Reconnaissance Report
Santa Barbara Earthquake
August 13, 1978

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Abstract

A reconnaissance visit was made to the August 13, 1978 Santa Barbara earthquake. The primary purpose of the visit was to assess the damage to public school and hospitals and to evaluate their applicable building regulations. The secondary purpose was to assess the damage to other structures.

Introduction

This earthquake occurred at 3:54:50.8 local time on the afternoon of Sunday, August 13, 1978. The Richter magnitude of the event was reported by California Institute of Technology at 5.1, the University of California Berkeley at 5.5 and 5.9, and the National Earthquake Information Service of the U. S. Geological Survey at Golden Colorado at 5.5. The epicenter is reported to be about 4 miles offshore and due south of Santa Barbara. The focal depth is currently reported to be 6 to 10 kilometers below the surface of the earth.

This author was in Santa Barbara the following day, Monday, and by nightfall had visited three public schools and one hospital building. The following day, Tuesday, three more school building sites and the University of California, Santa Barbara (UCSB) were visited and on Wednesday was part of an Office of Emergency Services team to review the damage and estimate the cost of repair of the buildings at UCSB.

From the first telephone contacts made by the Los Angeles Area Office with the school districts and hospitals, it was learned that the Goleta area was the hardest hit. The first visit was to schools with a representative of the Goleta Union Elementary School District.

Public School Buildings

Foothill Elementary School, Goleta

This is a portable building built in 1964 under the provisions of the Field Act. The north wall is of wood mullions. One window pane about 4' x 4½' fractured which appeared to be the result of excessive drift. Small sharp glass particles were thrown about 13 feet into the classroom. No other damage was noted or reported at this site.
The buildings on this site, built in 1970 under the Field Act, are of permanent construction. The one-hour T-bar ceiling in the hexagon shaped multipurpose room failed around the perimeter of the room a width of about two to six feet. This building was constructed at a time when ceilings were considered to be a light weight non-structural item and offered little hazard to the occupants. The only requirements for their construction at that time was that the members be "securely" anchored. Each earthquake, since installation of this type of construction became popular, has demonstrated that T-bar ceilings may be hazardous to the safety of the occupants. At the perimeter of the multipurpose room where the T-bars were wire tied to nails driven into the framing, the T-bars did not fall to the floor but the pieces of tile fell to the floor. Where no anchorage was provided both the T-bars and tile fell to the floor.

Several plastic lenses or light diffusers on the light fixtures fell to the floor. No other damage was observed on this site.

El Rancho Elementary School, Goleta

This school building was built at the same time and from the same set of plans as the previously mentioned Mountain View Elementary. The damage was identical. That is, the T-bar ceiling in the multipurpose building fell to the floor in a similar pattern. Kitchen equipment which had no anchorage, such as the refrigerators, appeared to have displaced about three inches. Equipment such as stoves and sinks which had some lateral restraint provided by the piping, did not move. No damage was observed in any of the other buildings on the site.

Santa Barbara City College

During the initial telephone survey to determine if there was any damage, it was reported that some structural beams had split in the library building at this site. Upon arrival, the structural plans which had been approved under the provisions of the Field Act, were reviewed. The drawings indicated that the building construction consisted of precast concrete columns with a second floor beam seat pocket to receive the cast in place floor beam and slab. The beam was tied to the column with a horizontal hairpin bar placed 6" above the bottom of the beam and no top bars. Therefore, the joint was designed as a hinge. During the earthquake the hinge merely became apparent, thus the observed cracking was of no structural significance.

Books were thrown off the stacks. No stack overturned even though they were not completely anchored or braced.

The ceiling tile at the cross partitions on the second floor were dropped to the floor. These ceilings consisted of main T-bars in one direction with no continuous cross members.
There were reports that the slab on grade was cracked in one of the lecture rooms in one of the adjacent buildings. None could be found.

No other damage was reported on this site.

