 4 in between the cable anchors. This work was done under a Phase I contract.

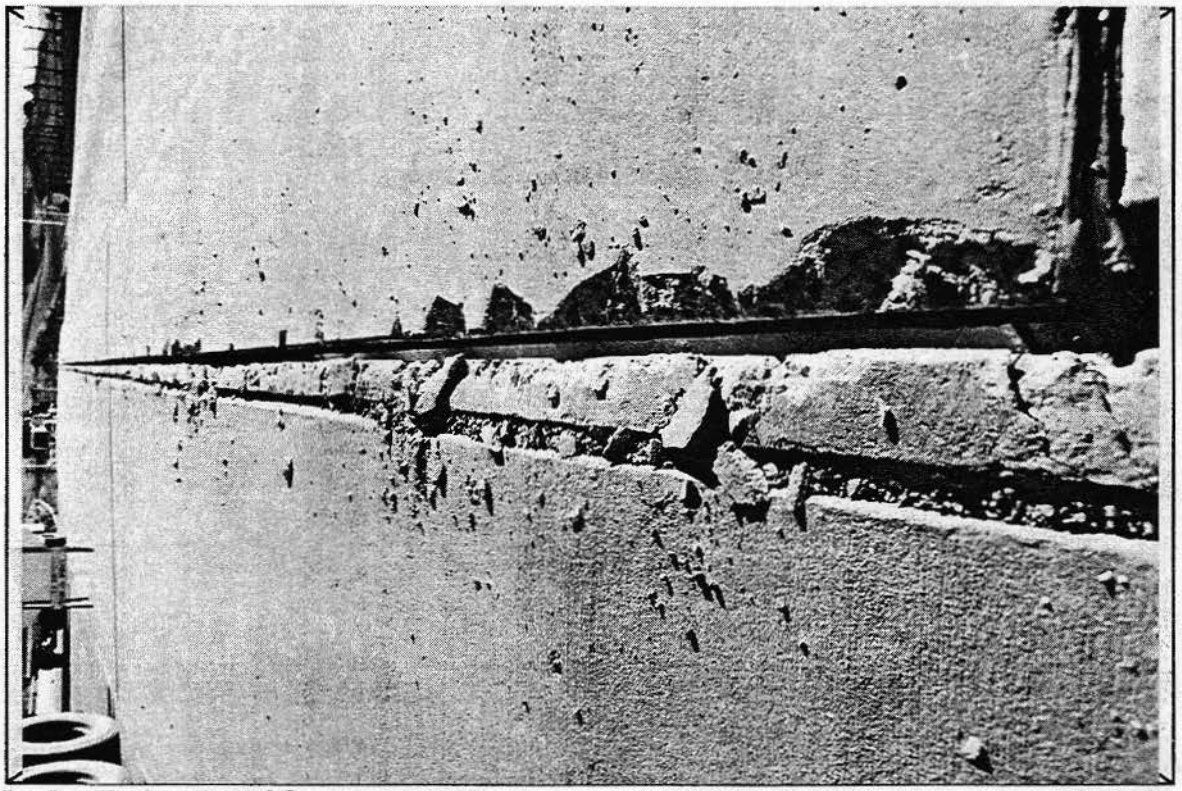
Description of Damage

There was evidence of structure banging between the two structures along the longitudinal deck gap. At various locations along this gap, concrete had spalled. Approach slabs at both ends of the structures had settled approximately six inches.

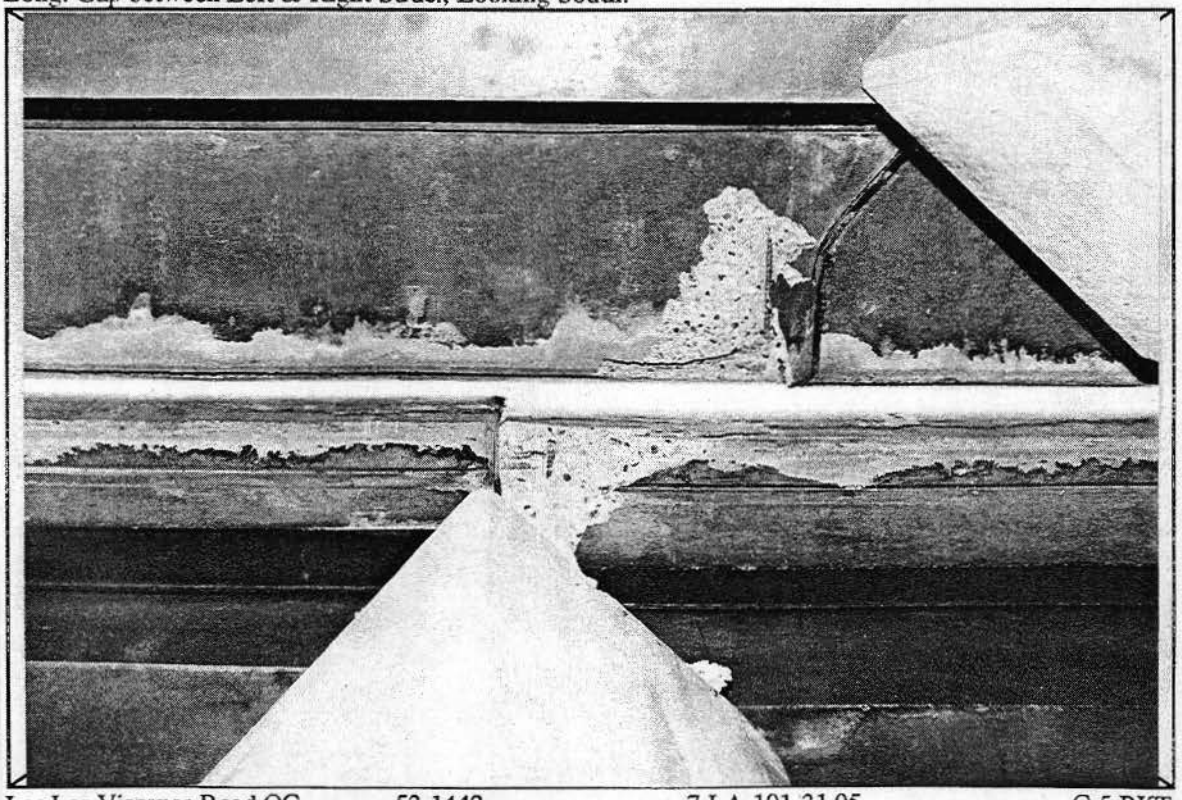
Analysis of Damage

The banging between the left and right structures was due to transverse movement of the bridge. It is difficult to say that the settlement of the approach was due to transverse or longitudinal movement.


AS BUILT PLANS
TYPICAL SECTION
INDEX TO PLANS
PROFILE GRADE
ELEVATION
PLAN
DESIGN SECTION
LAS VIRGENES ROAD OVERCROSSING
GENERAL PLAN



Las Las Virgenes Road OC 53-1442 7-LA-101-31.05 G-1-BKT
Long. Gap between Left & Right Struc., Looking South.



Las Las Virgenes Road OC 53-1442 7-LA-101-31.05 G-5-BKT
Spalling at longitudinal gap between structures near bent 4, looking up.

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Hayvenhurst Avenue UC 53-2204 07-LA-118-R8.34

Description of Structure

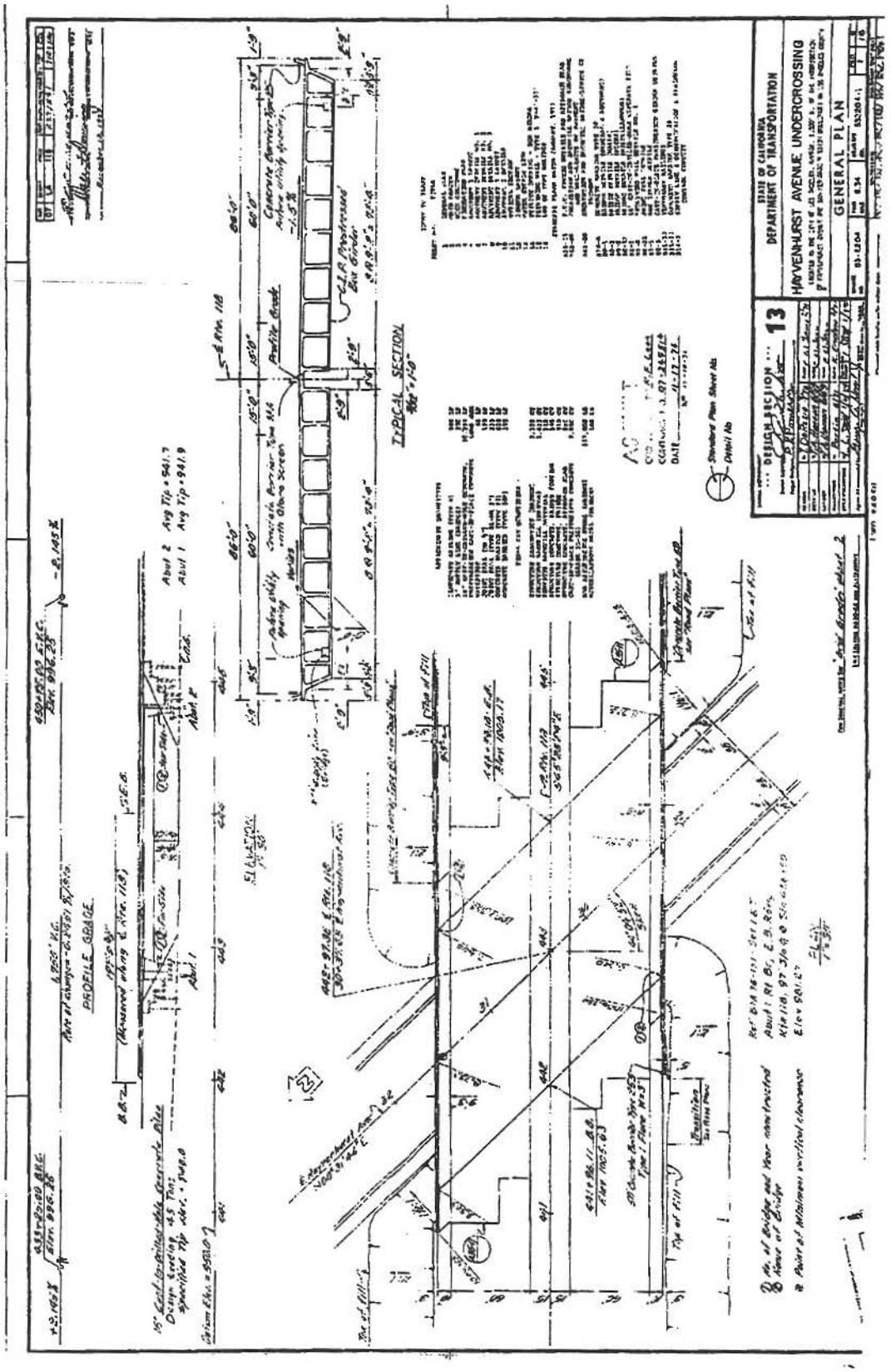
Hayvenhurst Avenue Undercrossing is on Route 118. It is a 199 foot long simple span bridge with 172 feet width. It was designed in 1973 and built in 1976. The superstructure is a CIP P/S box girder with structure depth of 8'-0". The skew is 44°. The abutments are seat type on 16" diameter CIDH concrete piles. The wingwalls are also on 16" diameter CIDH concrete piles.

Description of Damage

This bridge suffered only minor damage. On the north bridge, the longitudinal separation at abutment 1 is about 4 inches with a transverse offset of 2 to 3 inches. Abutment 2 shows a transverse movement to the south of about 1 inch. For the south bridge, abutment 2 has some minor spalling between the approach and the abutment. There is also a separation longitudinally of about 6 inches and some very minor cracking at this abutment. The approaches have settled slightly. This structure has rotated clockwise about 1 inch, looking in plan.

Analysis of Damage

This structure performed well.


HAVENHURST AVENUE UNDERCROSSING
GENERAL PLAN
TYPICAL SECTION
PROFILE GRADE
DEPARTMENT OF TRANSPORTATION
13

Woodley Avenue UC 53-2207 07-LA-118-R9.04

Description of Structure

Woodley Avenue Undercrossing is on Route 118. It is a 193 foot simple span bridge with a width of 172 feet. It was designed in 1973 and built in 1976.

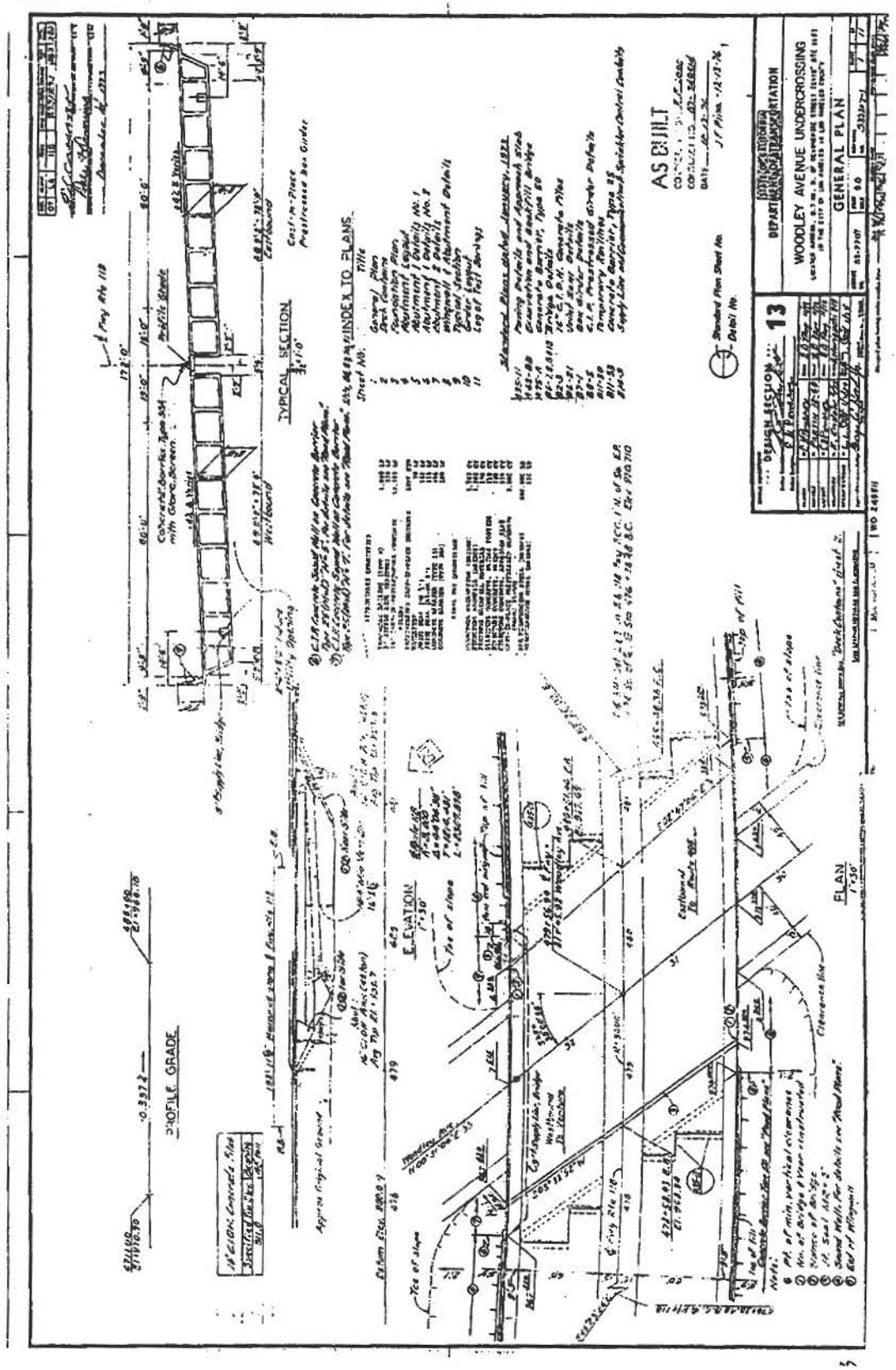
The superstructure is a CIP P/S box girder with a structure depth of 8'-0". The skew is 38°. The abutments are seat type on 16" diameter CIDH concrete piles with elastomeric bearing pads.

Description of Damage

This bridge suffered only minor damage. The south bridge has some minor cracking and spalling at abutment 1 with a transverse movement of 1 inch to the north. At the north end of abutment 2, south bridge, there is some minor spalling of concrete starting at the soffit and continuing down to the slope paving. There is approximately 4 inches of longitudinal separation between the approach and abutment 2. The north bridge suffered the same damage as the south bridge, only to a lesser degree. The overall structure has rotated clockwise about 1 inch, looking in plan.

Analysis of Damage

This bridge performed very well.


AS BUILT
WOODLEY AVENUE UNDERCROSSING
GENERAL PLAN
TYPICAL SECTION
PROFILE GRADE
ELEVATION
PLAN

San Fernando Road OH 53-2095 07-LA-118-R12.40

Description of Structure

San Fernando Road Overhead is located in the city of Los Angeles just outside the San Fernando city limit on Route 118. The structure consists of two bridges approximately 254 feet in length. The left bridge is 25 feet wide and the right bridge is 155 feet wide. They are connected by a 9 inch concrete slab. They were designed in 1975 and built in 1976.

