CITY OF FORT BRAGG

MAIN STREET FIRE STATION SEISMIC EVALUATION

I.L. Welty & Associates
Fort Bragg, CA

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EXECUTIVE SUMMARY

The City of Fort Bragg Public Facilities Master Plan (Grossman Design Group 2007), a previous study that included structural evaluations of city owned buildings, concluded that all three buildings in the Main Street Fire Station complex – the North Wing, the Offices and Crew's Rooms and the South Wing – do not satisfy the Immediate Occupancy level of performance criteria of ASCE Standard 31-03, "Seismic Evaluation of Existing Buildings" (American Society of Civil Engineers 2003). That study listed non-compliant ASCE 31 Tier 1 checklists statements and other potential deficiencies for all buildings. Most were associated with the older building, the North Wing structure, built in 1947. The study recommended a geotechnical evaluation of the site and a comprehensive evaluation of the buildings as the first steps in a structural rehabilitation program.

The methodology of ASCE 31 is a three "tiered" evaluation procedure used to determine if a building complies with acceptance criteria for a specified or chosen level of earthquake performance (Appendix I). The purpose of the evaluation procedure is to identify potential deficiencies in a building that would affect its meeting the selected level of performance. The first phase of the evaluation procedure, the Tier 1 evaluation, is a screening phase that compares observations of the structural and non-structural building components and site conditions against checklist statements. The procedure asks the evaluator to determine if the building complies or does not comply with the checklist statements, some of which are supplemented with "quick check" calculations. The Tier 1 screening process is relatively conservative and limited in detail. Those checklist items deemed non-compliant are potential deficiencies that may be found to comply with the standard's provisions through a more detailed analysis in a Tier 2 and Tier 3 evaluation.

The present study of the Fort Bragg Main Street Fire Station is a structural evaluation using the ASCE 31 Tier 2 procedures. Based on our review of the available construction documents, field observations, and analyses, it is our opinion the fire station buildings do not satisfy the criteria for the Immediate Occupancy level of performance. We also found the Offices and Crew's Rooms and South Wing buildings have few potential deficiencies compared to the North Wing building. As anticipated, we found some potential deficiencies from the Tier 1 evaluation were adequate for the calculated demands when examined using the Tier 2 procedures and we found other potential deficiencies not identified in the Tier 1 evaluation. We believe the potential deficiencies have been identified sufficiently to propose repair strategies and prepare budgetary cost estimates for those repairs. A list of deficiencies and repair recommendations for each building are included in the summary of findings.

SUMMARY OF FINDINGS

The Main Street Fire Station is comprised of three buildings that were constructed between 1947 and 1997. Each is a different type as defined in the ASCE 31 table of common building types (American Society of Civil Engineers 2003). These buildings were identified as the North Wing, the Offices and Crew's Rooms and the South Wing in the Public Facilities Master Plan (Grossman Design Group 2007).

Main Street Elevation

The primary use of North Wing and South Wing is to house fire fighting and emergency response vehicles. The Offices and Crew's Rooms building is used for operations and support activities. The Fire Station is located in a region of high seismicity as defined in ASCE 31. Based on the partial Tier 1 structural evaluations included in the Master Plan, all three buildings have potential deficiencies that would preclude their meeting the Immediate Occupancy performance level, which is the typically the desired level of performance for fire station buildings.

Two performance levels are defined in ASCE 31: Immediate Occupancy (IO) and Life Safety (LS). Although buildings that comply with the criteria for Immediate Occupancy are expected to experience damage in an earthquake, "the damage is not life-threatening, so as to permit immediate occupancy of the building after a design earthquake, and ...the damage is repairable while the building is occupied" (American Society of Civil Engineers 2003, p.1-9). Buildings that comply with the Life Safety level of performance criteria are expected to be damaged, but partial or total structural collapse is avoided and damage to nonstructural components is non-life threatening.

Although the primary focus of our effort was the Tier 2 evaluation, we also reviewed documents and drawings pertaining to the Fire Station in the city's files, made visual inspections to determine if the buildings were constructed as depicted in the drawings (noting differences where they occurred) and revisited the Tier 1 primary and supplementary checklist evaluation statements. We then performed a Tier 2 structural analysis of each building using the ASCE 31 Linear Static Procedure to evaluate the potential deficiencies. Based on this work, it is our opinion that, to varying degrees, the buildings do not satisfy the ASCE 31 acceptance criteria for the Immediate Occupancy performance level. Nevertheless, we believe structural improvements "typical" for the building type can be made to portions of the buildings to mitigate the deficiencies. We also believe the modifications to the Offices and Crew's Rooms building and the South Wing can be made with minimal impact on use of the building except for remedying the liquefiable soils. Structural improvements required to make the North Wing comply with the acceptance criteria are more substantial and will result in a temporary loss of use of the building and may also impact the occupants of the Offices and Crew's Rooms. The underlying liquefiable soils also affect the building performance. Earthquake induced differential settlements could render the buildings unusable. Consequently, we recommend a method of soil treatment (soil grouting) be used for all buildings. A prioritized list of recommended improvements and conceptual cost estimates are included in our recommendations for each building.