Dos Pueblo High School, Goleta
Gymnasium

It was reported that the buildings on this site received the greatest damage. All buildings were constructed under the provisions of the Field Act. There was particular concern of the concrete walls in the gymnasium. A review of the walls disclosed that there were light vertical cracks in the walls located between the columns. However, it was reported that there were vertical cracks in the walls before the earthquake. Since concrete shrinkage will usually produce vertical cracking in walls and lateral loads usually produce inclined cracking in walls, it was assumed that the cracking observed was merely representative of shrinkage and not due to the earthquake.

Several ceiling tiles, which were glued to the gypsum board, fell to the floor. Lockers showed evidence of having been displaced—possibly by the earthquake.

Boiler Room

No structural damage or mechanical damage was observed.

Quad Classroom Buildings

There are two quad classroom buildings on this site. They are of portable construction and consist of four classrooms with movable partitions between the rooms. Ceiling T-bars, panels and insulation fell to the floor in all four classrooms. Several plastic light fixture covers became displaced.

Library

Books and supplies fell from the shelves. The wall anchorage of two book cases pulled out. One anchorage was by means of a toggle bolt through the plaster and the other anchorage was a plastic insert containing a screw placed in a hole drilled in the plaster. Upon further consideration it is felt that this may not have been the result of the earthquake, because of the lack of any deformation of the toggle bolt.

Other Buildings

It was reported that several other buildings on this site had ceiling tile damage.
Goleta Valley Junior High School, Goleta

This site also contained two quad classroom buildings constructed similar to that at Dos Pueblo High School. The ceiling damage here was identical to that at the Dos Pueblo High School quad classrooms.

It was reported that one pane of glass was broken by the earthquake.

University of California, Santa Barbara

This site is located in Goleta on the coast. No building in the university system has been constructed under the provisions of the Field Act. Not all buildings were visited due to the lack of time.

Library

This shear wall building is composed of various units, built at different times but each unit is seismically separated about 2" to 3". No pounding of the units was observed; however, the joints showed evidence of movement. Portions of this building are two stories, four stories and eight stories with a penthouse.

Light diagonal cracks were observed in the lower floor shear walls.

There were literally hundreds of books thrown to the floor from the stacks. Some stacks were not anchored, some were anchored into the floor and some had a horizontal tie member at the top, and some such ties were connected to the walls or partitions. No stack is known to have overturned.

Ceiling tile, which was glued to the plaster ceiling, fell on the upper floor of the two story portion. This is of waffle slab construction. There appeared to be more damage to the ceiling tile in the column strips and essentially no tile fell within the middle strips of the slab. However, it was reported that some of the tile may have been removed by hand for safety reasons before the workers were allowed to replace the fallen books on the stack shelves.

Spring vibration isolators on the air conditioning equipment in the penthouse were destroyed on many pieces of equipment. The columns supporting the cooling tower were bent and their anchorage was broken. A cast iron "C" clamp of a pipe hanger broke and one pipe hanger became dislodged from the supporting roof beam.

Engineering Building

This is a five story shear wall building. Diagonal cracks were noted in the lower floor concrete shear walls.
North Hall

This three story shear wall building has a very interesting structural history. It was originally built in 1960/61. During a seismic study survey of the existing buildings at the university several years ago, it was noted that this building lacked proper seismic resistance. Forced vibrational studies were made by the University of California, Los Angeles by the use of shaking machines. (The design and construction of these machines had previously been sponsored by the Structural Safety Section of the Office of the State Architect.) The vibrational studies confirmed the analysis and the building was subsequently strengthened by adding reinforced concrete shear walls in both the longitudinal and the lateral directions in 1974/75.

Light diagonal cracks were noted in the walls.

This building was instrumented under the State of California Strong Motion Instrumentation Program. A total of 9 accelerometers were placed in the building. There were four on the ground floor, four on the 3rd floor and one on the roof. An unofficial uncorrected initial reading of the record by the California Division of Mines and Geology indicates peak accelerations of 47%G on the ground, 62%G on the 3rd floor and 94%G on the roof. A free-field instrument on the university site gave a peak ground motion of 37%G.