The superstructure consists of a RC box girder with a longitudinal joint in the center of the right bridge. The structure depth for both bridges is 7'-0".

The structure consists of multi-column, RC, fixed frame bents on the right bridge and single column bents on the left bridge. The columns are 4' octagons with a one-way flare transitioning to a 4' x 12' rectangle over a 12 foot length. The main longitudinal bars form the flare in all columns. Transverse reinforcement is #4 spiral @ 3 1/2 in the octagonal section and #4 @ 12 ties in the flared section. All columns are on spread footing foundations. The left structure has fixed footing connections and the right structure has pinned footing connections. All footings have top and bottom mats of steel and shear reinforcement.

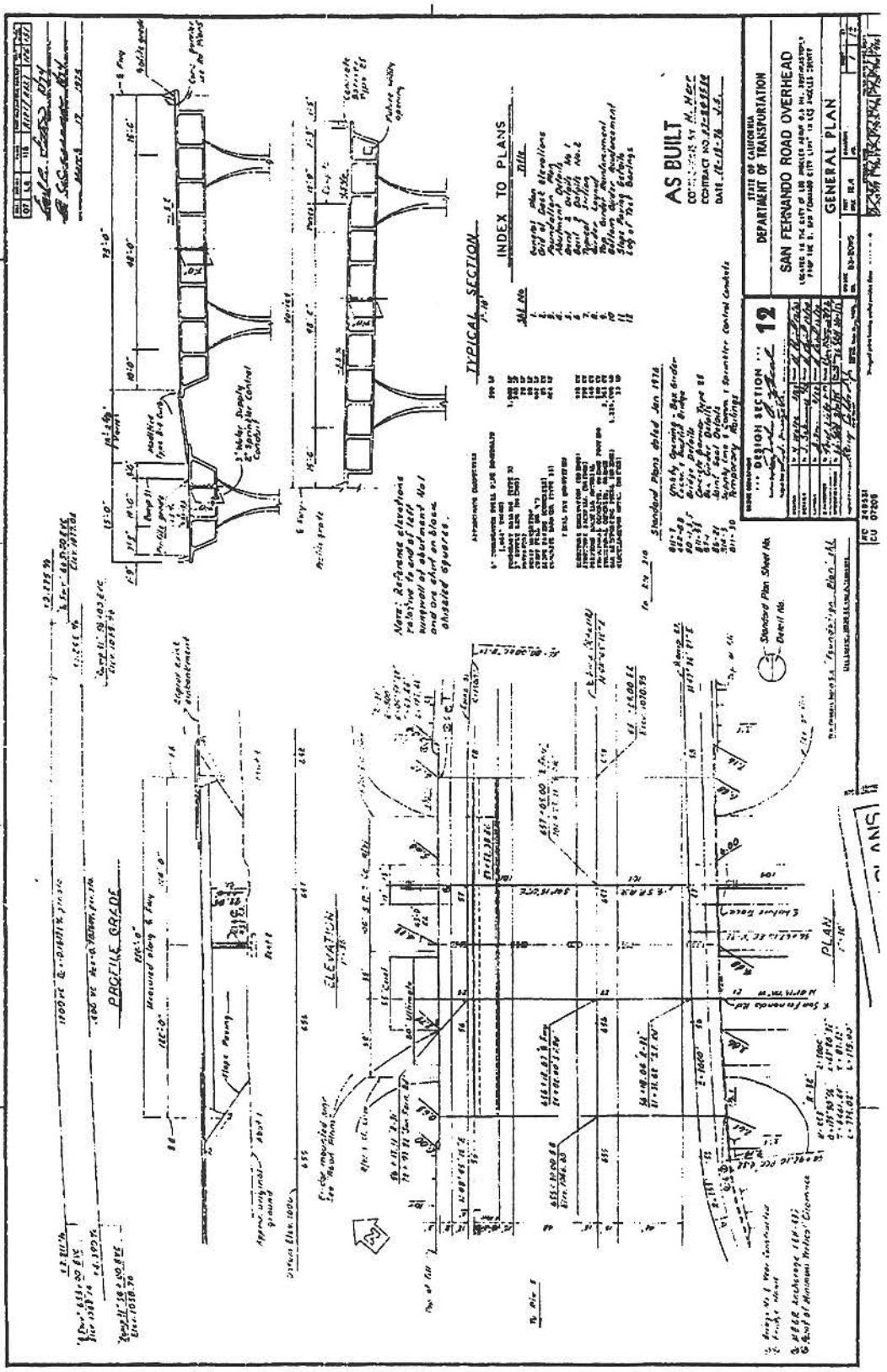
The abutments are end-diaphragm type on spread footing.

Description of Damage

This bridge sustained minor damage. Abutment 3 has minor spalling along the soffit parallel with the abutment face approximately 3 to 3 1/2 inches deep. The southern portion of abutment 3 appears to have taken most of the movement. Bent 2 and abutment 1 are both in good condition with no damage.

Analysis of Damage

These bridges performed well.


DEPARTMENT OF TRANSPORTATION
SAN FERNANDO ROAD OVERHEAD
GENERAL PLAN
AS BUILT
INDEX TO PLANS
TYPICAL SECTION
PROFILE GRADE
ELEVATION
PLAN

Southwest Connector OC 53-1989F 07-LA-210/5-R.06/R43.99

Description of Structure

This bridge was originally constructed prior to the 1971 San Fernando earthquake and was removed as a result of the earthquake. The rebuild of the current bridge incorporated new seismic details. The length of bridge is approximately 785 feet with a bridge width of 34 feet and 8 spans varying from 61'-7" to 131'-8". It was redesigned in 1974 and built in 1975.

The superstructure is a three-cell RC box girder with structure depth of 6'-6". It is fixed at the top of columns.

The bents are single column, fixed at top and bottom, and are supported by pile footings built over the existing large diameter shafts. The piles are both 16" diameter, CIDH, concrete piles and driven steel piles. The columns are oblong octagonal with #18 main longitudinal reinforcement and #4 spiral @ 3 1/2.

The abutments are seat type on existing concrete piles.

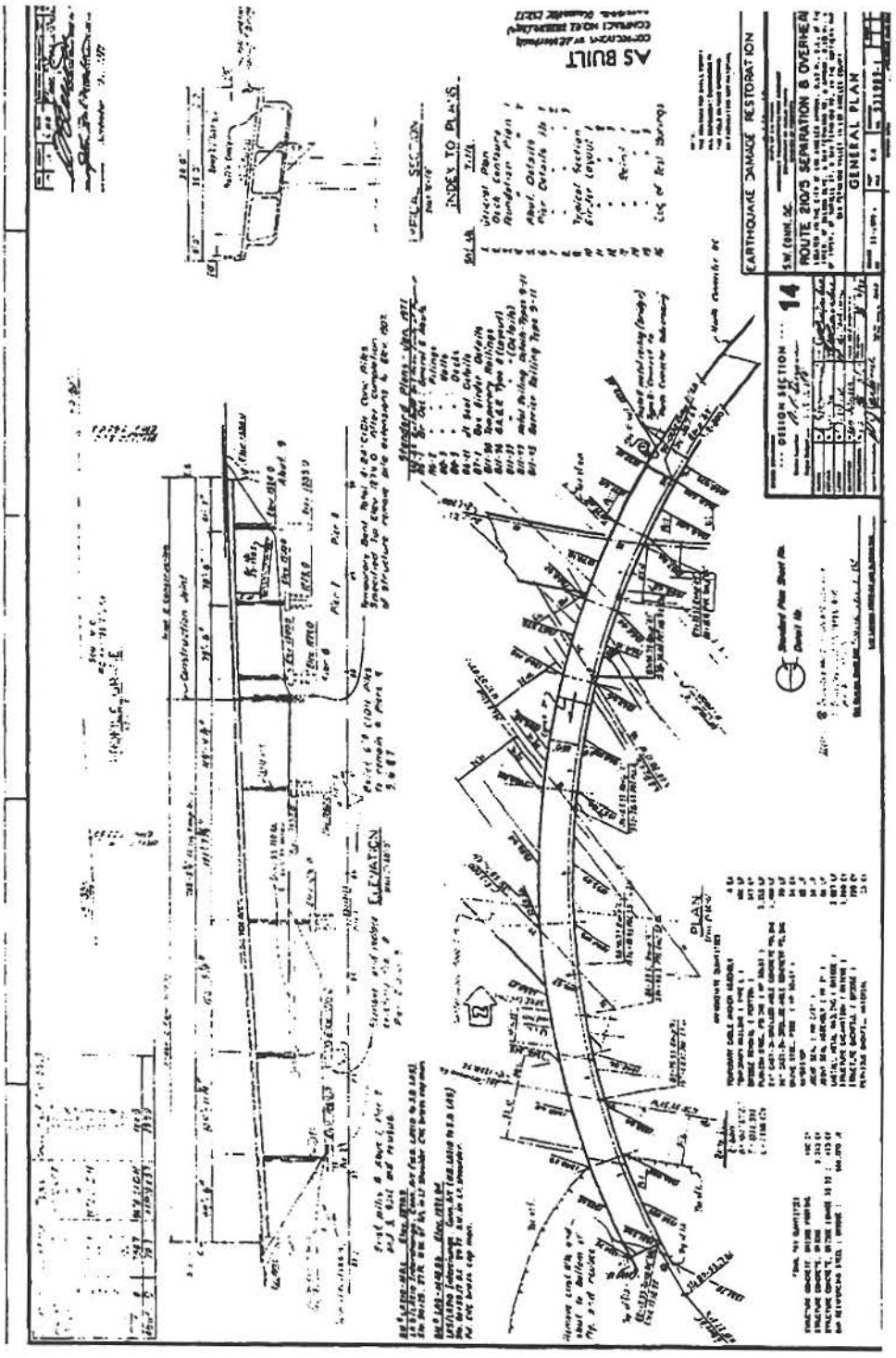
The detail changes made between pre-1971 and post-1971 were: the elimination of hinges in the superstructure, changing the column main longitudinal reinforcement from #18 with 6' embedment length to #18 with approximately 6'-0" embedment plus a hook, changing the column transverse reinforcement from #4 ties @ 12 to #4 spiral @ 3 1/2, and the column supports went from large diameter shafts to conventional pile footings.

Description of Damage

This bridge suffered minor damage. The external shear keys failed at abutment 9 and translated 6 inches longitudinally with a 4 inch vertical offset. The soffit near the abutment and at the abutment face sustained moderate spalling, exposing some damaged reinforcement. Some of the columns show minor cracking and slight spalling at the column/soffit connection. At abutment 1 there are shear cracks approximately 1/4 inch wide in the shear keys.

Analysis of Damage

This bridge performed well.


AS BUILT
INDEX TO PLANS
EARTHQUAKE DAMAGE RESTORATION
ROUTE 210/5 SEPARATION & OVERHEAD
GENERAL PLAN
DESIGN SECTION
14
ELEVATION
PLAN

Devonshire UC 53-1500 07-LA-405-46.24

Description of Structure

Devonshire Undercrossing is located in the city of Los Angeles at the intersection of the San Diego freeway (Route 405) and Devonshire Street. The structure is approximately 152 feet in length and 234 feet wide. The original structure was designed in 1962 and built in 1963. A widening on both sides of the structure was designed in 1974 and completed in 1977.

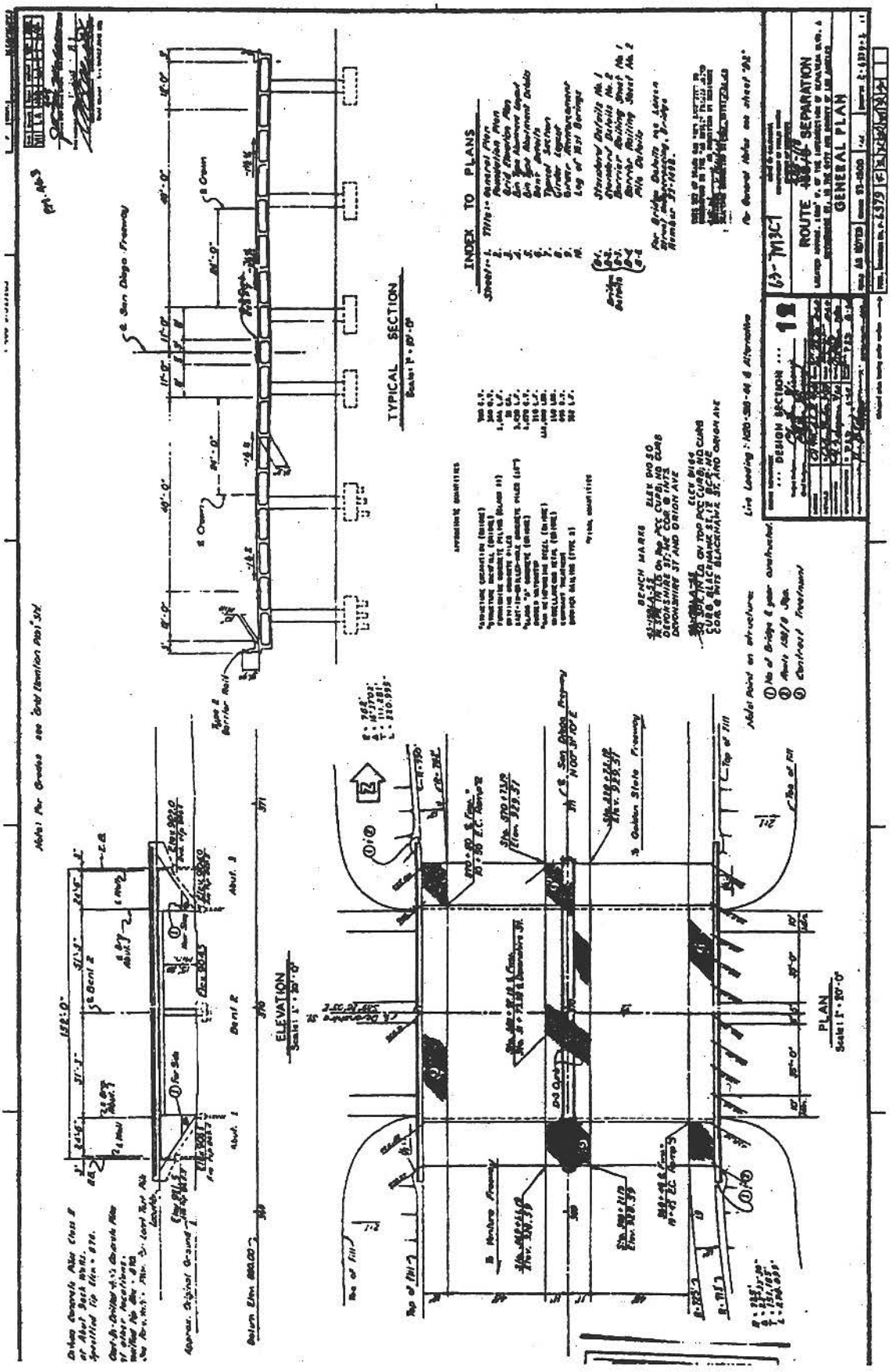
The superstructure is RC box girder for original and widened structures. The skew is negligible. The structure depth is 3'-3" for the original structure and the widened structures vary from 2'-6" to 3'-3". The superstructure sits on elastomeric bearing pads.

The bent is RC multi-column fixed frame with 3' x 4' rectangular columns on pile footings. The original structure bent has lap spliced footing/column connections, and is fixed at the top. The widened bent is fixed at the top and pinned at the bottom. All columns have #4 @ 12 transverse reinforcement. The footings have no top mat of steel or shear reinforcement, only a bottom mat. All piles are 16" diameter CIDH concrete.

The abutments are bin type with a 25'± RC T-beam span with a 4'-0" structure depth. The abutments and the backwalls are also on pile foundation. The abutment seats (original and widened) are on 16" diameter CIDH concrete piles. The original abutment backwalls (diaphragm portion) have Class II driven concrete piles.

Description of Damage

The only apparent damage to this structure was some minor spalling at the top of bent 2 columns on the north face only, near the soffit. No noticeable damage to the soffit. Movement of this structure, therefore, was probably longitudinal in the North/South direction.


INDEX TO PLANS
TYPICAL SECTION
ELEVATION
PLAN
GENERAL PLAN
ROUTE 405/10 SEPARATION
S. San Diego Freeway
S. Golden State Freeway
S. Harbor Freeway

No Damage

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The following structures experienced no apparent damage and/or noticeable movement.

NO DAMAGE

Olympic Avenue OC	53-1044	07-LA-710-23.44
Chatsworth Drive UC	53-1220	07-LA-5-39.92
Route 134/2 Separation	53-1919S	07-LA-2/134-R18.80/R8.92
North Connector Separation	53-1988F	07-LA-210-R0.12
Weldon Canyon OH	53-849	07-LA-5-C45.75
Weldon Canyon OH	53-849K	07-LA-5-C45.76
Weldon Canyon OC	53-996RL	07-LA-5-C45.86
Sierra Hwy UC	53-1936RL	07-LA-14/5-R25.13/C45.74
Sierra Hwy UC	53-1936G	07-LA-14/5-R25.13/C45.74
Sierra Hwy UC	53-1936F	07-LA-14/5-R25.13/C45.74

Note: Some structures located along the routes shown also showed no damage or movement and are not included in the above listing. Refer to the Office of Structure Maintence and Investigation for a complete listing of structures inspected along specific routes.