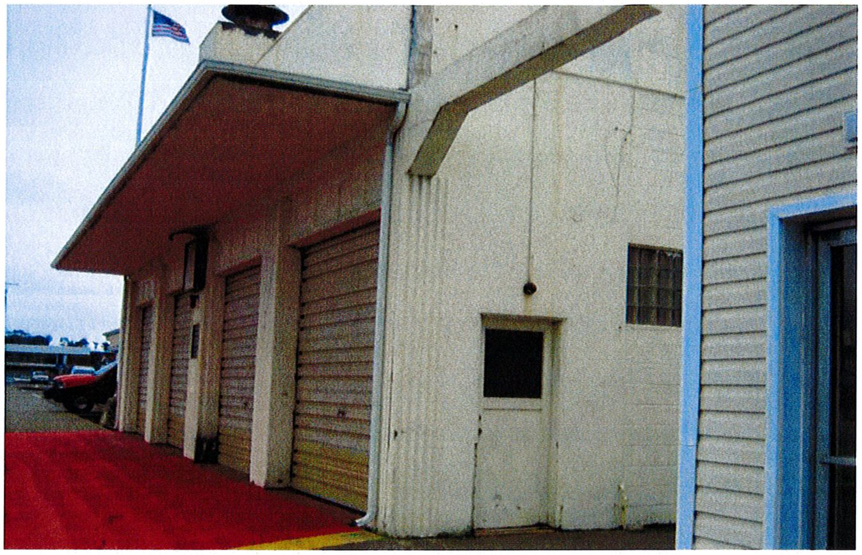
NORTH WING

The North Wing is the oldest building in the Main Street Fire Station complex. It is the north most of the three buildings and is a single story structure that was constructed in 1947 (assumed from the plaque on the front of the building). The ASCE 31 building type 13: Reinforced Masonry Bearing Walls with Flexible Diaphragm (RM1) best describes the structure. The building consists of two distinct portions: the eastern portion called the North Apparatus Room, an open plan structure which contains four engine bays and an area to the west ("rear area" in the Facilities Master Plan Report) whose rooms house support functions/activities. The Apparatus Room roof is approximately 14 feet above the floor elevation and the rear area roof is approximately 12 feet above the floor elevation. We found a single drawing for a roof replacement/renovation of the North Apparatus Room dated June 1972 (Griffiths). The renovation shows the addition of plywood sheathing over the existing roof deck. We found no drawings of the original construction.

The North Wing has concrete masonry unit (CMU) shears walls on the north, south and west exterior walls and the interior wall between the North Apparatus Room and the rear area.

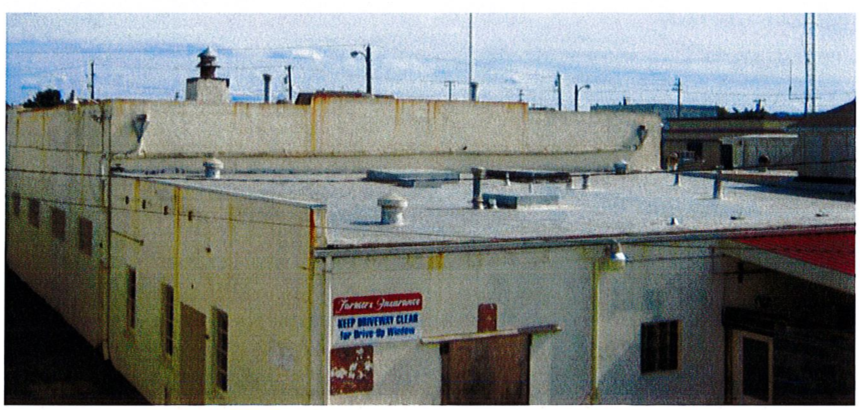
North Wall. Openings in Masonry Wall

The east wall is a reinforced concrete frame. This frame is tied to the front wall of the building to the north (the former police station) by a concrete beam near the roof level.



Concrete Frame and Tie Beam on East Wall

The shear walls and frame are the vertical elements of the building's lateral force resisting system. The vertical elements transfer the lateral forces in the plane of the roof to the foundation, and, in bearing wall buildings like the North Wing, also support gravity (vertical) loads. We assumed in our analysis that the concrete frame is the lateral force resisting element, but the frame was likely designed for gravity loads only and the masonry wall of the adjacent building was designed to resist lateral forces from both buildings. The walls extend above the roof level to form parapets around the perimeter of the building and between the Apparatus Room and the rear area.



West Elevation

There are many openings in the masonry walls, especially on the north side of the building. As a result, the capacity of the walls to resist lateral forces is limited by the length of the full height segments and the reinforcing detailing around the wall openings. Resistance to lateral forces in the direction parallel to the wall will be concentrated in the longer, stiffer segments and reinforcing along the length of the wall is required to transfer or "collect" the forces generated in one portion of the building to the stiffer segments. On the north wall line for example, the longest wall segment is near the west end of the rear area. Based on its length, this segment should resist approximately half the lateral force on the line. However, collector reinforcing would have to be provided to account for the change in roof height between the building segments. If the collector element is lacking, the force in the narrow segments will be larger and may exceed the capacity of the wall.

These openings also affect the performance of the building when subjected to lateral loads out-of-plane. Resistance to seismic loads in the direction perpendicular to the walls is a special concern in RM1 buildings. Large inertial forces due to the mass of the masonry walls must be resisted by the walls in bending between supports at the roof and the foundation. We determined that a minimal amount of vertical wall reinforcing is needed to satisfy the out-of-plane load requirements specified in ASCE 31. The amount of reinforcing provided is more critical in walls with openings because resistance to out-of-plane forces are concentrated in the full height segments. More vertical reinforcing is required each side of openings to provide the necessary bending strength in the full height segments. Additional horizontal reinforcing is also required above and below the opening in the wall to provide the strength for these segments to span between the full height segments. Lacking original construction documents and given the age of the building, a program of nondestructive testing would be required to determine the amount and distribution of vertical and horizontal reinforcing that is in the walls. We did not perform this testing because both the 1977 and 1997 project drawings indicate the city plans to demolish the North Wing and replace it with a new structure in the future. We mention the need for testing because it should be considered in any plan to rehabilitate the North Wing.

The roofs of the North Apparatus Room and the rear area are sheathed with tongue and groove lumber perpendicular to supporting wood joists (Apparatus Room) and wood trusses (rear area). The roofs are the horizontal elements (diaphragms) of the lateral force resisting system. Their function is to transfer lateral forces in the plane of the roof to the vertical elements in addition to supporting gravity loads. Straight sheathed lumber diaphragms are very flexible and have little in-plane shear capacity compared to plywood sheathed diaphragms. Straight sheathed diaphragms typically are not used in combination with masonry or concrete structures in regions of high seismicity because the lateral seismic forces associated with these buildings often exceed the capacity of these diaphragms. The Apparatus Room roof diaphragm is supported by wood joists that span between steel girders vertical elements on the interior to the east wall and the interior shear wall.

Roof Framing in North Apparatus Room

We could not determine if plywood sheathing was installed over the lumber sheathing as shown in the 1972 roof modification drawing. The rear area roof diaphragm is supported by field-built wood trusses that span in the east-west direction.