San Nicolas Residence Hall

This is an eight story shear wall building. There was light cracking noted in the lower floor walls of the building.

One elevator was in operation, the other was inoperable.

Administration Building

This is a five story plus basement shear wall building. No damage was readily visible.

Campbell Lecture Hall

This building is one story, round in plan, with a folded plate concrete roof. Following the above mentioned seismic resistance survey of the existing buildings, this building was strengthened by replacing a number of narrow windows with concrete. No damage was visible.

Anacapa Residence Hall

This is a multi-winged, two story, tiled roof, shear wall building. The various wings are seismically separated. The buildings contain a substantial number of plastered concrete block shear walls in the
corridor. It was noted that the cracking patterns were heavier in this two story building when compared to the other buildings on the site. A face shell of a concrete block was removed at the upper edge of a shear wall. The cell contained two reinforcing bars but no grout.

It was recommended to the university personnel that a complete investigation be made to determine the extent of this substandard construction.

Several panes of glass were broken.

Subsequent to the visit it was reported that more unfilled concrete block cells were found in the shear walls. Further, as a corrective measure, the concrete block walls were being removed, and at this stage, it was reported that some reinforcing dowels were of insufficient length and some reinforcing was missing. The replaced walls will be of cast-in-place reinforced concrete.

Santa Rosa Residence Hall

This residence hall construction is similar to that of Anacapa Residence Hall. The damage was also similar and the recommendation was also made to have a complete investigation made of this residence hall.

It was reported that epoxy injection repairs were scheduled for this residence hall.

Santa Cruz Residence Hall

A visit to this site was not made due to time limitations, however, it was reported that this residence hall was of similar construction to that at Anacapa and Santa Rosa Residence Halls. It was then recommended that Santa Cruz Residence Hall should also be investigated.

Subsequent to the visit it was reported that Santa Cruz Residence Hall also had unfilled concrete masonry cells in the shear walls and that the walls were being replaced with concrete.

Chemistry Building

This is a four story concrete shear wall building containing seismic separation joints. There appears to have been vertical displacement at one of the seismic joints on the fourth floor of a laboratory. Further investigation should be made to determine if indeed there is vertical displacement.

Roof mounted room ventilators supported by spring vibration isolators were displaced.
The ceiling of the lecture room contained strip ventilators, strip openings and strip light fixtures. The strip openings were covered with solid sheet metal pieces about 8\" x 18 \text{ ga} \times 48\" which was unanchored. They fell producing deep grooves in the backs of the metal seats. Plastic lenses from the light fixtures also fell. At the time of the visit the metal plates and plastic fixture covers were being replaced without any anchorage. It was recommended that these items be anchored mechanical fastenings.

**Elevators**

It is reported that there are 36 elevators on the university campus in state operated buildings. Ten of these were completely operable following the earthquake, the other 26 were inoperable. It was further reported that one elevator out of about 200 was out of service in the downtown area.

**Goleta Valley Community Hospital**

This one story hospital, built in 1964 and 1972 had no significant damage. Two hair line cracks occurred in the plaster. A chiller, weighing 10,000 pounds, in the basement was supported by vibration isolators. The isolators collapsed. A few pipes were broken. The emergency power equipment started and operated a short time even though the electric power source did not fail. Several shelves fell.

About 50 people were treated in the temporary emergency service which was set up in the parking lot. Most of the injuries were a result of items falling from shelves and glass on the floor. One person was reported taking a shower at the time of the earthquake who slipped and fell resulting in a broken neck.

**Conclusions and Recommendations**

1. Public school buildings performed very well in this earthquake as they have in all past earthquakes since the passage of the Field Act.

2. All damaged T-bar ceilings in school buildings were installed prior to the time that detail anchorage and strength requirements were adopted. It was reported that ceilings which were recently installed performed satisfactorily. It is believed that the current provisions adopted for T-bar ceilings and light fixtures will greatly reduce or eliminate the damage.