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Appendices

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Appendix A

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1971 San Fernando Geology Report

The following pages contain a reprint of the extensive geology report included with the 1971 San Fernando Post Earthquake Investigation Report. Many of the same interchanges and routes affected in the 1971 event were also challenged by the Northridge Earthquake on 17 January 1994.

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ENGINEERING GEOLOGY

The San Fernando Valley earthquake of February 9, 1971, had a magnitude of 6.6 on the Richter Scale. The epicenter of the main shock was located north of the San Gabriel Mountains near Soledad Canyon. Major damage to highway structures occurred at the Route 5/14 Interchange, at the Route 5/210 Interchange, and along Routes 5, 14, 210, and 405. These interchanges and structure sites are located within a belt about five miles long, about ten miles southwest of the epicenter. The causative faults are about two miles southeast of the Route 5/210 Interchange and even closer to other structures.

GENERAL GEOLOGY

The area is located within the Transverse Range Geomorphic Province. Weldon Canyon at the eastern extension of the Santa Susanaa Mountains is the site of the Route 5/14 Interchange. Route 14 extends to the east from the interchange. The Route 5/210 Interchange, the Route 210 Freeway and the Route 405 Freeway are located in northwestern San Fernando Valley. The Route 5 Freeway traverses both geographic areas.

Route 14

The damaged area of Route 14 is situated on the extreme western flank of the San Gabriel Mountains. In general the structures are located on late Tertiary rocks of the Towsley, Pico, Saugus and Mint Canyon formations. Rocks of these formations generally consist of well consolidated and sometimes cemented granular sediments. Alluvium is present in the lower portions of canyons and in the Santa Clara River Valley.

Route 14/5 Interchange

This interchange is located on steeply dipping, well consolidated sandstone of the Towsley formation. Alluvium is present locally. Structures are founded in the sandstone with abutment fills present at most approaches.

Route 5 & Route 405

Structures on Route 5 and 405 are located on late Tertiary rocks of the Towsley, Pico and Saugus formations and on unconsolidated Recent alluvium. The formational materials consist of poorly to well consolidated granular sediments. Some of the sediments show various degrees of cementation.

Route 5/210 Interchange

The interchange is situated on consolidated coarse granular sediments of the Saugus formation (Sunshine Ranch member) overlain by alluvium with fairly low relative density. Ground water is about 30 to 40 feet below the ground surface in the alluvial material.

Route 210

Foothill Freeway (Route 210) structures are located at the northern margin of the San Fernando Valley at the base of the San Gabriel Mountains. Granular alluvia soils vary in density from loose to very dense. Goundwater is not present at any of the sites.

STRUCTURE GEOLOGY

Thick sections of late Cenozoic rocks in the Santa Susana Mountains have been thrust southward in geologic time along the east-west trending Santa Susana fault. The fault crosses Interstate 5 near the Balboa Blvd. O.C. The zone continues easterly as a series of high-angle faults near the southern base of the San Gabriel Mountains. In the past, the San Gabriel have been thrust southward over the northern margin of the San Fernando basin along these faults.

The major fault near the area, and the one which was originally attributed to the earthquake, is the San Gabriel fault; a feature which is about 90 miles long.

Surface Tectonic Features

Geologists and seismologists investigating the earthquake have mapped primary tectonic features. These features which are several miles long consist of a series of related but discontinuous east-west trending fault segments located near the northerly margin of the San Fernando Valley. The Sylmar segment intersects the Interstate 210 Freeway just north of the McClay Street Separation. Vertical movement on the order of four feet, and horizontal movement on the order of three feet has been reported.

Route 5/405 Interchange

Fracture zones in the area of this Interchange are of two distinct types. An extension of the Sylmar fault segment crosses the I-5 and I-405 Freeways in this area. The Route 5 (Truck Lane)/405 Separation, Southbound Truck Ramp is located within a few hundred feet of the fault. The rupture is distinct and horizontal displacement was several inches.

Thrusting to the southwest of three to four inches was noted on the fault in consolidated sediments of the Sunshine Ranch member (Saugus formation). Secondary tectonic movement caused damage to the freeway, to embankments, and to fills. Contacts between cuts and fills were, in many locations, areas of rupturing and compressional movement. Ground failure was evident in soils adjacent to the freeway.

Route 5/210 Interchange

Numerous indications of surface movement were located a few hundred feet south of the interchange in unconsolidated alluvium. Several offsets in the pavement and on slopes were present in the site area. The major zone of movement has a bearing of N55° E and extends from west of the I-5 freeway to east of San Fernando Road and the railroad tracks. Compressional ridges were evident in the freeway which also was offset about three feet. A portion of this offset may be due to fill displacement. There were many cracks in the fields and furrows were offset. San Fernando Road was offset about one foot. The railroad rails were bent and shifted.

The zone of disturbance then continued through the Juvenile Hall. Sand boils indicated that liquefaction occurred.

Route 5, (North of Route 5/210 Interchange), the Route 5/14 Interchange, and Route 14

Primary tectonic movement was not noted at bridge sites at these locations. Secondary movement in natural ground was minor. Most of the surface cracking and movement was confined to embankments and this was principally in the Route 5 area between the 5/210 and 5/14 Interchanges.

Route 210

Except where the Sylmar Fault segment crosses the freeway near McClay Street and the displacement near Astoria, movement at structure sites in this area consisted mostly of fill settlement and displacement.

GEOLOGIC AND SEISMIC FACTORS AFFECTING BRIDGE DAMAGE

Structural damage can be related to several geologic and seismic factors. The San Fernando Valley earthquake had a Richter magnitude of 6.6, a so called moderate earthquake. It should be noted here that magnitude does not give an indication of ground response. Horizontal ground accelerations recorded near the Route 5/210 Interchange were on the order of 0.6 g (H. B. Seed, Panel Discussion March 16, 1971).

The horizontal ground acceleration measured at Pacoima Dam (a few miles northeast of the area) was the highest ever recorded for any earthquake anywhere. Accelerations as high may have occurred in previous earthquakes, but this is the first time a record has been obtained. The accelogram (from Cal-Tech) indicated a maximum horizontal acceleration of 1.0 g with an average of 0.5 to 0.6 g. The vertical acceleration at this location exceeded 0.5 g. Ground motion has been reported to have lasted for about one minute in the area of the affected bridges. Structures were probably shaken not only by direct earthquake waves but also by reflected and

refracted waves. Damage to bridges, utilities, roads, etc., indicated intensities as high as IX or X on the modified Mercalli Scale of 1931.

Surface geologic features and boring information give a good indication of subsurface conditions at the various structure locations. These conditions are related to the degree of ground movement and the resulting structural movement. Structures located on unconsolidated material were subject to more severe ground movement than those located on consolidated or formation material. Actually the situation is quite complex because foundation type, depth and type of unconsolidated deposits, degree of consolidation, depth to ground water, and distance from the epicenter also must be taken into consideration. Ground movements caused distress in approach fills which in turn effected structural performance.

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DAMAGE REPORT

Jan. 17, 1994 Northridge Earthquake

Pat Hipley

Summary of damage to bridge instrumented for strong motion at the
Southwest Connector OC (Br. # 53-1630G)
I-10/405 Interchange

Strong motion instruments were placed at the I-10/405 Interchange a few months prior to the Northridge Earthquake. Three sensors were placed at Abutment 11 on the edge of the superstructure near the diaphragm. Two sets of horizontal sensors were placed at bent 9, one set on the edge of the superstructure and the other set at the ground level of the column. (see attached sketch) The two sensors at the ground level of bent 9 and the bent 9 longitudinal superstructure sensor gave data for about 6 seconds then went off line. This may be due to the severe shaking the recorders were subjected to at the abutment. Data for the working sensors is attached. Note the exceptionally large vertical accelerations. Records from aftershocks have all channels working.

DAMAGE

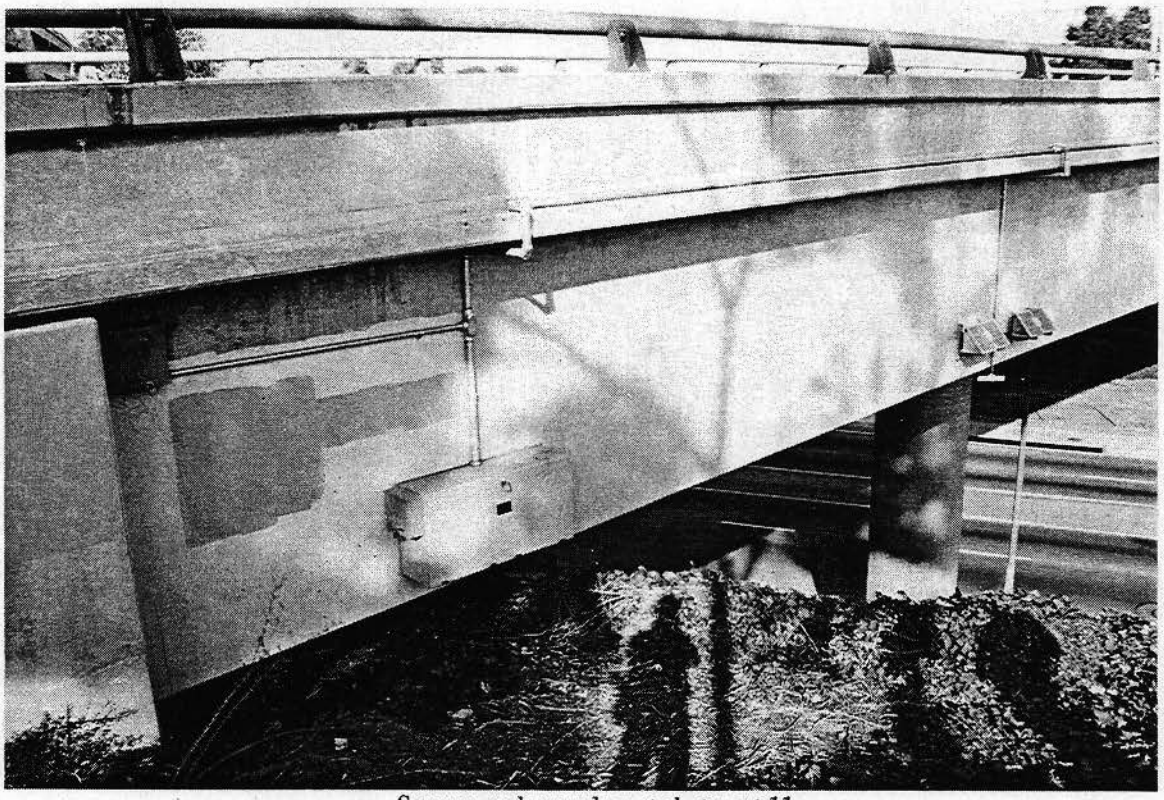
Many of abutment 1 rocker bar keeper bolts (1 in. dia.) sheared and the bars were displaced up to 4 inches. One rocker bar fell over. Some of the supplementary catcher blocks had been engaged and had some spalling. The north return wall had moment cracking and spalling due to being engaged at the superstructure level during transverse displacement. The south edge of the superstructures' diaphragm had some minor spalling. There was indications of movement around 3" transversely.

The columns showed no obvious signs of movement at the ground level with the exception of bent 6 (Shortest column) in the middle of route 10 in which both barrier rails were displaced about one inch away from the column. The rails were cracked slightly. The designed gap was about one inch, so this indicated a transverse movement back and forth of about 2" for this column at the route 10 roadway elevation. I think the retrofitted columns (steel shells) and

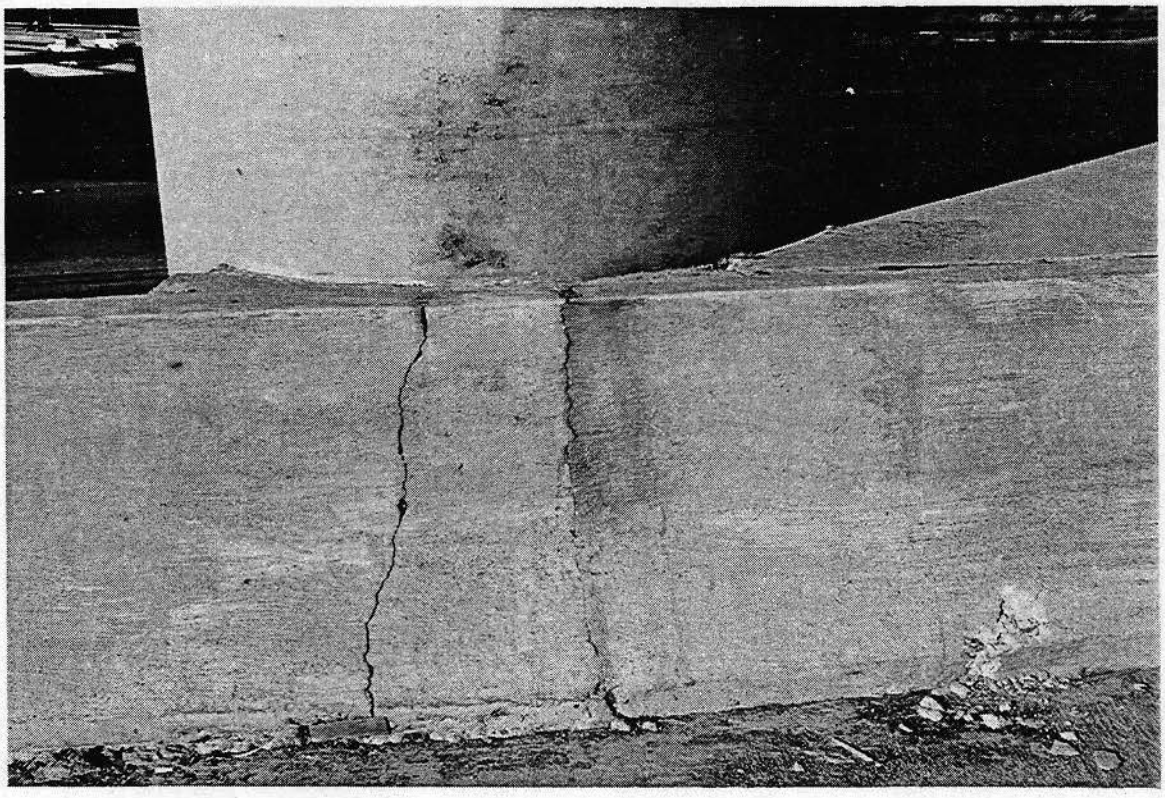
footing work held so well (stiff base) the center of flexing was near the ground level and this may be why no heaving of the soil took place around the columns.

Abutment 11 had a more orderly displacement of the rocker bars. All the bars sheared the keeper bolts and moved roughly 3" to the south and 3" towards the backwall. The bars all rotated clockwise from 30 to 45 degrees. The catcher blocks were not engaged. The most southern rocker bar fell back and now rests on the lower bearing plates' anchor bolt. This caused the south side of the diaphragm to drop down about 1". The backwall was cracked up in this area at the road level.
In my opinion, this retrofit performed excellently through a very violent ground shaking and experienced only minor damage.

The Colton Interchange (Br. No. 54-823G) and the Vincent Thomas (Long Beach) Br. No. 53-1471 have complete main shock records with readings as high as .47g and .65g respectively.



Sensors and recorders at abutment 11.



Cracked barrier rail next to bent 6 comlumn.