Roof Trusses in Rear Area

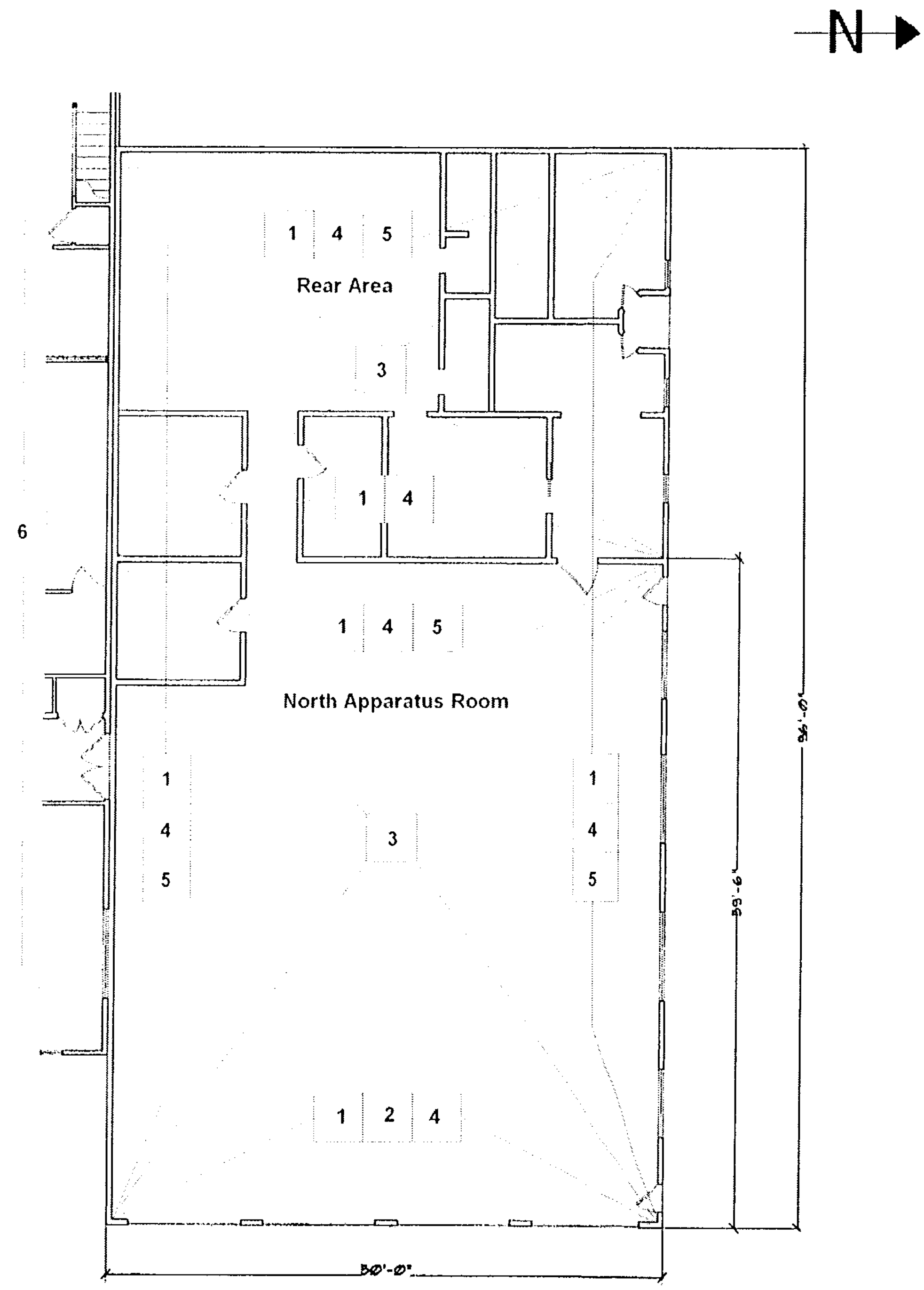
There were very few connections between the roof framing and wall in both portions of the building.

This lack of connection is a reason RM1 type buildings have performed poorly in past earthquakes. Connections between the walls and roof transfer the out-of-plane lateral forces into the roof diaphragm and the diaphragm distributes these forces to the vertical lateral force resisting elements. It is also necessary to have continuous cross ties (interconnected framing members in the roof) to keep the walls from separating from the roof. The steel beams in the Apparatus Room are the only continuous roof elements.

This building fared worse than the others in our evaluation. We found this building did not satisfy the Immediate Occupancy or Life Safety performance levels. In addition, we believe there is a risk of partial collapse due to a failure of the out-of-plane connection between the wall and roof and shear failure of the concrete frame columns. However, the potential deficiencies listed below are not atypical for a building of this type and age:

1. Inadequate out-of-plane ties between CMU walls and concrete frame and the roof. There is no positive connection between the walls and the roof diaphragm in the east-west direction (verified by observation). Steel girders connected to concrete column on the north and south walls of the North Apparatus Room provide a means of transferring load to the roof diaphragm. However, the framing on top of the steel beams is unsheathed and connections to the steel beam were not apparent. Ledger connections to the walls were not apparent. No other wall ties were observed. Cross ties are present in the north-south direction of the North Apparatus Room (steel girders approximately 14 feet on center). There are none in the east-west direction and there are no connections of roof framing to walls to transfer wall out-of-plane forces to the roof diaphragm. There are no cross ties in the rear area.
2. Non-ductile concrete moment frame at east (front) elevation. Most of the non-compliant checklist statements are reinforcing detailing requirements such as transverse tie spacing, bar hooks and bar splices that were not requirements at the time of construction. Historically, failures of reinforced concrete columns without closely spaced transverse reinforcing ties have occurred when the column deforms in an earthquake. Furthermore, the original design may have relied on the masonry walls of the building to the north for the lateral system and the concrete frame may have been designed for gravity loads only.
3. Inadequate shear strength in the roof diaphragm. The straight sheathed diaphragm does not have adequate capacity for the demands in either direction for both the North Apparatus Room and the rear area. The plywood overlay on the North Apparatus Room, if installed, does not have adequate capacity for the demands in either direction.
4. Inadequate in-plane shear transfer capacity between the roof diaphragm and CMU walls and concrete moment frame. Few connections between ledgers or edge members and shear walls were observed. Connections between the roof diaphragm boundary members and shear walls were not observed.

5. Inadequate in-plane shear capacity in CMU walls. The non-compliant statements from the Tier 1 checklists were based on the assumption that the walls were likely to have minimal reinforcing and the walls have large openings. The wall reinforcing may also be inadequate to resist out-of-plane loads in bending.
6. No seismic separation with adjacent construction. The 1977 plan drawings show no gap between the north wall of the Offices and Crew's Rooms building and the concrete columns on the south wall of the North Apparatus Room. Drawings of 1997 addition show the new wood framing built up against the CMU walls. This condition was confirmed by observation.