3. The unexpectedly high accelerations recorded by the strong motion instrument in North Hall clearly indicates that a complete investigation should be made of this building. This should include the geology, foundation and structure.
4. It is interesting to note that several years ago a survey was made of the seismic resistance of the buildings at the University of California, Santa Barbara. This survey disclosed that a number of buildings were deficient in seismic resistance. Two of the buildings were strengthened, they were North Hall and Campbell Hall. The remaining buildings found to be deficient have not been strengthened. The strengthening of the buildings was, no doubt, costly but saved the buildings from more costly earthquake damage.

Also, Anacapa Residence Hall and Santa Cruz Residence Halls are being reconstructed as a result of improper construction disclosed by the earthquake. It is possible that Santa Rosa Residence Hall may also have construction defects.

Since the structural performance of Field Act constructed public school buildings again proved to be quite satisfactory and no structural design nor construction defects could be detected, and since the University of California buildings did not perform well in this low magnitude earthquake, it is recommended that some means be developed to establish design and construction controls for university buildings similar to those employed for public school buildings.

Very briefly some of the highlights of the Field Act are: design must be prepared by an architect or structural engineer, plans and specifications are given an independent review by the Office of the State Architect (OSA), a fee may be charged, OSA may adopt regulations, the construction must be observed by the responsible designers, the construction must be continuously inspected by an inspector approved by the designers and the OSA, all those involved in the construction, i.e. the designers, the inspector and the contractor must provide a verified report, under penalty of perjury, indicating that the building was constructed in accordance with the approved documents, violations of the Act or false reports carry a felony penalty.
The August 13, 1978 Santa Barbara Earthquake caused relatively minor damage to three bridges in the area. The most damage was sustained by the Route 217/101 Separation-Left Bridge. It is located near the town of Goleta, approximately 7 miles west of downtown Santa Barbara. The Bridge is 660 feet long with 8 spans. It is a continuous reinforced concrete box girder structure except for two single precast-prestressed concrete I girder spans over Highway 101. The structure is partly in curve and most of the two and three column bents are sharply skewed.

All steel rocker bearings at one abutment had keeper bars sheared off on one side and some on both sides. One rocker rotated $25^\circ$ from normal. Many of the steel bearings which supported the precast-prestressed girders on three of the bents also had sheared keeper bars. Some of the fixed bearings on the bents didn't fail in themselves but the seismic forces on them caused spalling of the bent cap. The outer columns of one three column bent had concrete spalled from the upper corners next to the cap, exposing column reinforcement. One #10 corner bar was exposed for about 18 inches and bowed out about 2 inches. Most of the other columns had small incipient cracks at corresponding locations. Railings and edges of deck were spalled at abutments and expansion joints, some abutment curtain walls and wingwalls were cracked and pushed outward. Cracks as great as 3/4 inch were formed between abutments and columns and adjacent earth. Continuous cracks were formed in the earth some distance away from the columns along lines approximating the edges of the footings, indicating considerable movement of the footings. Approach fills settled behind the abutments, but the pavement sagged rather than dropping off abruptly at the paving notch. Maintenance forces filled the worst sags before measurements could be made; maximum depression was probably about 5 inches.

Local maintenance men closed the bridge to traffic almost immediately, but it was opened about 24 hours later--after it was inspected by a Bridge Maintenance Engineer. This was the only bridge on which traffic was stopped.

The Route 217/101 Separation-Right Bridge is connected to the left bridge at one end. It is 482 feet long with 6 spans. It is a continuous reinforced concrete box girder structure with one intermediate hinge. It is curved and the bents and one abutment are sharply skewed.

All steel rocker bearings at the abutments had keeper bars sheared off on one side. Most of the columns had small incipient corner spalls where the columns joined the bent caps. Spans at the hinge were offset about 2 inches laterally. Railings and edges of deck were spalled, spans were slightly dis-
placed laterally and abutment curtain walls and wingwalls were pushed outward. Earth adjacent to abutments and columns was pushed back and was cracked approximately above the edges of bent footings. Approach fills settled a few inches.