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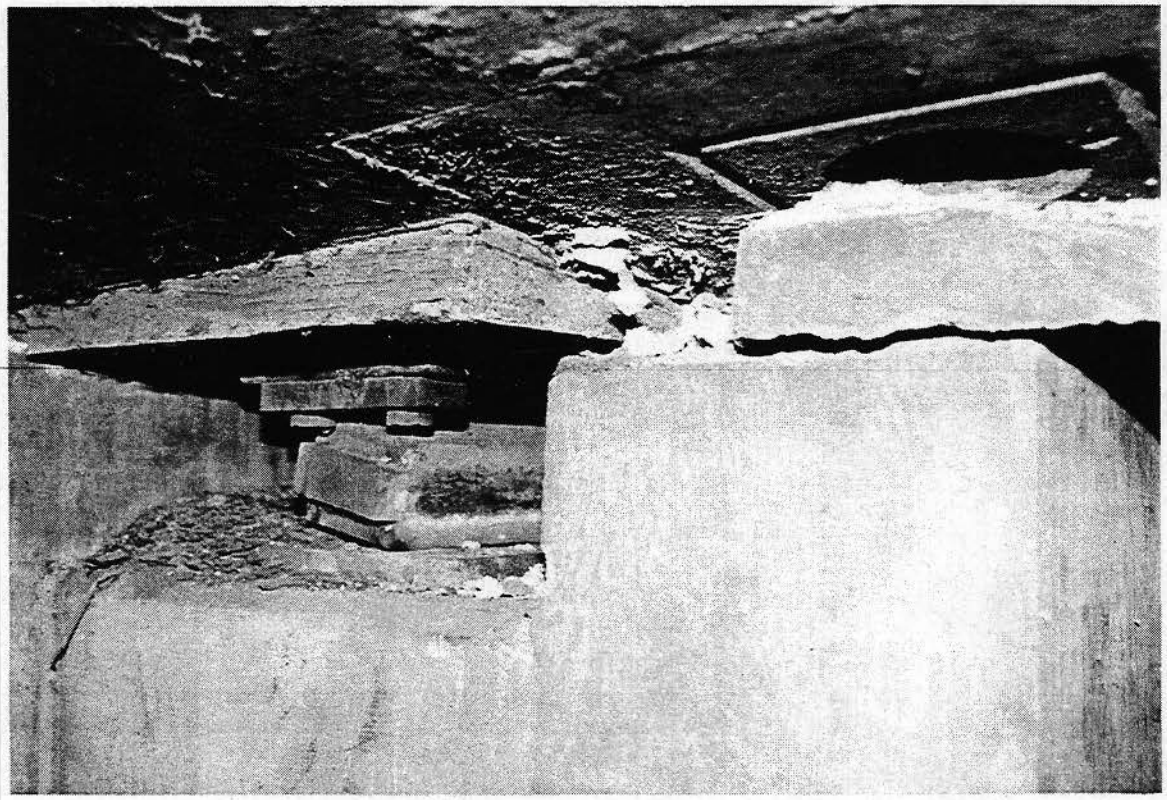
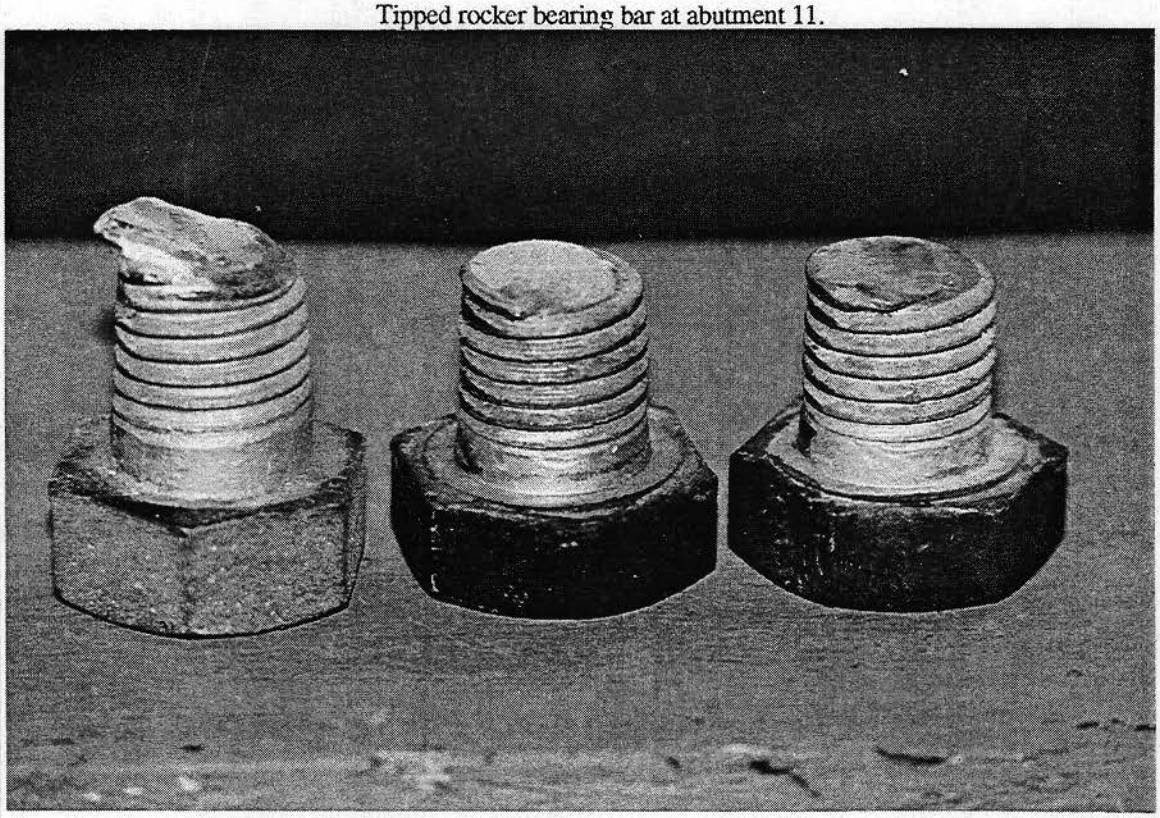


Tipped rocker bearing bar at abutment 11.



Sheared 1 inch diameter bolts from abutment 11.

Appendix C

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STRUCTURES MAINTENANCE DAMAGE SUMMARY

The following pages contain a reprint of the Office of Structure Maintenance and Investigation's damage summary. It contains a listing of all of the structures damaged in the Northridge Earthquake and a brief summary of the damage and/or status of each structure.

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SORTED BY CO-RTE-PM

CO	RTE	PM	BRIDGE NAME	BR NO	COMMENTS
LA	1	36.25	MONTANA AV POC	53-2602	Possible hinge damage.
LA	1	39.62	CASTELMARE POC	53-0068	Minor spall at east abutment seat.
LA	2	R018.81	NE CONNECTR OC	53-1921F	Shear keys cracked and spalled. One hinge diaphragm damaged.
LA	5	17.21	HOLLENBECK LAK	53-1359R	A1 bearing keeper plate bolts sheared.
LA	5	17.21	HOLLENBECK LAK	53-1359L	Minor edge of deck spall.
LA	5	18.38	S CONNECTOR UC	53-1316	Minor cracks at exterior shear keys at both abutments.
LA	5	18.52	ECHANDIA OH	53-1333	Sheared keeper plate bolts at abutment 1. Minor spalls at abut 1 rails.
LA	5	18.53	ECHANDIA OH	53-1332F	Crack at abutment 9 curtain wall. Minor spall at abut 1 left rail.
LA	5	18.62	MISSION RD R U	53-1317F	Sheared keeper plate bolts at abutment 1. Spalls at abutment 1 backwall.
LA	5	18.78	MISSION RD UC	53-1312	Broken 2" utility pipe supports. Wingwall separated from abutment.
LA	5	18.96	ALHAMBRA AV OH	53-0368	Spalls under three girders at abutment 5.
LA	5	20.31	ELYSIAN VIAD	53-1424	Spalls at columns 3 and 4 at bent4. Minor soffit and shear key spalls.
LA	5	23.66	GLENDALE BV OC	53-1068	Possible bearing damage. Minor sidewalk spalls.
LA	5	24.61	GRFTH PK OR OC	53-1181S	Joint seal (Type A) damage at hinge in span 3.
LA	5	29.16	OLIVE AVE OC	53-1087	Minor spalling at bent joints. Need joint seals.
LA	5	29.39	MAGNOLIA BV OC	53-1088	Minor spall beneath bearing at pier cap.
LA	5	34.65	TUXFORD ST UC	53-1117	Sheared keeper plate bolts and curtain wall cracks at abutment 3.
LA	5	35.01	LANKERSHIM PP	53-1118W	Hairline cracks in backwalls.
LA	5	36.34	SHARP AVE ONRP OC	53-1222K	Keeper plate anchor bolts sheared. Minor spalls on restrainer outrigger.
LA	5	38.5	VAN NYS BL UC	53-1126	Abutment 2 embankment washed out due to broken water line.
LA	5	39.19	PACOIMA WASH	53-1128	Columns damaged. Shored.
LA	5	39.26	PACOIMA WASH	53-2346F	Minor spalling at abutment 1.
LA	5	39.30	SOEAST CONN OC	53-2327F	Moderate damage at abutments. Damage at hinge brgs and restrainers.
LA	5	39.31	SOWEST CONN OC	53-2329G	Moderate abutment damage. Shear cracking at B2. Hinge bearing and restrainer damage.

SORTED BY CO-RTE-PM

CO	RTE	PM	BRIDGE NAME	BR NO	COMMENTS
LA	5	39.36	NE CONN OC	53-2330F	Hinge restrainer and bearing pad damage. Deck spalls at abutment joints.
LA	5	39.98	BRAND BLVD UC	53-1130	Shear cracks and spalling in external shear keys at bents 2 & 5.
LA	5	40.46	RINALDI ST UC	53-1132	Shear cracks and spalling in external shear keys atabutment 1.
LA	5	41.55	RTE 5T/405 SEP	53-1548	Minor cracks at two columns.
LA	5	41.57	RTE 5/405 SEP	53-1133	Minor cracks in wingwall at abutment1.
LA	5	42.65	ROXFORD ST UC	53-1115	Minor cracks at curtain wall and shear key. Minor approach settlement.
LA	5	R043.83	SAN FERN RD OH	53-1990G	Approach slab damage. Joint seal damaged.
LA	5	R043.84	SAN FERN RD OH	53-0730	Damage at all abutment shear keys. Minor top of column fractures.
LA	5	R044.01	RTE 210/5 SEP	53-1985F	Abutment shear keys damaged. Spalls at deck joints.
LA	5	R044.43	BALBOA BV OC	53-1986	Minor column damage. Approach slab buckled.
LA	5	R044.87	W SYLMAR OH	53-1984L	Abutment and shear key damage. Spalling at expansion joints.
LA	5	R044.87	W SYLMAR OH	53-1984R	Abutment and shear key damage. Spalling at hinges.
LA	5	C045.49	SIERRA HWY SEP	53-0848	Bearing pedestal and shear key failure. Crack at deck closure pour.
LA	5	R046.58	WELDON CYN OC	53-1796	Minor column cracks.
LA	5	R047.83	GAVIN CANYON U	53-1797L	Partial collapse. Replacement under construction.
LA	5	R047.83	GAVIN CANYON U	53-1797R	Partial collapse. Replacement under construction.
LA	5	R049.03	CALGROVE BV UC	53-1792L	Approach settlement. Slope paving damage.
LA	5	R049.03	CALGROVE BV UC	53-1792R	Approach settlement. Slope paving damage.
LA	5	R050.33	PICO LYONS OC	53-1783	Bearing damage.Cracks in girder web.Restrainer damage.
LA	5	R50.80	BUTTE CANYON	53-0387	Cracks and spalls at abutments. Westerly half of box culvert racked 12".
LA	5	R051.44	MCBEAN PKWY OC	53-2057	Crack in abutment.
LA	5	R052.47	VALENCIA BV OC	53-1815	Major abutment damage.
LA	5	R053.70	SANTA CLARA R	53-0687L	Bearing damage. Spalls at abutments and piers. Restrainer damage.
LA	5	R053.70	SANTA CLARA R	53-0687R	Bearing damage. Spalls at abutments and piers. Restrainer damage.

SORTED BY CO-RTE-PM

CO	RTE	PM	BRIDGE NAME	BR NO	COMMENTS
LA	5	R055.48	RTE 126/5 SEP	53-1626G	Cracks and minor spalling at columns and abutments.
LA	5	R056.12	HONOR RHO R OC	53-1807	Cracks and spalls at abutments and bents. Girder seats cracked.
LA	5	R056.60	HASLEY CYN R O	53-1809	Cracks in columns.
LA	5	R059.49	LK HUGHES R UC	53-1908L	Minor approach settlement.
LA	10	R002.61	14TH STREET OC	53-1596	Sheared keeper plate bolts. Displaced bearings.
LA	10	R002.84	17TH STREET OC	53-1597	Minor spalls and cracks at top of all columns.
LA	10	R003.07	20TH STREET OC	53-1598	Minor damage. 30' LongTransverse AC Crack over N'ly Abut.
LA	10	R003.34	CLOVERFIELD OC	53-1599	Minor spalls at tops of columns. Keeper bolts sheared. Cracked shear key.
LA	10	R004.24	CENTLA-PICO UC	53-1603	Minor cracks at tops of columns. Rail spalls.
LA	10	R005.28	NORTHW CONN OC	53-1627G	Longitudinal displacement of two spans. Restrainer damage. Minor spalls.
LA	10	R005.65	SE CONNECTR OC	53-1637F	Cracks in bent 7 exterior girders. Unknown interior damage.
LA	10	R005.99	COVENTRY PL UC	53-1634	Curtain wall damage.
LA	10	R006.31	NATIONAL BL OC	53-1615	Sheared keeper plate bolts. Cracks in curtain walls. Spalls at columns and rail.
LA	10	R006.40	OVERLAND AV OC	53-1616	Cracks at tops of columns and abutment seat.
LA	10	R007.08	MANNING A R OC	53-1553S	Minor cracks at east abutment diaphragm. Minor edge of deck joint spall.
LA	10	R007.92	ROBERTSON-N UC	53-1557	Sheared keeper plate bolts. Cracked wingwall. Spall at EB gore on deck.
LA	10	R008.83	LA CNG-VEN SEP	53-1609S	Column damage. Shoring required at four bents.
LA	10	R008.83	LA CNG-VEN SEP	53-1609	Partial collapse. Replacement under construction.
LA	10	R009.12	BALLONA CREEK	53-1579	Minor column spalls. Retaining wall displacement. Approach settlement.
LA	10	R009.13	BALLONA CREEK	53-1671K	Crack below soffit at abutment 1 diaphragm. Approach slab settled 5".
LA	10	R009.22	CADILLAC RP SP	53-1485F	Crack in slope paving. Approach settlement.
LA	10	R009.31	FAIRFAX WASH U	53-1580	Partial collapse. Replacement under construction.
LA	10	R009.74	HAUSER BLVD UC	53-1582	Cracks and spalls in B3 wingwalls & curtain walls.
LA	10	R010.12	REDONDO BLD UC	53-1584	Minor damage at pier walls. Sidewalk buckled at four corners.

SORTED BY CO-RTE-PM

CO	RTE	PM	BRIDGE NAME	BR NO	COMMENTS
LA	10	R010.43	LA BREA AVE UC	53-1586	Minor spalls at bent 2 and curtain wall.
LA	10	R10.72	HARCOURT AVE UC	53-1587	Minor crack at bent 3 curtain wall.
LA	10	R011.03	WEST BLVD OC	53-1572	Hairline cracks at tops of columns. Slope paving cracked.
LA	10	R11.39	CRENSHAW BLVD. OC	53-1571	Minor cracks at the tops of all columns.
LA	10	R011.70	TENTH AVE OC	53-1570	Minor cracks at the tops of all columns.
LA	10	R12.10	FOURTH AVE POC	53-1590	Minor spalling of external bolsters at both abutments..
LA	10	14.23	SANTA MONICA VI	53-1301	Minor spalls at tops of columns. Possible internal hinge damage.
LA	10	18.41	ECHANDIA OH	53-1333F	Sheared keeper plate bolts at abutments. Minor spall at abut 1 right rail.
LA	10	19.98	CITY TERRC POC	53-1856	Minor cracks near hinge 2.
LA	10	20.95	CAMPUS RD RAMP	53-2055K	Minor cracking in columns at bent 2.
LA	10	C021.07	WBD BUSWAY OC	53-2540L	Crack in outrigger bent.
LA	10	21.33	RAMONA BLVD UC	53-1459G	Minor cracks at top of columns in bent 2.
LA	10	31.72	BESS AVE POC	53-1288	Cracks in easterly girder stem. Picket rail damaged.
LA	14	R024.73	RTE 14/5 SOH	53-1960F	Partial collapse. Replacement being designed.
LA	14	R24.77	RTE 14/5 SOH	53-1960G	Severe hinge and abutment damage. Replacement being designed.
LA	14	R024.81	TRUCK CONN OC	53-1962F	Minor cracking and spalling at abut 1. Structure to be retrofitted.
LA	14	R24.82	SOUTH CONN OC	53-1963F	Hinge damage. Abutment damage. Replacement being designed.
LA	14	R024.97	NORTH CONN OC	53-1964F	Partial collapse. Replacement being designed.
LA	14	R025.13	SIERRA HWY UC	53-1936R	Abut. 1 rt. W.W. (minor spalling).
LA	14	R028.08	PLACERITA R UC	53-2076L	Minor spall at southern abutment.
LA	14	R028.08	PLACERITA R UC	53-2076R	Minor spalls at abutment.
LA	14	R030.55	CEDAR VL WY OC	53-2171	Minor spalls on columns at bent 2 and at abutments.
LA	14	R030.81	RTE 126 /14 SEP	53-2200S	Major column damage. Abutment backwall and wingwall damage.
LA	14	R030.90	VIA PRNCSSA UC	53-2166R	Wingwall damage.