1 Deficiency item number

North Wing Potential Deficiencies

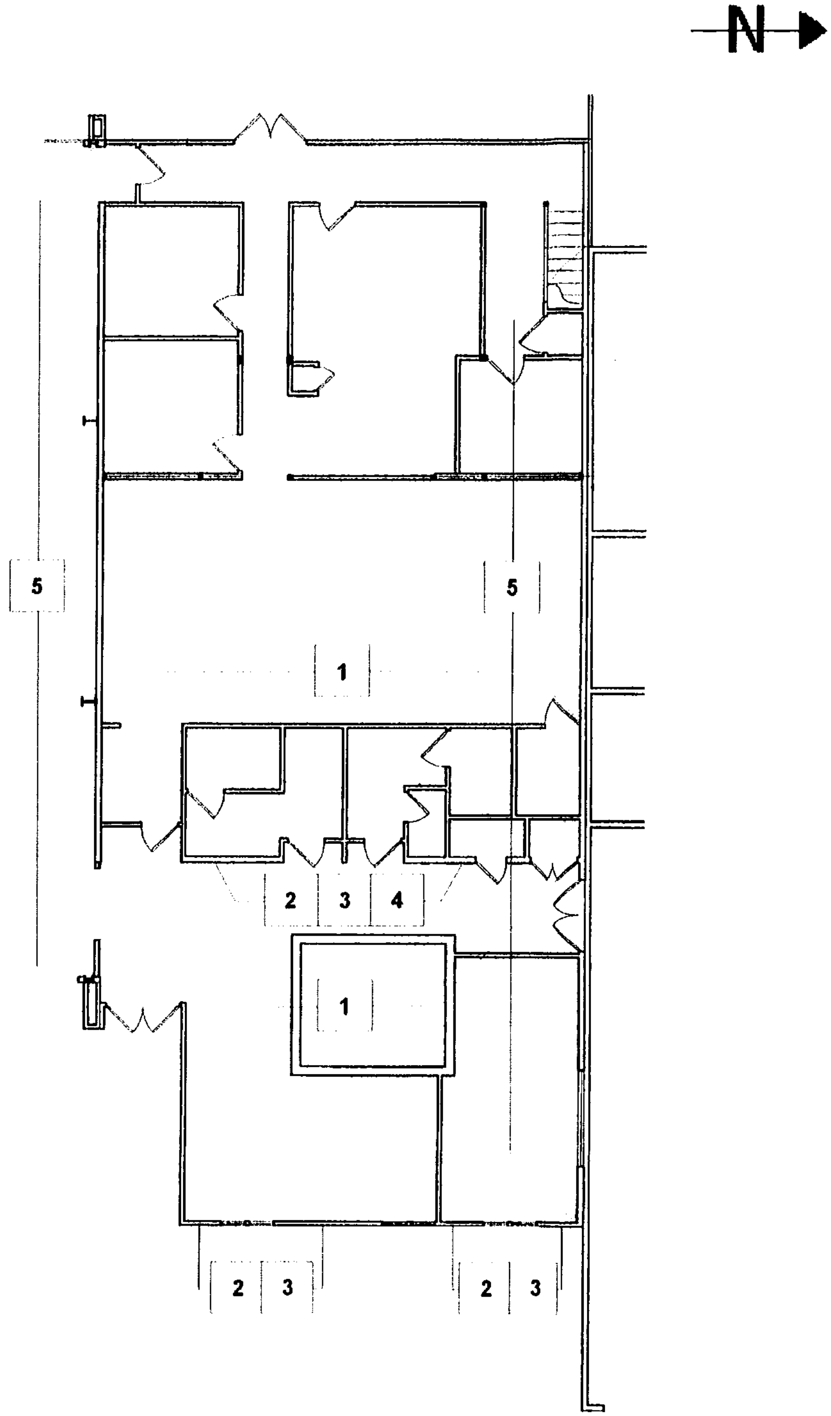
OFFICES AND CREW'S ROOMS

The Offices and Crew's Rooms building is located between the North Wing and South Wing. It is a one and two story building of wood framed construction with plywood diaphragms and shear wall. The building is classified as an ASCE 31 building type 1: Wood Light Frames (W1). The one story portion fronts on Main Street and contains offices, operations and meeting rooms. It was constructed in 1977 based on two sets of drawings that depict the one story portion (Griffiths 1977; City of Fort Bragg Fire House 1977). The two story portion is an addition on the west end of the one story portion.

Offices and Crew's Rooms West Elevation

It contains a kitchen and offices on the first floor and a dormitory and exercise room on the second floor. It was constructed in 1997 according to the available drawings (Taubold 1997). Based on our evaluation of the building, the following are potential deficiencies that would need to be resolved to satisfy the criteria for the Immediate Occupancy level of performance:

1. Both lines of north-south interior shear walls are not connected to the roof diaphragm. The 1977 construction drawings call for the interior shear wall on the through corridor to be extended to the roof. The wall does extend to the roof but the blocking between roof trusses is not connected to the wall. The 1997 construction added another wall to the west, we assume to compensate for removing some of the existing wall on the through corridor. There was no detail showing this new wall's connection to the roof. The wall does not extend above the bottom of the trusses and there are no panels or infill between trusses to transfer forces from the roof to the top of the wall.
2. The 1977 construction likely lacks foundation hold-downs at the ends of shear walls. The foundation plan and details and the framing plans and sections do not show hold-downs at the ends of plywood sheathed shear walls. Based on our analysis, the shear walls at the front of the building and the interior shear walls on the west side of the north-south through corridor require hold-downs.
3. The 1977 construction likely lacks sufficient anchor bolts at shear walls. The 1977 and 1997 drawings show anchor bolts in walls at 4 feet on center. Based on our analysis, the shear walls at the front of the building and the interior shear walls on the north-south through corridor do not have the required anchor bolts to transfer the wall shear to the foundation.
4. The interior shear walls on the north-south through corridor do not have adequate shear capacity.
5. There are no seismic separations between this and the two adjacent buildings. The north wall of the Offices and Crew's Rooms are built against the south wall of the North Wing. The roof diaphragm of the one story portion abuts the south wall of the North Wing. The buildings will move laterally in an earthquake and may impact each other and create additional loads in the structure and possible damage. The south wall is common to both the Offices and Crew's Rooms and the South Wing and poses a similar problem.