Hollister Ave. Overcrossing is 5½ miles west of the Route 217/101 Separation. It is 241 feet long with two simple precast-prestressed concrete girder spans and two simple cast-in-place concrete T-Beam spans. It is on tangent alignment with a 30° skew. All of the steel rocker bearings at one abutment had keeper plates sheared off on one side. Identical bearings at the other abutment were undamaged. The spans were shifted laterally with an offset of about one inch at one abutment. Wingwalls were pushed outward, ends of the railing were spalled at joints, and bent caps were spalled where the girders and cast-in-place diaphragms were seated. Approach fills settled slightly. This bridge is very close to where the Southern Pacific train was derailed 7 minutes after the earthquake.

A number of other bridges in the area showed signs of movement but no significant structural distress. Bridge approaches as far away as Refugio State Park, 23 miles west of Santa Barbara, required leveling. None of the numerous bridges in the City of Santa Barbara showed any sign of having been shaken.

Although the August 13, 1978 earthquake had no immediate serious consequences, two of the bridges have lost their first line of defense against following events until repairs can be made. The various degrees of damage give an interesting picture of how total collapse could ultimately occur if the structure would be subjected to sustained or more severe shaking.

Bridge damage was surveyed by the CALTRANS Post Earthquake Investigation Team on August 14-15, 1978.
SPALLED CONCRETE AND BUCKLED COLUMN BAR

ABUTMENT WINGWALL PUSHED OUTWARD

TYPICAL SPALLING OF CONCRETE RAILING
REPORT OF INSPECTION TRIP

To

UNIVERSITY OF CALIFORNIA AT SANTA BARBARA

ELEVATOR DAMAGE

On August 21, 1978 I visited the University of California at Santa Barbara to review the damage to elevators caused by the August 13, 1978 earthquake. The purpose of the trip was primarily to assess the type of damage and determine the potential of the new elevator requirements to eliminate such damage in future quakes.

The trip was arranged by Mr. William Dolby, Assistant Facilities Director of UCSB. Mr. Tom Averill of Oliver & Williams Elevator Corp. guided the inspection and was able to operate the elevators from the top of the cab. Mr. Glen W. Keese, consulting elevator engineer for the University, also inspected the elevators.

The new elevators installed within the last year were undamaged. Power was cut off by the earthquake switch. The counterweight guide rails were laterally supported at about 4'-0" on center, which precluded spreading. A novel safety feature was observed; a cable running in a zig zag pattern was installed in front of the guide rails and connected to a shut-off switch. If the counterweight left the rails, it would strike the cable and turn off the power. Since the counterweight remained on the rails, this device was not activated.

Electric Traction Elevators

There was no apparent damage to the cabs, cab rails or brackets. The major damage was limited to the counterweight rail brackets and guide devices. The elevators that were high in the building (counterweight low) were undamaged. The elevators that were low (counterweight high) were disabled; the counterweights were out of the rails and the auxiliary components were damaged.

The counterweight rails were supported at story height spacing by any of several types of brackets:

1. "U" brackets surrounding both rails and attached to the structure. Many were shimmed out for adjustment, permitting the bracket to bend from the edge of the shim instead of the angle bend point.
(2) Angle brackets with the leg connected to the wall facing in or out, and connected to the wall by concrete inserts or by Unistruts.

The brackets were bent outwardly at the location where the counterweight left the rails.

An attempt to operate the elevators after the counterweights left the guide rail resulted in further damage to the system. As the car was raised, the counterweight collided with the top corner of the car; and when the car reached the top, the counterweight smashed the protection guard in the pit. The counterweight also dislodged some of the rail support brackets. Some guide rollers were damaged. As this car was later lowered, the counterweight struck the bottom corner of the cab and caused further damage. On two elevators the top of the counterweight snagged the lower edge of a concrete bond beam; the driving motor kept running and abrading the sheave against the cables. Two sheaves were worn and will require regrooving or replacement.