SORTED BY CO-RTE-PM

CO	RTE	PM	BRIDGE NAME	BR NO	COMMENTS
LA	14	R030.90	VIA PRNCSSA UC	53-2166L	Wingwall damage.
LA	14	R030.91	VIA PRNCSSA UC	53-2201K	Cracks in abutments and rails.
LA	14	R031.62	HUMPHREYS OH	53-2029L	Damage at acute wingwall / abutment corners.
LA	14	R031.62	HUMPHREYS OH	53-2029R	Damage at acute wingwall / abutment corners.
LA	14	R031.88	SANTA CLARA RI	53-2027R	Hinge and restrainer damage.
LA	14	R031.88	SANTA CLARA RI	53-2027L	Hinge and restrainer damage.
LA	22	1.42	SAN GABRIEL R	53-0302R	Minor spalls at pier wall.
LA	60	R001.26	WHITTIER BV UC	53-0075L	Shear key spalls at abutment 1 left.
LA	60	R001.48	LORENA ST OC	53-0081	Keeper plate anchor bolts sheared at both abutments.
LA	60	R003.26	NE CONNECT OC	53-1717H	Keeper plate bolts sheared and fallen rocker at girder 4, abutment 12.
LA	60	R003.88	BELVEDERE POC	53-1728	Minor column spalls.
LA	71	R000.58	E CONNECTOR OC	53-1987F	Crack at hinge near span 2.
LA	90	2.54	RTE 90 405 SEP	53-1851	Damage to bent common with Bridge Number 53-1255.
LA	90	2.73	JEFFERSON B UC	53-1855F	Minor rail damage.
LA	91	R011.64	RTE 91/710 SEP	53-2240	Minor rail damage.
LA	101	5.81	WESTERN AVE OC	53-0676	Buckled AC at abut joint. Girder displacement at abutment?
LA	101	6.15	WILTON PLACE O	53-0731	Sheared keeper plate bolts. Cracks and spalls at curtainrwalls.
LA	101	6.41	VAN NESS A RP	53-0732K	Damaged curtain walls at abutments. Barrier spall.
LA	101	11.63	134/101,170SEP	53-1339F	Column damage. Sheared keeper plate bolts. Exterior shear key damage.
LA	101	11.75	101/134,170 SP	53-1336R	Spalls at columns, bents and wingwalls. Shear key and bearing damage.
LA	101	13.27	TUJUNGA WASH	53-1337	Buckled cross frames. Bent hanger plate. Cracks at wingwall. Rail spalls.
LA	101	15.38	LOS ANGELES R	53-1371	Sheared keeper bolts. Spalling at tops of columns. Curtain wall damage.
LA	101	25.34	ROUTE 101/27 SEP	53-1064	Crack in bent 2.
LA	101	31.05	LAS VIRGENE OC	53-1442	Keeper bolts sheared. Vertical offset and spalls at abuts. Possible pile damage.

SORTED BY CO-RTE-PM

CO	RTE	PM	BRIDGE NAME	BR NO	COMMENTS
LA	105	R3.47	IMPERIAL HWY OC	53-2655	Minor spalls at South Abutment shear keys.
LA	105	R7.39	RTE 105/110 SEP	53-2405R	Bearing damage. Abut face spall.
LA	105	R7.68	NE TRANSIT CONN OC	53-2680	Minor spalls at hinge #8.
LA	105	R14.65	PARAMOUNT BLVD OC	53-2425	Spall at corner of one wingwall.
LA	105	R14.95	MERKEL AVE OC	53-2428	Spall at corner of one wingwall.
LA	105	R15.76	LAKEWOOD BL OC	53-2565S	Minor conc spalls in abut faces.
LA	105	R16.39	ARDIS AVE OC	53-2572	Minor conc spall in abut face.
LA	110	9.07	190TH ST UC	53-0960	Minor spall at North abutment wall.
LA	110	10.49	GARDENA BV UC	53-0956	Minor spalls at exterior of rail at abutment joints. Soundwalls on rails OK.
LA	118	R002.55	BROWNS CYN WA	53-2182S	Abutment shear keys are cracked. Delaminated bearing pads.
LA	118	R002.55	BROWNS CYN WA	53-2182	Abutment shear key damage. Delaminated bearing pads.
LA	118	R003.13	RINALDI ST OC	53-2498	Possible pile damage. Wingwall displacement. Cracked slope paving.
LA	118	R003.22	MASON AVE OC	53-2499	Slope paving damage. Approach settlement. Abutment spalls.
LA	118	R003.86	WINNETKA AV OC	53-2500	Approach settlement. No work recommended. Bridge not in service.
LA	118	R006.58	ZELZAH AVE OC	53-2513	Cracks and spalls in slope paving.
LA	118	R006.80	WHITE OAK A OC	53-2464	Damaged shear keys.
LA	118	R007.05	ENCINO AVE OC	53-2465	Broken bearing. Curtain wall damage. Approach settlement.
LA	118	R007.80	BALBOA BLVD OC	53-2395	Broken water main washed out abut. Appr slab & A1 corner damage.
LA	118	R008.05	RUFFNER AVE OC	53-2396	Major column damage.
LA	118	R008.34	HAVENHURST UC	53-2204	Aproach slab damage.Minor cracking at abutments.
LA	118	R008.63	MISSN GOTHIC U	53-2205	Partial collapse. EB structure being designed.
LA	118	R008.84	BULL CR CYN CH	53-2206	Partial collapse. Major column damage. EB structure being designed.
LA	118	R009.04	WOODLEY AVE UC	53-2207	Spalls at abutments. Severe approach slab damage.
LA	118	R009.33	GAYNOR AVE UC	53-2208	Slope paving and city sidewalk damaged

SORTED BY CO-RTE-PM

CO	RTE	PM	BRIDGE NAME	BR NO	COMMENTS
LA	118	R009.57	HASKELL AVE UC	53-2209	Slope paving cracked.
LA	118	R009.70	CHATSWTH ST UC	53-2210G	Spalls at abutments.Cracks in wingwalls.
LA	118	R009.74	DEVONSHIRE UC	53-2217H	Minor cracks at abutments and soffit. Wingwall displacement.
LA	118	9.85	CENTER CONN OC	53-2212F	Pile cap damage at abut 7. Possible pile damage. Hinge restrainer damage.
LA	118	R010.07	SEPULVEDA B UC	53-2213	Slope paving damage.
LA	118	R010.51	CHATSWORTH D U	53-2214	Cracks at abutments. Wingwall displacement.
LA	118	R010.83	FOX STREET UC	53-2215	Minor abutment and joint seal damage.
LA	118	R011.05	ARLETA AVE UC	53-2357	Wingwall displacements. Cracked slope paving.
LA	118	R011.31	SHARP AVE UC	53-2342L	Minor Abutment Damage.
LA	118	R011.32	SHARP AVE UC	53-2342R	Cracks at abutment 2. Joint seal damage. Approach settlement.
LA	118	R011.32	SHARP AVE UC	53-2343G	Cracks at abutments. Approach settlement.
LA	118	R011.41	PACOIMA WASH	53-2328G	Abutment and shear key damage. Cracks in columns. Barrier rail damage.
LA	118	R011.42	RTE 118 5 SEP	53-2324L	Cracked bridge rail.
LA	118	R012.27	PAXTON ST UC	53-2354S	Minor spalls at abutment. Approach settlement.
LA	118	R012.40	SAN FERN RD OH	53-2095	Damage at abutment 3. Spalls at soffit.
LA	118	R013.89	PAXTON-FTHL UC	53-2103G	Minor spalling at hinge seats (restrainers and bearings OK). Joint seal torn.
LA	118	R013.94	RTE118/210 SEP	53-2102G	Hinge restrainer damage. Vertical offset. Broken electrolier bases.
LA	126	R005.80	RTE 126/ 5 SEP	53-2694G	Cracks at column tops and shear keys. Approach slab damage.
LA	126	8.2	SFK SANTA CLAR	53-0015	Sheared anchor bolts at all supports. Slight permanent displacement.
LA	134	0	RIVERSIDE D OC	53-1493S	Column damage. Keeper bolts sheared. Curtain wall damage. Joint seals.
LA	134	.03	RIVERSIDE DR U	53-1452F	Spalls at external shear keys and bearings. Keeper bolts sheared.
LA	134	.04	RIVERSIDE DR U	53-1345F	Sheared keeper bolts at abut 1. Spalls at abut 3 backwall and shear key.
LA	134	1.36	FORMAN AVE UC	53-1276	Damaged exterior parapet shear key at abutment 1.
LA	134	2.24	OLIVE AVE OC	53-1280	Sheared keeper plate bolts at abutment 4.

SORTED BY CO-RTE-PM

CO	RTE	PM	BRIDGE NAME	BR NO	COMMENTS
LA	134	R005.67	LA RIV BOH	53-1790H	Minor rail and joint seal damage.
LA	134	R008.88	NW CONN OC	53-1907G	Hinge restrainer, bearing and diaphragm damage. Deck overhang spalls at hinges.
LA	134	R009.04	SOUTH CONN OC	53-1917F	Shear key damage at hinge and east abutment.
LA	134	L009.72	MONTE BONITO U	53-1023R	Crack in abutment 1 external shear key.
LA	134	L009.91	FIGUEROA ST UC	53-1024R	Sheared keeper plate bolts at both abutments. Cracks at abut 1.
LA	134	L009.91	FIGUEROA ST UC	53-1024L	Sheared keeper plate bolts at both abutments.
LA	138	51.06	PEARLAND UP	53-2033	High load hit.
LA	170	R014.78	RIVERSIDE T UC	53-1344	Broken keeper plates. Spalls at rails. Failed hinge joint seal.
LA	170	R015.63	CHANDLER BV OH	53-1644	Minor rail damage.
LA	170	R018.65	WHITSETT AV OC	53-0490	Superstructure rotated with permanent displacement. Column cracks.
LA	170	R020.52	RTE 170/5 SEP	53-1122G	Keeper plate bolts sheared at abutment 1. Large deck spall. Joint seals.
LA	210	R000.06	SW CONNECTR OC	53-1989F	Major damage both abutments. Damaged shear keys.Column damage.
LA	210	R000.12	NORTH CONN SEP	53-1988F	Minor wingwall cracking at left side A1.
LA	210	R003.01	TYLER ST POC	53-1925	Spalling at abutment 1. Minimal Bearing.
LA	210	R003.57	ASTORIA ST POC	53-1896	Cracking and spalling of abutment 1 seat.
LA	210	R006.08	RTE118/210 SEP	53-2104F	Spalls at hinge seats. Broken hinge restrainers. Joint seals failed.
LA	210	R007.16	TERRA BEL ST U	53-2117	Approach slabs have settled.
LA	210	R018.53	WALTONIA DR UC	53-2219K	Joint seal damaged.
LA	210	R046.36	SAN DIMAS A UC	53-2009	Settlement of approach. Columns spalled
LA	405	23.71	LA CIEN BV S O	53-1250	Sheared keeper plate bolts.
LA	405	25.91	SOUTH CONN OC	53-1852F	N Side Spall at Hinge Seat Extender Bolster.
LA	405	29.42	SEPULVEDA B UC	53-1638G	Sidewalk damaged at east abutment.
LA	405	29.43	SW CONNECTR OC	53-1630G	Keeper bolts sheared. Rockers out of place. Bolster damage.
LA	405	29.62	NE CONNECTR OC	53-1629F	Rocker bearing and hinge restrainer damage. Approach slabs have settled.

SORTED BY CO-RTE-PM

CO	RTE	PM	BRIDGE NAME	BR NO	COMMENTS
LA	405	29.85	EXPOSITION OH	53-0704	Cracks and spalls in columns. Cracks in bent caps.
LA	405	36.72	RIMERTON RD OC	53-1490	Crack in closure wall at abutment 1.
LA	405	37.03	MULHOLLAND D O	53-0739	Bearing damage. Joint seals failed. Spalls at wingwall. AC Settlement.
LA	405	38.59	SEPULVEDA BV U	53-0740	Spall at bent 2 in right overhang soffit.
LA	405	41.27	W VAN NUYS OH	53-1362	Minor cracks at abutment 1.
LA	405	41.36	VICTORY BV UC	53-1449	Bearing pad failure at bent 2.
LA	405	44.24	PARTHENIA ST U	53-1439	Approach slab settlement. Spalls in rail at bent 2.
LA	405	46.24	DEVONSHIRE UC	53-1500	Minor cracks at abutments and tops of columns..
LA	405	46.74	CHATSWRTH ST U	53-1501	Minor cracks and spalls at abutments and shear keys. Approach settlement.
LA	405	46.8	SE CONN OC	53-2216G	Major damage at abut 1. Restainer and bearing damage at hinges. Approach settlement.
LA	405	46.83	RT 405 118 SEP	53-2211	Minor cracks at bent walls and columns. Incipient spalls at shear keys.
LA	405	47.24	SAN FERN BL UC	53-1507	Cracks in abutments and wingwalls. Joint spalls. Aproach settlement.
LA	405	47.75	RINALDI ST UC	53-1506	Major damage at bent 3. Cracks in closure wall.
LA	710	24.61	SE CONN OC	53-1714G	Steel rocker bearing damage at abutments.
LA	710	24.64	NW CONN OC	53-1716F	Steel rocker bearing damage at abutments.
VEN	23	R007.16	SUNSET HL B OC	52-0311	Shear key damaged at abutments. Wingwalls cracked.
VEN	23	23.62	SANTA CLARA R	52-0118	Minor to moderate cracks and spalls at pier walls.
VEN	101	7.89	WENDY DRIVE OC	52-0266	One minor spall at exterior girder fillet.
VEN	118	T19.19	PRINCETON AV UC	52-0334L	Minor spall at abutment 1.
VEN	118	R029.56	YOSEMITE ST OC	52-0300	Cracks at tops and bottoms of columns. Approach settlement.

Total number of records 212

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Appendix D

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Aerial Photographs

The following pages contain aerial photographs of several collapsed structures.

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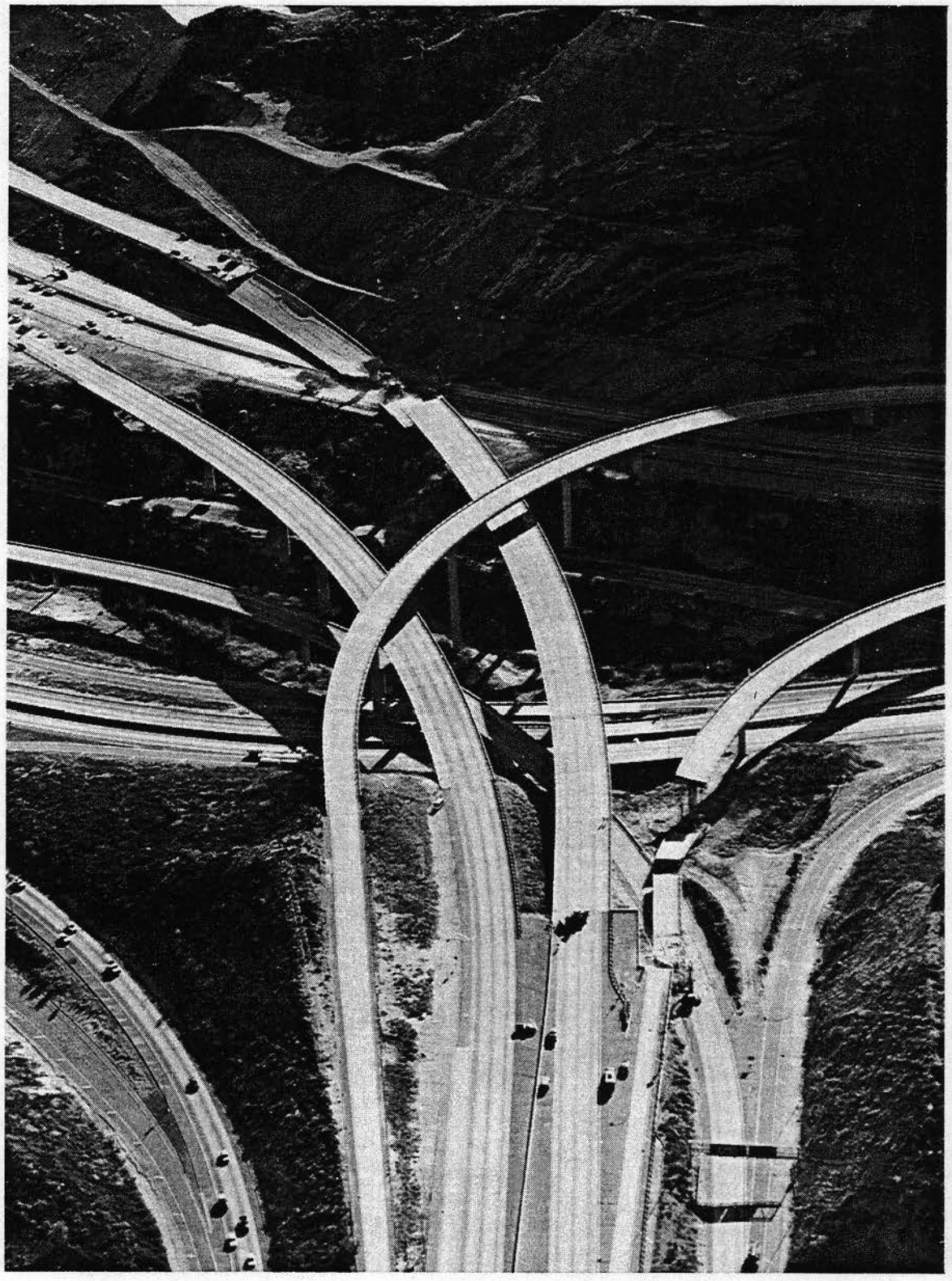