1 Deficiency item number

Offices and Crew's Rooms Potential Deficiencies

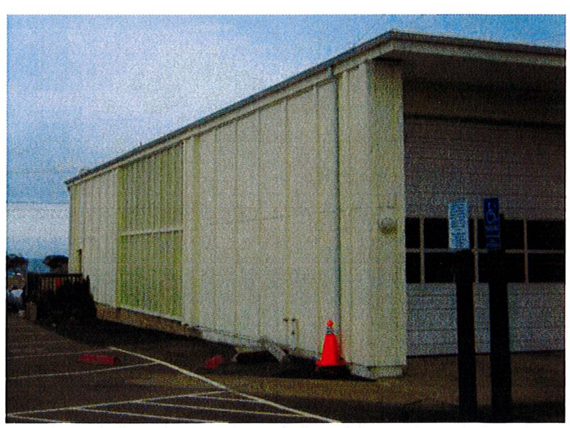
SOUTH WING

The South Wing is a single story, open structure that contains three engine bays. The building was constructed in 1977 at the same time as the one story portion of the Offices and Crew's Rooms and is included in those two sets of drawings. The South Wing's structural systems are steel frames and wood framed walls. The ASCE 31 Building Type 5: Steel Light Frames (S3) and Building Type 2: Wood Frames, Commercial and Industrial (W2) checklists were used to evaluate this building. These structural systems support vertical and lateral loads. In the north-south direction, there is a three-bay steel frame on the east and west ends and two steel arch frames that span the width of the building on the interior.

South Wing West Elevation

South Wing Interior Frames

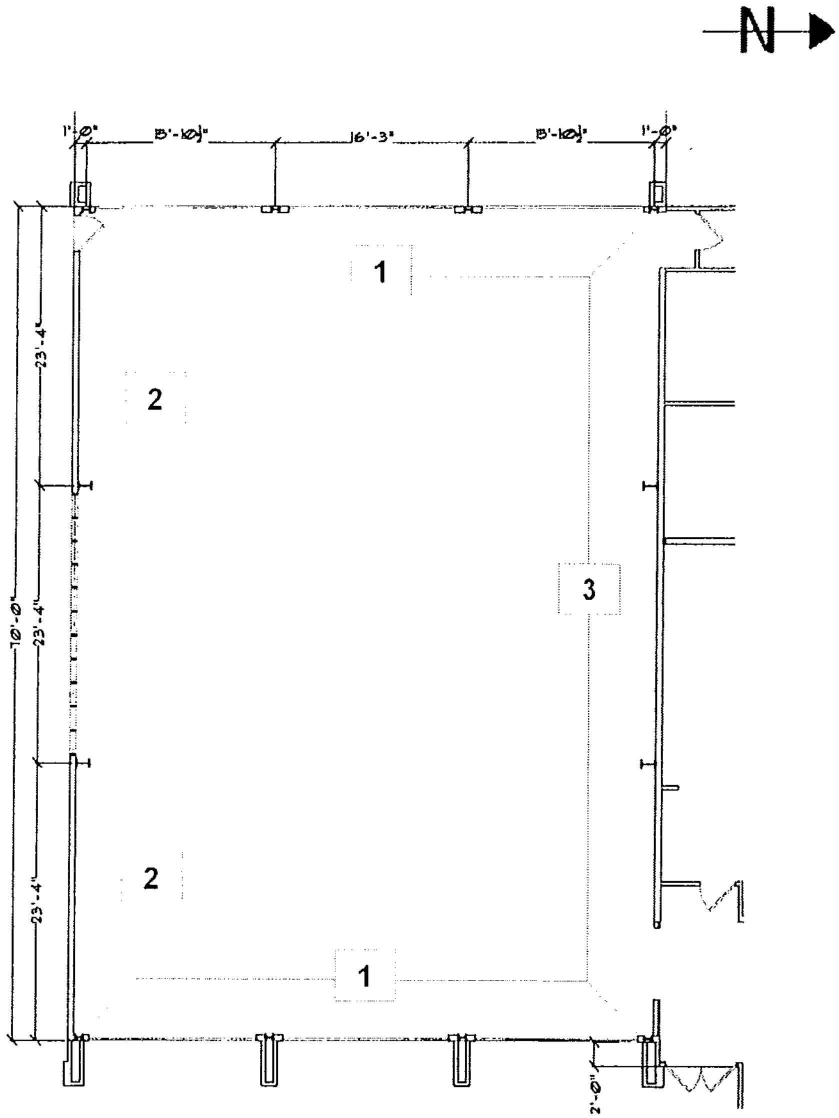
Full height wood framed walls on the north and south side run the length of the building in the east-west direction.



South Wing

The north wall appears to be sheathed with plywood most of its length. It is a common structural element of the South Wing and the Offices and Crew's Rooms. Two segments of the south wall are sheathed with plywood. The length of sheathed segments is approximately two thirds the total wall length. The north and south walls have steel rod bracing in one frame bay. The roof diaphragm is plywood sheathing on wood joists that span between the steel frames. Based on our evaluation of the building, the following are potential deficiencies that would need to be resolved to satisfy the criteria for the Immediate Occupancy level of performance:

1. The steel gravity frames on the east and west elevations may permanently deform and block egress from the building.
2. The plywood sheathed wall segments on the south side require hold-downs at the ends.
3. There is no seismic separation between the South Wing and the Offices and Crew's Rooms building.



1 Deficiency item number

South Wing Potential Deficiencies

RECOMMENDATIONS

The improvements we propose are intended to correct the deficiencies identified in the evaluation process. We have chosen to end the ASCE 31 Evaluation process because we believe the potential deficiencies have been adequately identified and continuing to a Tier 3 evaluation will not change our findings or recommendations. Most of the improvements we propose are typical for seismic rehabilitations of similar buildings. We have suggested alternate concepts for major repairs. Still, an engineered design and construction documents must be prepared for the improvements, and some as-built conditions and material properties need to be determined for the North Wing repairs. Because ASCE 31 is an evaluation standard and not appropriate for design, we recommend the improvements be designed to using the 2007 California Building Code.

We have provided cost estimates for the proposed structural improvements that are suitable for planning and developing an overall project budget. We have used two estimating methods, as appropriate for the level of detail of the proposed improvements. For example, we have provided a square foot cost for the North Wing because there are a number of improvements required to rehabilitate the structure and there are alternate rehabilitation concepts to consider. Typically, the square foot cost is used at this conceptual stage. We did not use the square foot method to estimate the cost of the proposed structural repairs to the Offices and Crew's Rooms building and the South Wing because the relatively small amount of work is limited to specific locations in the buildings. Nevertheless, the estimates for these two buildings, although based on more detail, are for conceptual repairs that must be refined by a design. Design fees and project management costs are included in the project budgetary cost estimate at the end of this section.