Two of the counterweights twisted on the vertical axis after leaving the guide rails. One had twisted three turns; the other, only one turn. On one elevator, one of the multiple cables jumped out of the groove in the sheave.

Motor generators in overhead machine rooms were shifted laterally (they were not anchored); however I noted no displacement of the traction machinery. Motor generators in basement machine rooms were not displaced.

Bus duct cover plates that were not fastened after maintenance fell across a relay panel. Relay panels were adequately supported and braced.

Hydraulic Elevators

The only damage to hydraulic elevators was the displacement of pumping machinery and the rupture of an oil tank in a penthouse machinery room. Several elevators were inoperable because of oil leakage. Piping appeared to have sufficient flexibility to sustain movement because connections were made with Victaulic Couplings.

There were 49 elevators on the campus and 19 were disabled. It appears that the new requirement of additional support for guide rails and anchorage of machinery would prevent most or all of the damage sustained.

Leon Stein
Supervising Structural Engineer

Office of the State Architect
Los Angeles, California
North Hall
University of California Santa Barbara
Goleta, California

ACCELEROMETER
Earthquake of 13 August 1978
Epicenter: 34°22.15 North, 119°42.95 West
Depth 11.5 km

PRELIMINARY

STATE OF CALIFORNIA
DEPARTMENT OF CONSERVATION
North Hall
University of California - Santa Barbara
Goleta, CA  34.42° North; 119.96° West

Strong-Motion Instrumentation Scheme

Note: Accelerometers 1 through 6,8, attached to topside of floor slab; accelerometer 7 attached to underside of roof beam. Horizontal starter adjacent to accelerometer 6. Vertical starter and recorder adjacent to accelerometers 1,2 and 3.

Recorder trace order:

- Accelerometer 1
- Accelerometer 2
  Fixed trace
  Accelerometer 3
  Fixed trace
  Accelerometer 4
  Fixed trace
  Accelerometer 5
  Fixed trace
  Accelerometer 6
  Fixed trace
  Accelerometer 7
  Fixed trace
  Accelerometer 8
  Fixed trace

2½" rc slab supported by rc joists spanning between rc floor beams running in transverse direction; floor beams supported by 14"x10" rc interior columns and rc and masonry-block exterior columns. Designed 1960, rebuilt 1975. After strengthening rc shear walls in both directions throughout. Caissons under exterior columns; 12"x18" tie beams; 4" rc slab.
Freitas Building,
200 East Carrillo Street
Santa Barbara, California

34.423 North; 119.698 West
4 story/ half basement; 137'6" x 109'5"
Steel frame, steel decking with 2½" concrete topping.

Isolated exterior r.c. shear walls. Spread footings with uplift
 drilled helical piles under shear walls. Designed 1968; built 1970

Accelerogram of earthquake of 13 August 1978
Epicenter: 34 22.15 North, 119 42.95 West
1.9 cm = 1.0 g

Preliminary
Freitas Building
200 E. Carrillo Street
Santa Barbara, Calif.

Strong-Motion Instrumentation Scheme

Roof

4
3
2nd floor

E-W Section
137'-6"

Basement

Recorder trace order:
Accelerometer
Fixed trace
Accelerometer
Fixed trace
Accelerometer
Fixed trace
Accelerometer
Fixed trace

Note: Horizontal accelerometers at roof and 2nd floor levels to be attached to underside of slab.
Accelerometers 3, 8, 9 to be attached to topside of basement floor slab in telephonic room.
Vertical starter to be located in basement, horizontal starter to be attached to roof level.
Recorder to be located in basement.

23. Aug. 78
University of California at Santa Barbara / Coleta Free Field Accelerogram
Earthquake of 13 August 1978. Epicenter 34°22.15' North; 119°42.95' West
Station location #885 (C91), on ground in 1 story building: 34.42° North; 119.85° West
1.0 cm = 1.0 g