Route 14/Interstate 5 Interchange
Collapsed Connectors 53-1964F & 53-1960F

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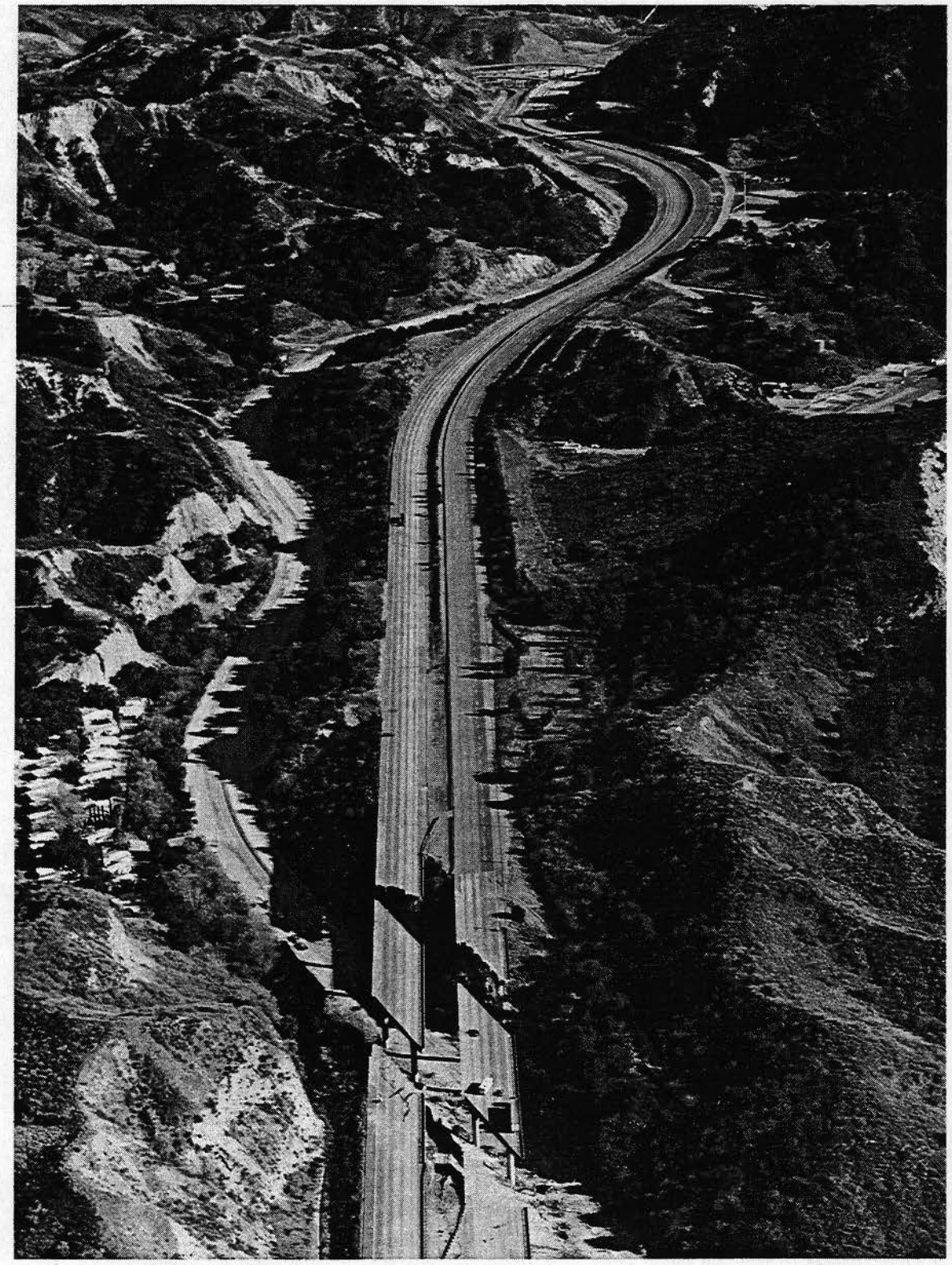

Overview of Gavin Canyon Road (53-1797R/L),
with Route 14/Interstate 5 Interchange in distance.

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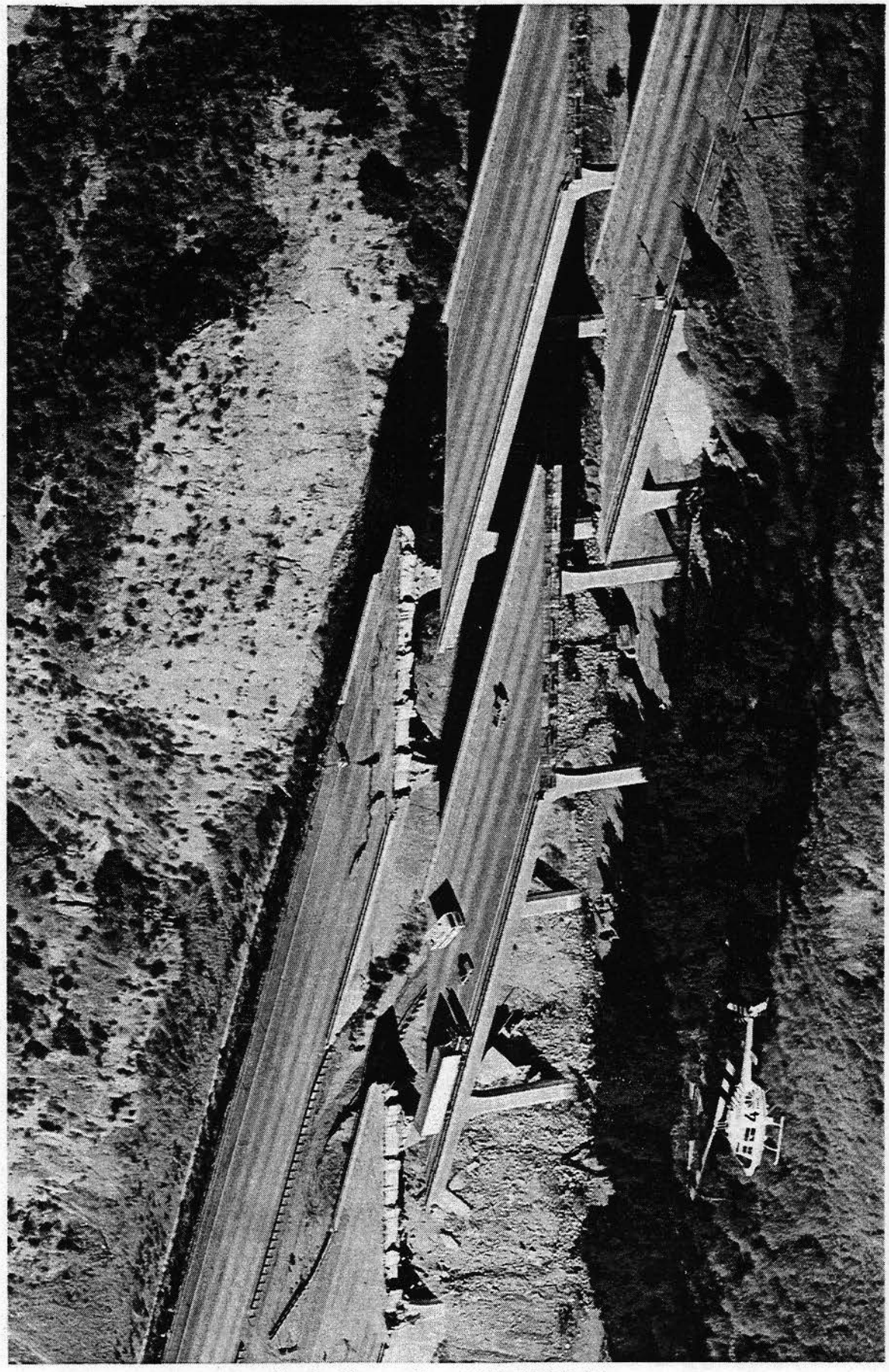

Gavin Canyon Road (53-1797R/L)

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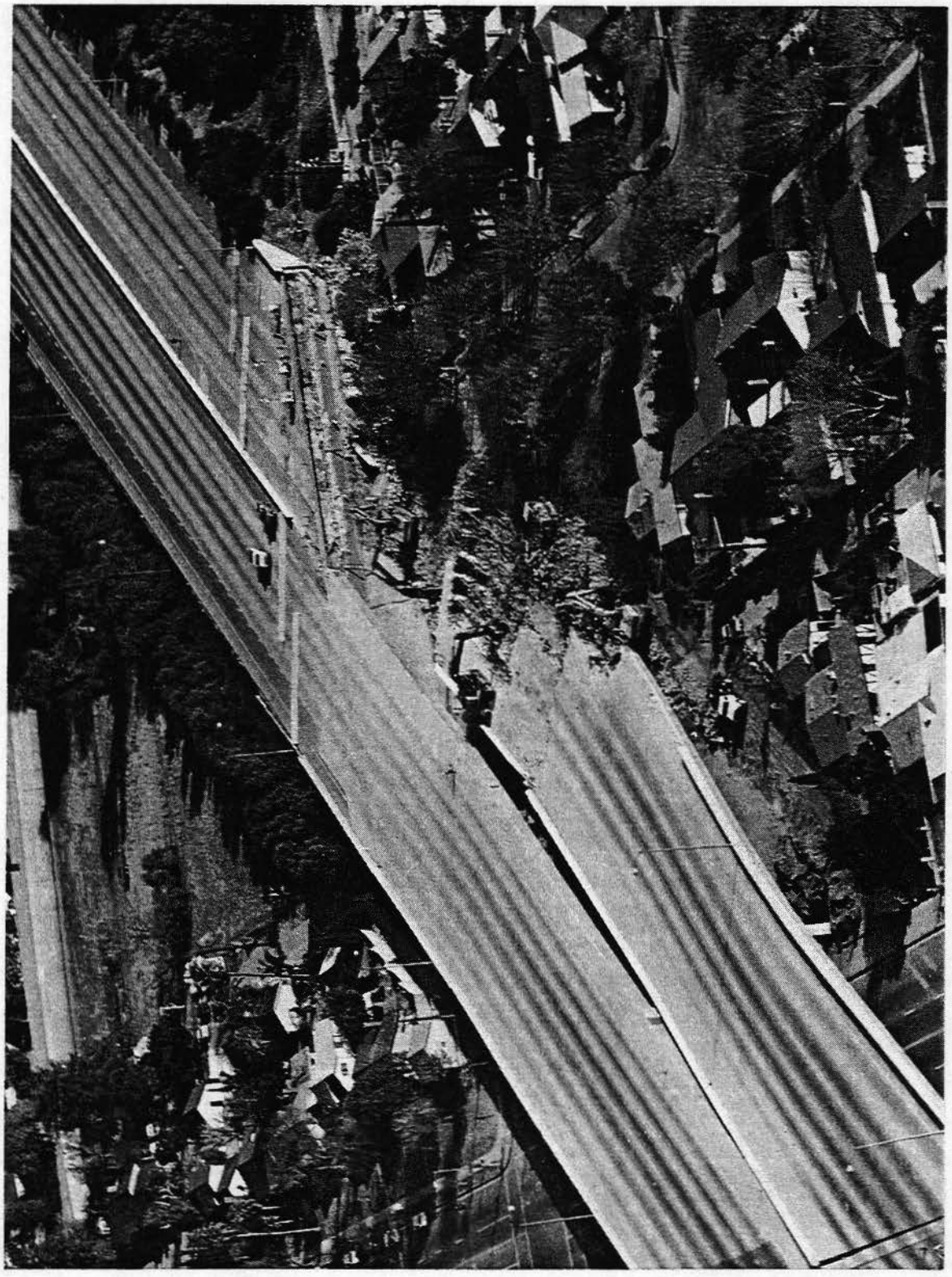

Overview of Mission - Gothic Undercrossing (53-2205)

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Overview of Fairfax - Washington Undercrossing (53-1580)

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Appendix E

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Soundwall Damage

R.C. Anderson

The following is a reprint of a brief report on damage to various soundwalls in the Los Angeles area caused by the Northridge Earthquake.

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Soundwall on Route 101 near Route 405 07-LA-101

Description of Structure

12 ft. high (total ht.) masonry soundwall on concrete barrier approximately 320 ft. long.

Description of Damage

All the soundwall panels had offsets of ±6" except on the 50 ft. portion which had collapsed.

Analysis of Damage

This wall had a single row of #5 bars in the center of the wall and were spliced in the base of the masonry wall. At the base of the masonry wall a gap was formed by elongation of the bar and/or slippage of the splice. This condition caused the total lateral load to be resisted in flexure by the #5 bar. Subsequent shaking probably caused the bars to fracture. Approximately half of the bars in the collapsed panel were fractured.

Other damage on Route 101:

The following walls had gaps between the masonry wall and the concrete barrier. These walls were non-salvageable and were demolished.

(1) 10 ft. high wall on WB 101 East of Shoup Ave UC.
(2) 12 ft. high wall on WB 101 West of Winnetka Ave UC.

The following wall had gaps in the masonry 2 ft. above the top of the concrete barrier. This wall was non-salvageable and was demolished.

(1) 16 ft. high wall on EB 101 East of Colfax Ave UC.

Damage on Route 118:

The following wall had gaps between the masonry wall and the concrete barrier. This wall was non-salvageable and was demolished.

(1) 6 ft. high (ht. of masonry) wall on barrier on top of retaining wall on the North R/W line between Louise Ave OC and Balboa Blvd. OC .

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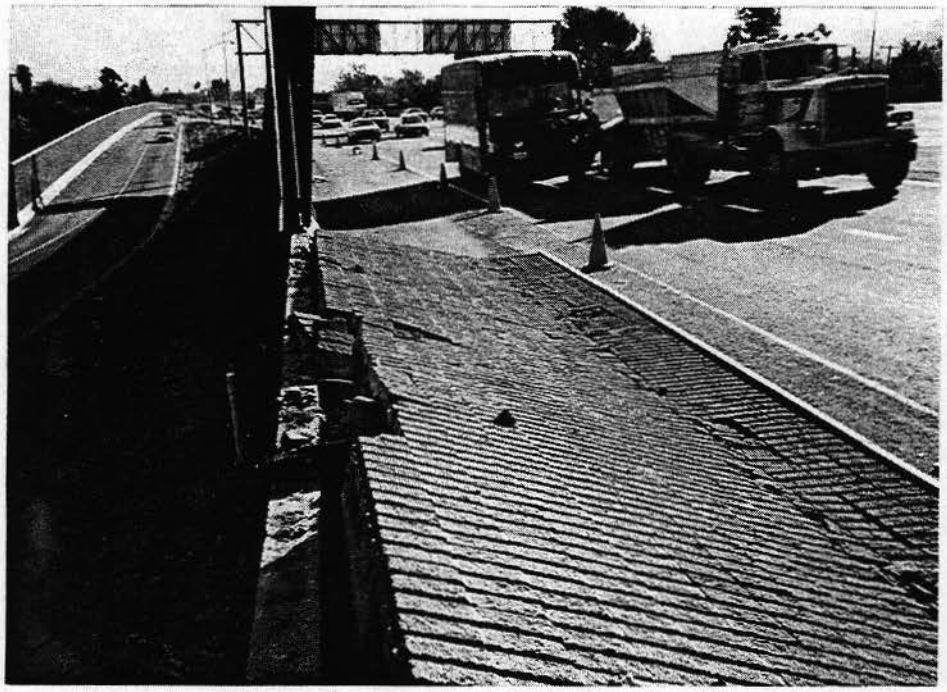
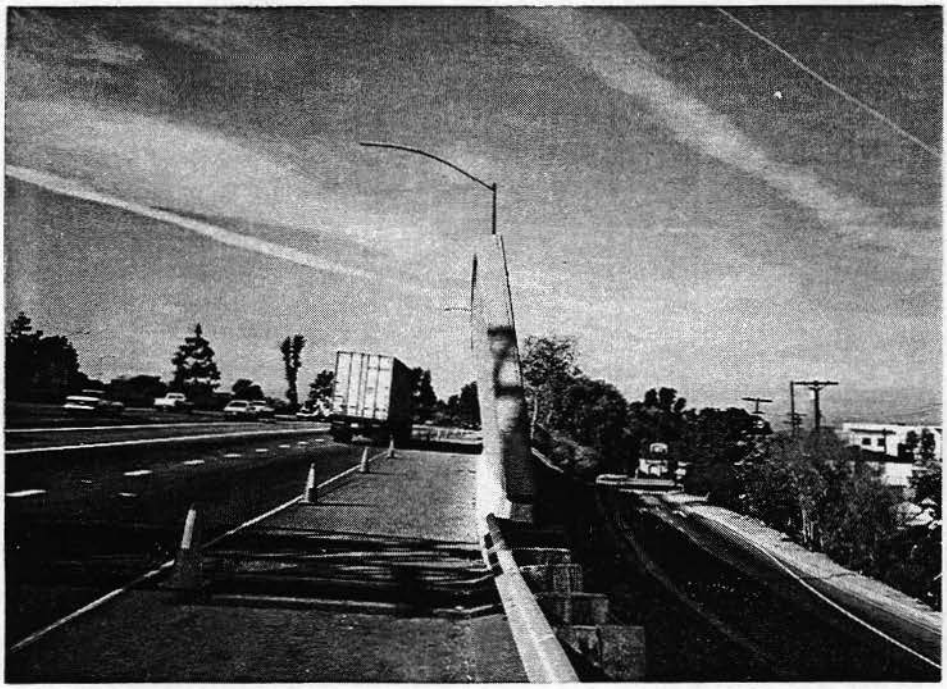


Collapsed Soundwall on WB Route 101 near Interstate 405



Damaged Soundwall on WB Route 101

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Appendix F

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Steel Bridge Damage

Santa Clara River Bridge 53-687L/R

Joe Gallipi
Senior Bridge Engineer

The following is a reprint of a supplemental bridge maintenance inspection written by Joe Gallipi, Senior Bridge Engineer, Office of Structure Maintenance and Investigation, following his inspection of the Santa Clara River Bridges on Interstate 5.