Regardless of the method used to estimate the repair costs, there are other factors that will have to be considered when developing an overall project construction cost estimate. Some of these considerations are code-mandated nonstructural improvements (accessibility requirements, energy efficiency requirements), modernization or replacement of building systems, functional changes desired by the occupants, abatement of hazardous materials and the relocation of occupants to temporary facilities. The project budgetary cost estimate includes allowances for hazardous materials abatement, relocating building occupants and restoring building finishes.

NORTH WING

The North Wing requires significant upgrades to the structural systems. In addition, should the city choose to rehabilitate this building, there will be a significant cost and impact to the Offices and Crew's Rooms building to create a seismic separation between the two. The following are proposed repairs and alternate schemes, listed in descending order of priority:

1. Brace the tops of the CMU walls and concrete frame for out-of-plane loads and strengthen the roof diaphragm of the North Apparatus Room and the rear area (no alternative). These repairs address deficiencies 1, 3 and 4. Work scope items are
   a. Add ties between the walls and roof around the perimeter of both the North Apparatus Room and the rear area.
   b. Add continuous cross ties in the east-west direction of the North Apparatus Room.
   c. Add continuous cross ties in the north-south and east-west direction of the rear area.
   d. Remove the existing roof sheathing and replace with new structural wood panel (plywood or oriented strand board) sheathing.
   e. Add blocking and special nailing at boundaries of diaphragms and subdiaphragms.
   f. Add in-plane shear transfer connections between the walls and roof.
2. Strengthen the in-plane shear capacity of the east wall (one of the methods below). This repair addresses deficiency 2.
   a. i.) Add a steel braced frame in a frame bay.
      ii.) Fill in a frame bay with a reinforced concrete shear wall.
      iii.) Add a steel moment resisting frame to back the concrete frame.
      iv.) Add a fiber reinforced polymer (FRP) overlay on the concrete frame.
   b. Strengthen the foundation to resist shear and overturning forces.[1]
   c. Remove concrete beam between the North Apparatus Room and the

adjacent building to the north.

3. Strengthen the exterior walls and the interior wall between the North Apparatus Room and the rear area for out-of-plane seismic forces. Add vertical structural steel "strong backs" between the foundation and roof each side of window openings.[1] This repair addresses deficiency 5.
4. Strengthen the exterior and interior CMU shear walls for in-plane seismic forces (one of the methods below).[1] This repair addresses deficiency 5.
   a. Add steel braced frames and new foundations on the interior.
   b. Add reinforced concrete shear walls and new foundations on the interior.
5. Improve shear transfer from the CMU walls to the foundation.[1] Add structural steel angles at the base of the wall with epoxy set anchors in the wall and foundation. This repair addresses deficiency 5.

Our estimate for the structural repairs outlined above is approximately $60 per square foot. We used the FEMA Structural Rehabilitation Cost Estimator (Federal Emergency Management Agency 2009) to determine this cost. This estimate is for a project in California in 2002 dollars. Adjustments for location and time may need to be applied to this cost. The cost to remediate the liquefiable soils is not included in the above figure. However, it is included in the project budgetary cost estimate. Actual costs of completed rehabilitation projects of buildings similar to the North Wing in the FEMA data base ranged from approximately $80 per square foot to $120 per square foot. Descriptions of these projects and FEMA estimates may be found in Appendix II.

[1] Nondestructive testing is required to determine masonry strength, the amount of reinforcing in the wall and the anchorage between the wall and the footing.

OFFICES AND CREW'S ROOMS

The repairs we propose for the Offices and Crew's Rooms are required at specific locations in the building. We believe most of these repairs are relatively simple to make and require no alternative.

1. Connect the two north-south interior shear walls to the roof diaphragm. These repairs address deficiency 1. Work scope items are
   a. Add plywood sheathed blocking panels between existing roof trusses above the east wall of the Meeting Room/Day Room. Nail the roof sheathing to the top of the blocking panels.
   b. Connect the walls to the existing blocking on the west side of the north-south through corridor. Nail the roof sheathing to the blocking.
2. Add hold-downs on the ends of four shear walls on the east exterior wall and two shear walls on the west side of the north-south through corridor. These repairs address deficiency 2.
3. Add epoxy anchors in the sill plates of four shear walls on the east exterior wall and two shear walls on the west side of the north-south through corridor. These repairs address deficiency 3.
4. Add edge nailing to the two shear walls on the west side of the north-south through corridor. This repair addresses deficiency 4.
5. Provide seismic separations from the adjacent buildings at the roof level (1 story portion) and the second floor level (2 story portion).

Our estimate for the cost structural repairs outlined above is approximately $80,000.00 in current dollars. We used Means Building Construction Cost Data (2007) to prepare this estimate. It includes an adjustment for project location. A separate cost to remediate the liquefiable soils is included in the project budgetary cost estimate.

SOUTH WING

The repairs we propose for the South Wing are required at specific locations in the building. We believe most of these repairs are relatively simple to make and require no alternative.

1. Weld cover plates on the east and west steel frame columns to create box sections. Separate the wood framing from the columns and reframe the wood sheathed enclosure around the column and make the support for the roll up doors independent from the steel frame. These repairs address deficiency 1.
2. Add hold-downs on the ends of the two shear wall segments on the south wall. This repair addresses deficiency 2.
3. Provide a seismic separation at the north wall. These repairs along with the repair in the Offices and Crew's Rooms building address deficiency 3.
    a. Block out the wood framed wall at the interior frame columns.
    b. Add hold-down at the ends of the remaining shear wall segments.

Our estimate for the cost structural repairs outlined above is approximately $52,000.00 in current dollars. We used R.S. Means Building Construction Cost Data to prepare this estimate. It includes an adjustment for project location. A separate cost to remediate the liquefiable soils is included in the project budgetary cost estimate.