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53-687L

SCOPE

This report is limited to: 1.) Out-of-plane-bending fatigue cracks in the web plates of the superstructure girders, 2.) Anchor bolt connections of girders to caps, 3.) Condition of the pier caps and 4.) Recommendations, immediate and long range.

1.) A snooper assisted investigation has identified approximately 40 crack locations in the girder webs, mostly occurring on girders 2 & 3 of the six girder cross section. Girders 1, 2 & 3 of span 7 were not thoroughly investigated because of danger in further aggravating the loss of bearing area under the left exterior girder. There were several teams of investigators, two personnel from the lab & four personnel from structures maintenance, using as many as three snooper-type vehicles. The attached compilation of crack locations is taken from various field notes and is not necessarily 100% complete or correct. Eight cracks are less than 7 inches; thirty-two are larger. The maximum measured crack length was 44 inches.

Girders 2 & 3 carry the truck lanes. Crack initiation and propagation is the result of skewed supports and staggered intermediate cross frames between the girders. There are no vertical stiffeners opposite those on the web that connect to the cross frames. Stains on the girders indicate that cracks were not newly formed.

It was decided, in consultation with Sacramento Maintenance, to mitigate immediately the fatigue crack problem as follows:

a) Reduce out of plane bending by connecting "T" clips to both the intermediate cross frame stiffener and bottom flange of girder.
b) Drill stress relief holes at the termini of all cracks.
c) Field weld all cracks in the web that exceed 7 inches in length.

The above work will permit a second line of traffic to be carried on the deck.

Because girders 2 & 3 will once again carry truck loads when traffic is fully restored, it was further agreed, that all intermediate cross frame attachments to these girders would be retrofitted with "T" clips.

2.) The girders are connected to the pedestal seat abutments and pier caps by two 1-1/2 inch diameter X 1'-4" steel bolts in 3" standard pipe sleeves. Fixed bearing are grout filled. A large number of bolts have failed in shear. In many cases, this includes both bolts at a single end. Most of these failures are earthquake generated. There is little connection between the superstructure and substructure except for the earthquake cable connections at the piers..

No immediate remedy has been proposed. It is necessary to reconnect the substructure and superstructure together as quickly as possible.

3.) The earthquake has heavily fractured the ends of pier caps at several locations; especially beneath girder 6 in span 1 at pier two and girder 1 of span 7 at pier seven. There is zero support beneath these girders. The girder in span seven has dropped over 3-1/2 inches. The exterior girders do not have earthquake restraining cables attached to them. There is an absence of steel encapsulating the anchor bolts. There is but one horizontal #6 bar, which did not have adequate lap splice length, about the anchor bolts.

The immediate recommendation is to support all exterior girders at all ends over the piers. Posts will be placed between good support on the pier cap and the channel member beneath the thickened deck haunch of the deck slab. Ultimate repair shall consist of constructing adequate support beneath the girders, including seat width and anchorage. This may entail reconstruction of the pier cap or total replacement of the pier supports.

NOTE: There are serious scour problems at this structure.

Summary of Cracking in 53-687L

SPAN	BAY	INTERMEDIATE FRAME NO.	ATTACHED TO GIRDER NO.	CRACK Inches Vert.	LENGTHS Inches Hor.	COMENTS
1		ALL	1, 2, & 3	NONE	NONE	
2	1	4	2	21	12"	
2	2	2	2	35	14 1/2"	
2	2	3	2	12	15 1/2"	
2	3	3	3	5	4	
3	1	3	2	2	NONE	
3	2	2	2	40	17	
3	2	3	3	17	8	
3	2	3	2	39	17	
3	2	4	2	25	17	
3	3	3	3	10	81/2	
4	1	1	2	5	9	
4	2	3	2	20	13	
4	3	2	4	0-1/2	NONE	
4	3	3	3	9	7	
5	2	2	2	35	17	
5	2	3	2	29	18	
5	2	4	2	15	12	
5	3	2	4	0-1/2	0-3/4	
6	2	2	2	44	20	
6	2	3	2	29	18	
6	2	4	2	16	12	
6	3	2	4	0-1/2	NONE	
7		ALL	1, 2, & 3	?	?	COULD NOT INSPECT W/SNOOPER

53-687R

SCOPE

This report is limited to: 1.) Out-of-plane-bending fatigue cracks in the web plates of the superstructure girders, 2.) Anchor bolt connections of girders to caps, 3.) Condition of the pier caps and 4.) Recommendations, immediate and long range.

1.) A snooper assisted investigation has identified approximately 24 crack locations in the girder webs, mostly occurring on girders 4 & 5 of the six girder cross section. Girders 1, 2 & 3 of span 7 were not thoroughly investigated because of danger in further aggravating the loss of bearing area under the left exterior girder. There were several teams of investigators, two personnel from the lab & four personnel from structures maintenance, using as many as three snooper-type vehicles. The attached compilation of crack locations is taken from various field notes and is not necessarily 100% complete or correct. Twenty cracks are less than 7 inches; four are larger. The maximum measured crack length was 18 inches.

Girders 4 & 5 carry the truck lanes. Crack initiation and propagation is the result of skewed supports & occasional staggered intermediate cross frames between the girders. There are no vertical stiffeners opposite those on the web that connect to the cross frames. Stains on the girders indicate that cracks were not newly formed. The right bridge differs from the left structure in that the cross frames between girders in bays 4 & 5 are not staggered except in span 6.

It was decided, in consultation with Sacramento Maintenance, to mitigate immediately the fatigue crack problems as follows:

a) Reduce out of plane bending by connecting "T" clips to the intermediate cross frame stiffener and bottom flange of girder at four locations.
b) Drill stress relief holes at the termini of all cracks.
c) Field weld all cracks in the web that exceed 7 inches in length.

2.) The girders are connected to the pedestal seat abutments and pier caps by two 1-1/2 inch diameter X 1'-4" steel bolts in 3" standard pipe sleeves. Fixed bearing are grout filled. A large number of bolts have failed in shear. In many cases, this includes both bolts at a single end.

Most of these failures are earthquake generated. There is little connection between the superstructure and substructure except for the earthquake cable connections at the piers..

No immediate remedy has been proposed. It is necessary to reconnect the substructure and superstructure together as quickly as possible.

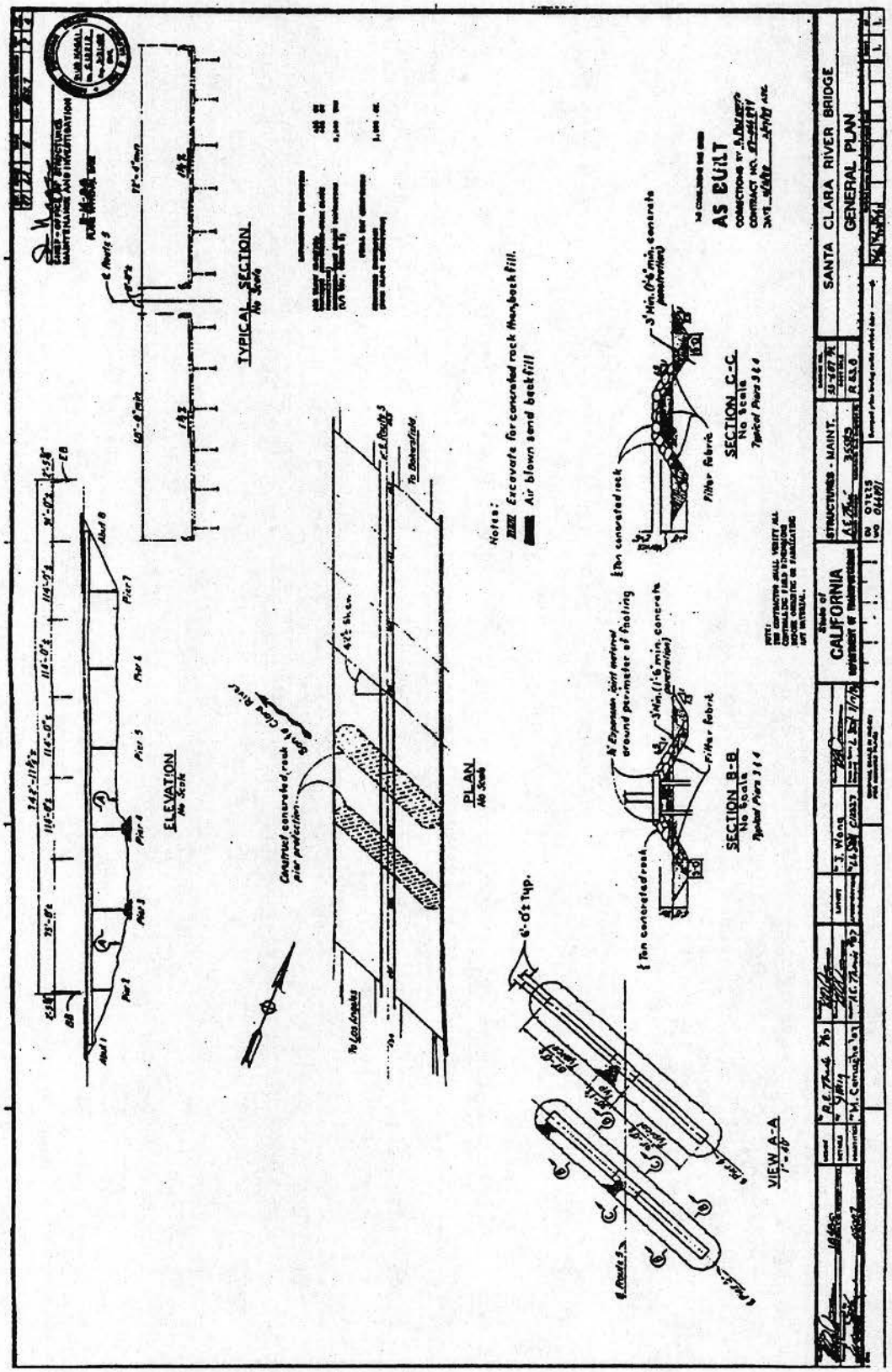
3.) The earthquake has heavily fractured the ends of pier caps at several locations; especially beneath girder 6 in span 1 at pier two and girder 1 of span 7 at pier seven. There is zero support beneath these girders. The girder in span seven has dropped over 3-1/2 inches. The exterior girders do not have earthquake retraining cables attached to them. There is an absence of steel encapsulating the anchor bolts. There is but one horizontal #6 bar, which did not have adequate lap splice length, about the anchor bolts.

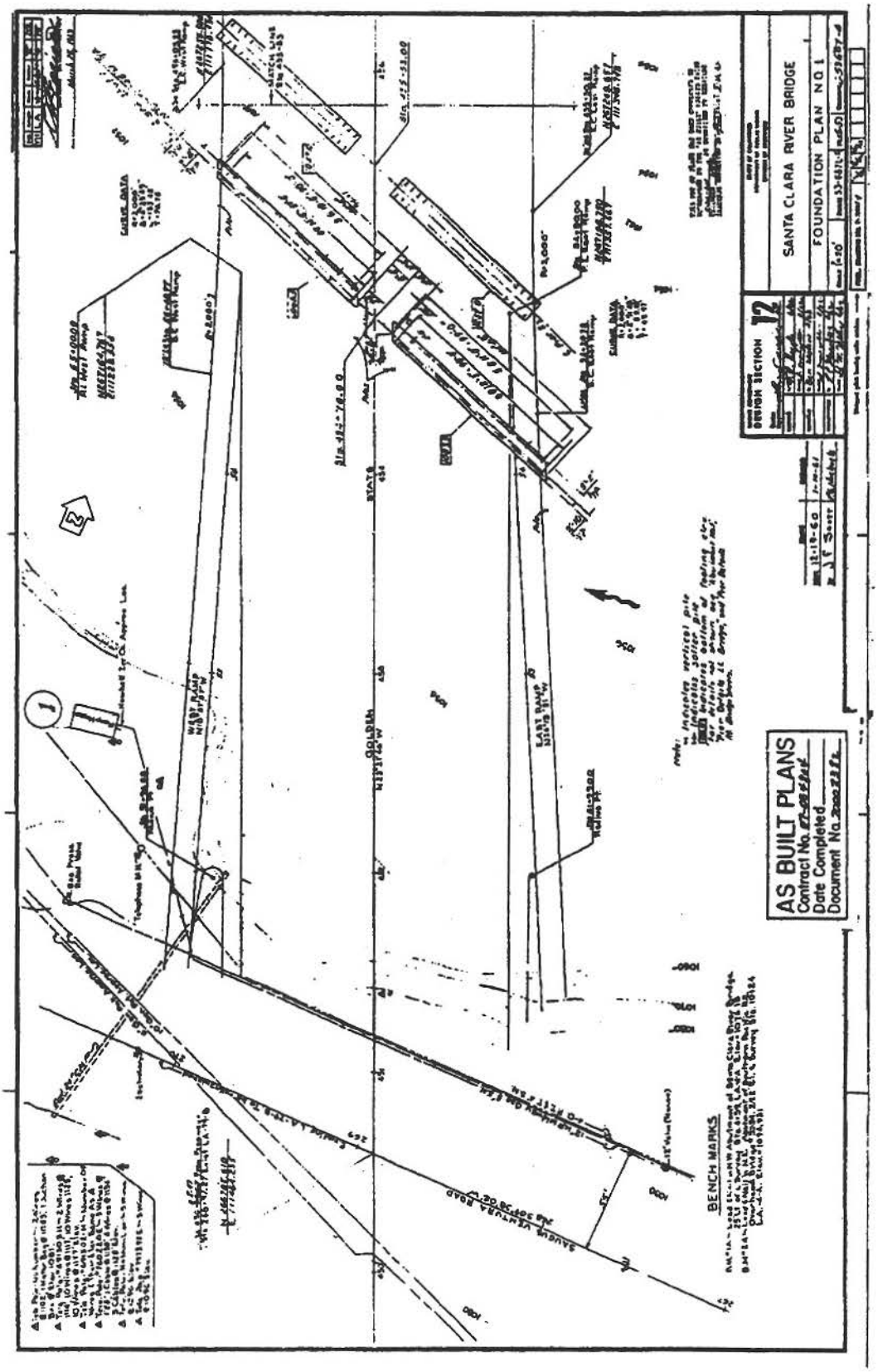
The immediate recommendation is to support all exterior girders at all ends over the piers. Posts will be placed between good support on the pier cap and the channel member beneath the thickened deck haunch of the deck slab. Ultimate repair shall consist of constructing adequate support beneath the girders, including seat width and anchorage. This may entail reconstruction of the pier cap or total replacement of the pier supports.

NOTE : There are serious scour problems at this structure.

Summary of Cracking in 53-687R

SPAN	BAY	INTERMEDIATE FRAME NO.	ATTACHED TO GIRDER NO.	CRACK LENGTHS Inches Vert.	Inches Hor.	COMENTS
1	4&5	ALL	4, 5, & 6	NONE	NONE	
2	4	2	4	NONE	4	
2	4	3	4	NONE	2	
2	4	3	5	1	4	
3	4	2	4	1	3	
3	4	3	4	1	2	
4	4	2	4	1	4	
4	3	2	4	NONE	2	
4	4	3	4	18	9	Use "T" Clip. Has branching 6" leg
5	3	2	4	NONE	5	
5	4	3	4	NONE	3	
5	3	3	4	NONE	3	
5	4	4	5	NONE	4	
6	3	1	4	1	3	
6	4	2	4	8	8	Use "T" Clip
6	4	3	4	0-3/4	NONE	
6	4	4	4	0-3/4	NONE	
6	4	3	5	0-3/4	NONE	
7	4&5	ALL	4, 5, & 6	NONE	NONE	


ELEVATION
No Scale
TYPICAL SECTION
No Scale
PLAN
No Scale
Notes:
Excavate for concrete rock Headwall fill.
Air blown sand backfill
SECTION B-B
No Scale
SECTION C-C
No Scale
AS BUILT
VIEW A-A
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
STRUCTURES - MAINT.
SANTA CLARA RIVER BRIDGE
GENERAL PLAN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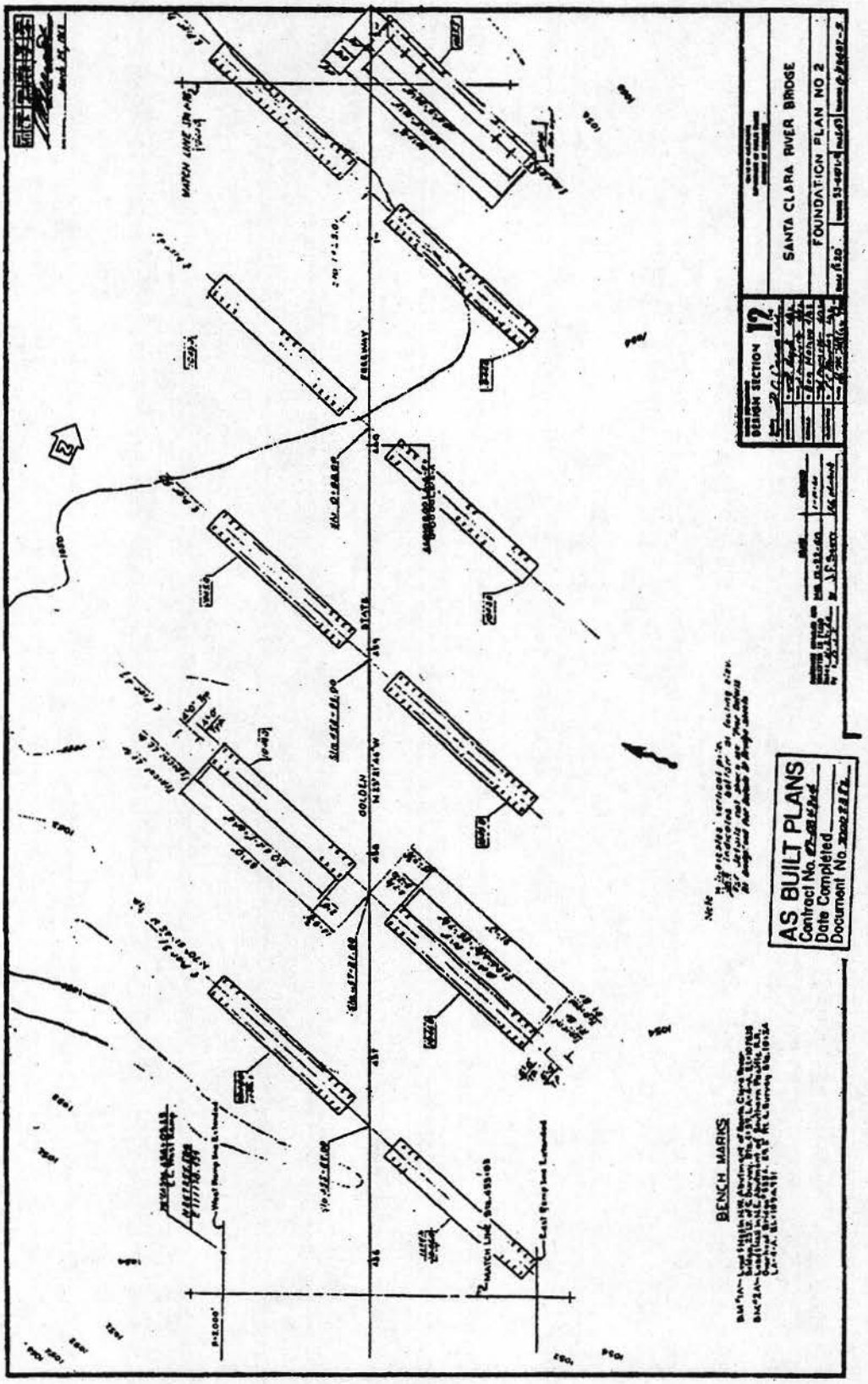
Contract No.
Date Completed
Document No.
BENCH MARKS
SANTA CLARA RIVER BRIDGE
FOUNDATION PLAN NO 1
BRIDGE SECTION 12


SANTA CLARA RIVER BRIDGE
FOUNDATION PLAN NO 2
AS BUILT PLANS
Contract No.
Date Completed
Document No.
BENCH MARKS

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Appendix G

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Restrainer Performance Photographs

The following pages contain photographs taken inside the box-girder cells of Route 14/5 Separation and Overhead (53-1960G) by Todd Day, ABME, Office of Structure Maintenance and Investigation, Toll Bridges Branch.

These pictures are typical of the conditions discovered in all of the box-girder cells investigated. There was no evidence of nuts "walking off" the assemblies.

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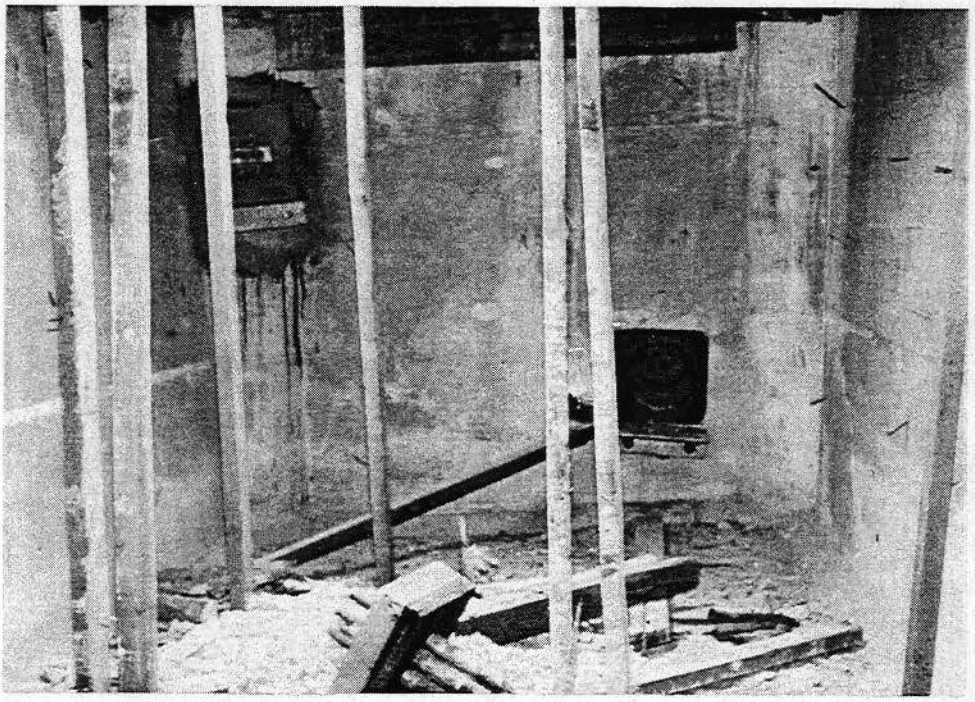
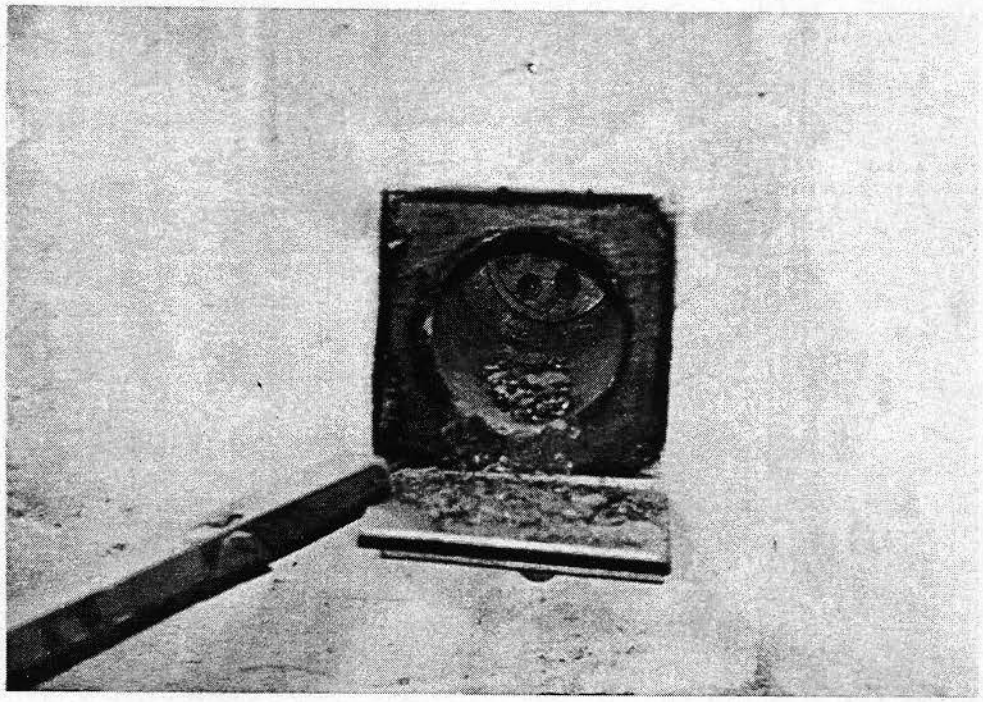


Inside cell, failed restrainer unit in foreground



Inside cell, close-up of cored hole.

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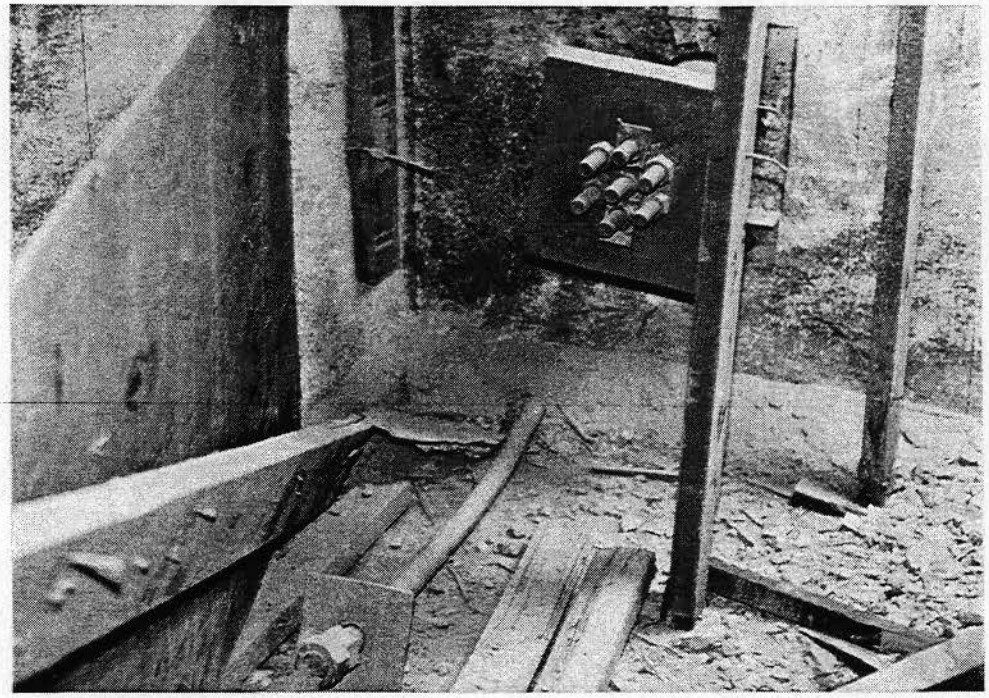
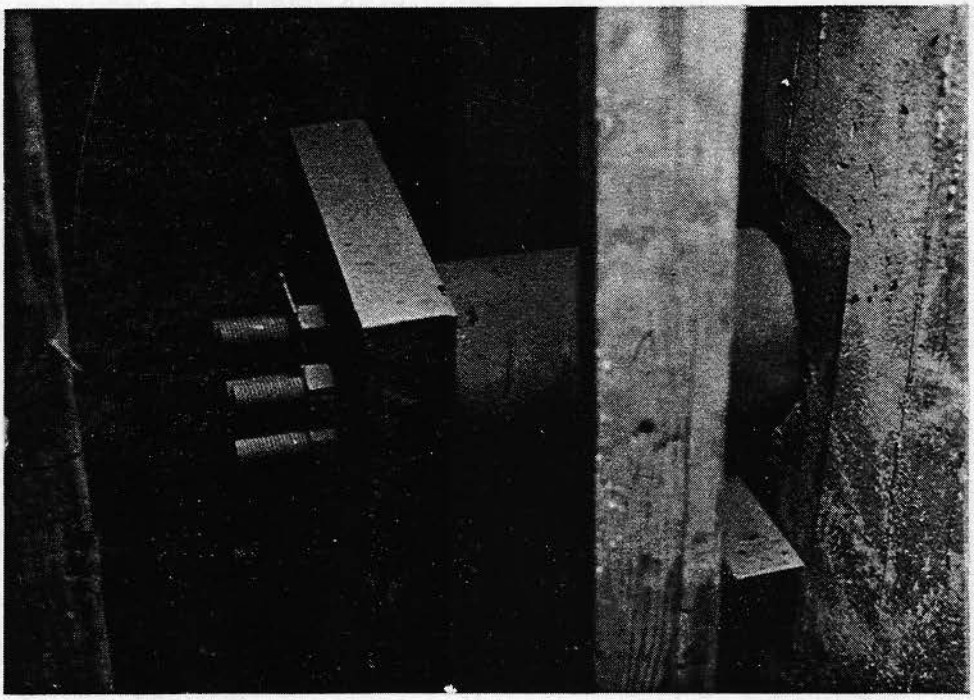


Inside cell opposite of previous pictures, equalizing bolt in fore ground.



Inside cell opposite of previous pictures, elevation view of restrainer unit.

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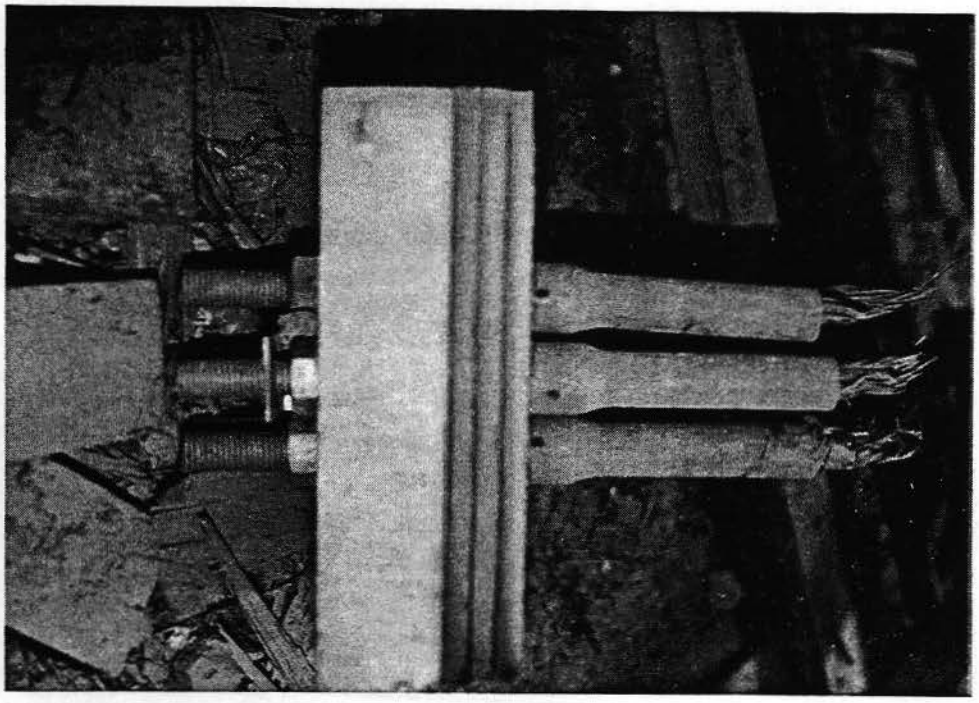
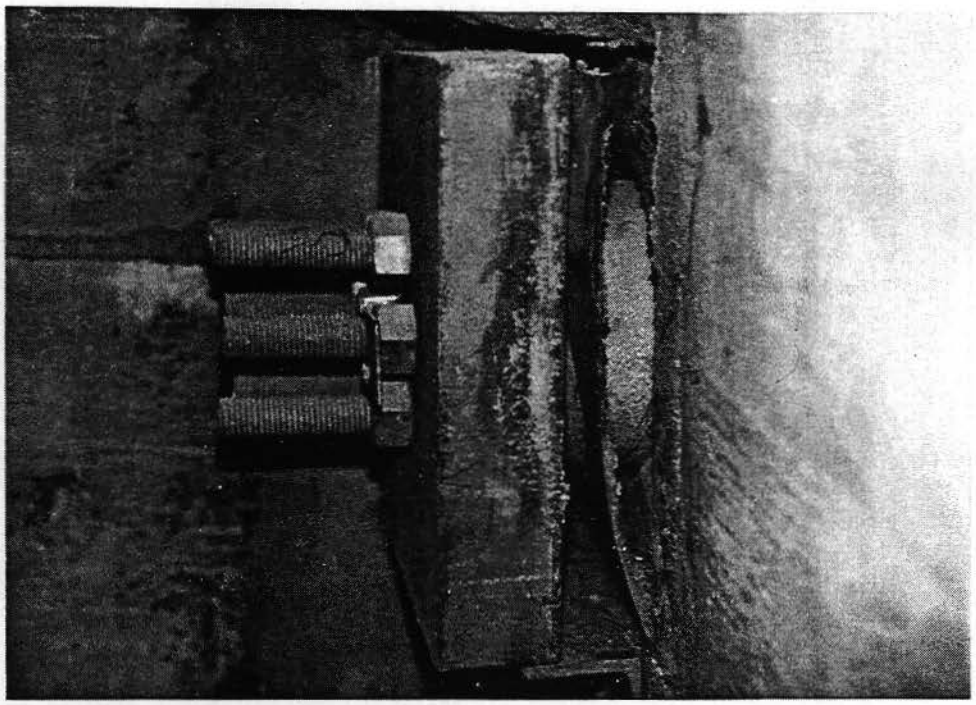


Close-up of failed restrainer cables.



Elevation view of intact restrainer.