Project Budgetary Cost Estimate

Item	North Wing	Offices and Crew's Rooms	South Wing	Line Total
Structural Improvements	$403,200 (1)	$80,000	$52,000	$535,200
Soil Grouting				475,000
Restore Finishes(2)	108,000	98,000	57,000	263,000
Remove and Replace Roof(3)	25,300			25,300
Hazardous Material Abatement(4)				57,000
Fire Sprinkler System	15,000			15,000
Subtotal				1,370,500
15% Contingency				205,600
Relocation Allowance(5)				10,000
Professional Fees(6)				95,900
Construction Management(7)				54,800
Project Total				$1,736,800

Notes

1. Total determined using the FEMA Seismic Rehabilitation Cost Estimator Q3 square foot cost increased 5% to 2009 dollars

2. Totals based on square foot costs as follows: $15/SF North Wing Apparatus Room and South Wing; $35/SF North Wing Rear Area and first floor Offices and Crew's Rooms

3. Roofing work included in structural improvements for the Offices and Crew's Rooms and the South Wing

4. Estimated as 5% of building ground floor area

5. Cost does not include rent/lease for interim facility

6. Approximately 7% of subtotal

7. Approximately 4% of subtotal

REFERENCES

American Society of Civil Engineers (2003). Seismic Evaluation of Existing Buildings, ASCE/SEI 31-03. American Society of Civil Engineers, Reston, VA.

City of Fort Bragg Fire House (October 27, 1977). [Fort Bragg, CA], sheets A-1 through A-9.

Federal Emergency Management Agency. "Seismic Rehabilitation Cost Estimator". <http://www.fema.gov/srce/> (February 19, 2009).

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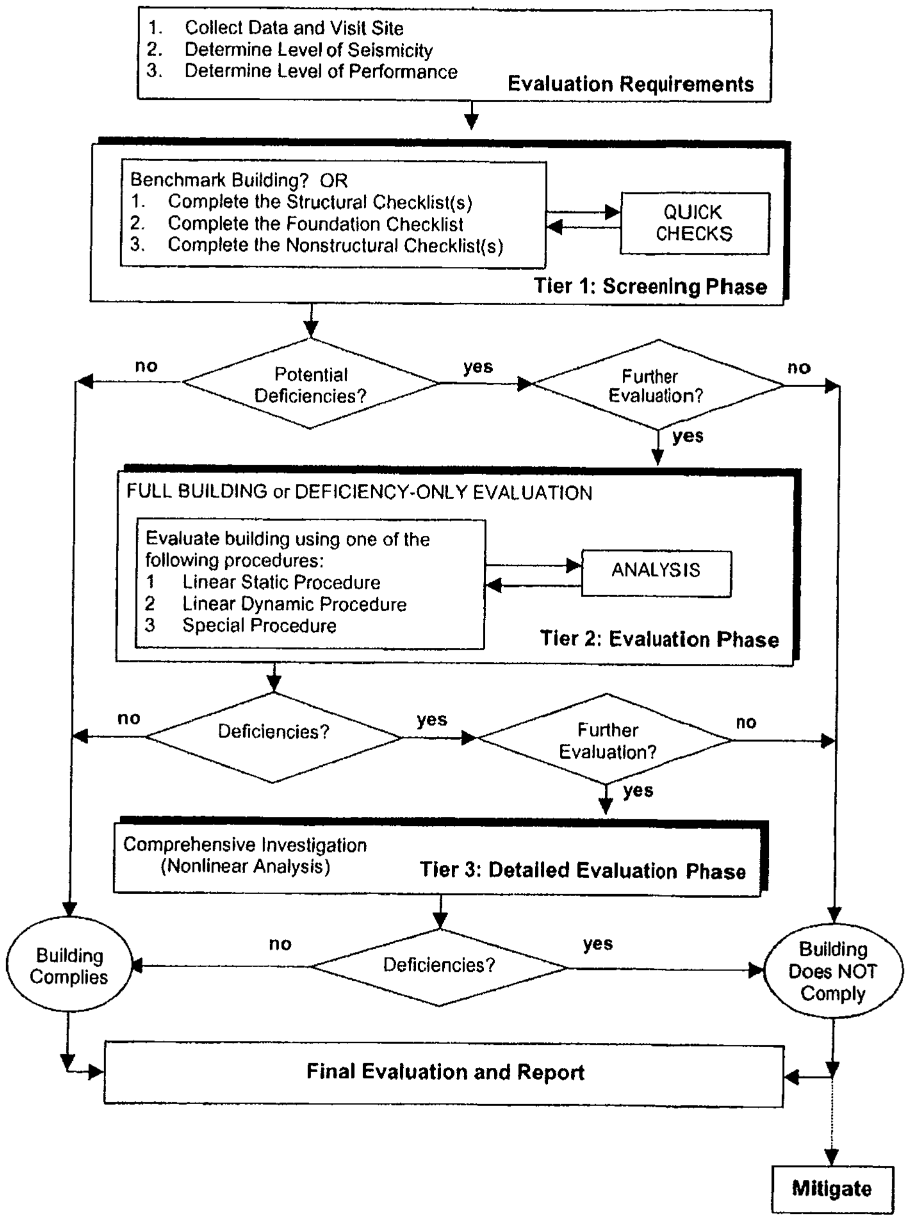
Taubold, E., Architect (February 24, 1997). A Remodel for Fort Bragg Fire-House. Fort Bragg, CA, sheets A1 through A13, E1, M1 and S1.

APPENDIX I: THE ASCE 31 EVALUATION PROCESS



Modified from ASCE Standard 31-03
Seismic Evaluation of Existing Buildings

APPENDIX II: FEMA STRUCTURAL REHABILITATION COST ESTIMATOR

Figure 1. NORTH WING COST REPAIR ESTIMATE USING FEMA CALCULATOR

Seismic Rehabilitation Cost Estimator

Detailed estimation method, Form Entry mode

Terminal node 43
Restart

FEMA recommends using both cost estimation methods to validate results. This estimate used the Detailed estimation method. Click here to restart.

Final Estimate for location California in **2002 dollars**:

$59.34 / sqft

50% of buildings in this node have a cost between $50.64 and $79.66

Q1: $50.64
Q3: $79.66
QR: 1.872

Number of building used in this estimate: 30
View buildings
Comprehensive datasheet for this node(PDF)

Figure 2. ACTUAL COST OF SIMILAR BUILDING (EXAMPLE 1)

FEMA FEMA

Seismic Rehabilitation Cost Estimator

Data for building 496
Back | Restart

Field	Value
ID	496
County	KELLEYLAKE
State	BC
Zone	Moderate
NEHRP/UBC Soil Type	S1
Num stories above grade	1
Num stories below grade	0
Total Area (sq. ft.)	4160.0
Approx. Year of Original Construction	1965
Model Building Type (before rehab)	reinforced masonry w/ metal or wood diaphragm
Historic building controls?	No
Base Year for Costs	1992
TOTAL CONSTRUCTION COSTS (1999 dollars)	$391,000.00
TOTAL CONSTRUCTION COSTS (2002 dollars)	$489,856.53
Source of cost	study
Overall scope of non-seismic work	minimum work required
Added space (sq. ft.)	0.0
Performance Objective	immediate occupancy
Rehabilitation Method 1	added shear walls
Rehabilitation Method 2	modified existing walls
Rehabilitation Method 3	strengthened diaphragm
Rehabilitation Method 4	URM or tilt-up wall ties
Rehabilitation Method 5	
Rehabilitation Method 6	
Non-seismic work included in construction cost:	
asbestos/hazardous material removal	No
disabled access	No
system improvements (arch., MEP)	No
repair of damage/deterioration	No
Condition of occupancy	vacant
Scope of seismic rehabilitation	
1 Structure	included in cost
2 Exterior falling hazards	evaluated and OK

3 Selected interior nonstructural	not evaluated
4 All interior nonstructural	not evaluated
STRUCTURAL COSTS (total of 1 & 2 including contractors overhead and profit)	190000.0
Estimate of uncertainty in data provided:	
Area	good (< 5%)
Total Construction Cost	poor (> 10%)
Structural Cost	poor (> 10%)
Non-Construction Project Costs:	
occupant relocation	$0.0
A & E fees, testing, permits	$43000.0
project management	$0.0
Duration of construction (months)	0
Construction Costs:	
repair of damage or deterioration	$0.0
hazardous material removal	$0.0
disabled access	$0.0
system improvements	$0.0
nonstructural mitigation	$0.0
Plan shape	rectangular
Base Dimensions	130.0 by 32.0
Typical Floor Plan Dimensions	130.0 by 32.0
Story Height	18.0
Total Height	18.0
Roof Framing (2nd Floor+)	wood joists / gluelams
Floor Framing (2nd Floor+)	
Diaphragms	wood (sheathing or plywood)
Exterior Non-Load Bearing Cladding	N
Evidence of Settling?	No
Condition of Building?	good
Column Type	
Bearing Walls Type	reinforced masonry
Foundations	spread footings
Longitudinal Lateral System	shear walls
Tranverse Lateral System	shear walls
Code or Design Guideline Used for Rehabilitation	1990 NBCC (I=1 5)
Special features (irregularities, interior partitions, etc)	
Rehabilitation Work Completed	

Figure 3. ACTUAL COST OF SIMILAR BUILDING (EXAMPLE 2)

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Seismic Rehabilitation Cost Estimator

Data for building 505
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Field	Value
ID	505
County	INGLEDOW
State	BC
Zone	High
NEHRP/UBC Soil Type	S1
Num stories above grade	1
Num stories below grade	0
Total Area (sq. ft.)	2640.0
Approx. Year of Original Construction	1966
Model Building Type (before rehab)	reinforced masonry w/ metal or wood diaphragm
Historic building controls?	No
Base Year for Costs	1992
TOTAL CONSTRUCTION COSTS (1999 dollars)	$196,000.00
TOTAL CONSTRUCTION COSTS (2002 dollars)	$245,554.68
Source of cost	study
Overall scope of non-seismic work	minimum work required
Added space (sq. ft.)	0.0
Performance Objective	immediate occupancy
Rehabilitation Method 1	added shear walls
Rehabilitation Method 2	strengthened diaphragm
Rehabilitation Method 3	URM or tilt-up wall ties
Rehabilitation Method 4	
Rehabilitation Method 5	
Rehabilitation Method 6	
Non-seismic work included in construction cost:	
asbestos/hazardous material removal	No
disabled access	No
system improvements (arch., MEP)	No
repair of damage/deterioration	No
Condition of occupancy	
Scope of seismic rehabilitation	
1 Structure	included in cost
2 Exterior falling hazards	not evaluated

3 Selected interior nonstructural	not evaluated
4 All interior nonstructural	not evaluated
STRUCTURAL COSTS (total of 1 & 2 including contractors overhead and profit)	116000.0

Estimate of uncertainty in data provided:	
Area	good (< 5%)
Total Construction Cost	poor (> 10%)
Structural Cost	poor (> 10%)

Non-Construction Project Costs:	
occupant relocation	$0.0
A & E fees, testing, permits	$21000.0
project management	$0.0

Duration of construction (months)	0
Construction Costs:	
repair of damage or deterioration	$0.0
hazardous material removal	$0.0
disabled access	$0.0
system improvements	$0.0
nonstructural mitigation	$0.0

Plan shape	rectangular
Base Dimensions	90.0 by 29.0
Typical Floor Plan Dimensions	90.0 by 29.0
Story Height	12.0
Total Height	12.0
Roof Framing (2nd Floor+)	wood joists / gluelams
Floor Framing (2nd Floor+)	
Diaphragms	wood (sheathing or plywood)
Exterior Non-Load Bearing Cladding	N
Evidence of Settling?	No
Condition of Building?	good
Column Type	
Bearing Walls Type	reinforced masonry
Foundations	spread footings
Longitudinal Lateral System	shear walls
Tranverse Lateral System	shear walls
Code or Design Guideline Used for Rehabilitation	1990 NBCC (I=1 5)
Special features (irregularities, interior partitions, etc)	
Rehabilitation Work Completed	

Figure 4. ACTUAL COST OF SIMILAR BUILDING (EXAMPLE 3)

FEMA FEMA

Seismic Rehabilitation Cost Estimator

Data for building 823
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Field	Value
ID	823
County	SANFRANCISCO
State	CA
Zone	Very High
NEHRP/UBC Soil Type	S4
Num stories above grade	1
Num stories below grade	0
Total Area (sq. ft.)	4800.0
Approx. Year of Original Construction	1960
Model Building Type (before rehab)	reinforced masonry w/ metal or wood diaphragm
Historic building controls?	No
Base Year for Costs	1993
TOTAL CONSTRUCTION COSTS (1999 dollars)	$309,000.00
TOTAL CONSTRUCTION COSTS (2002 dollars)	$387,124.47
Source of cost	study
Overall scope of non-seismic work	minimum work required
Added space (sq. ft.)	0.0
Performance Objective	immediate occupancy
Rehabilitation Method 1	added braced frames
Rehabilitation Method 2	strengthened foundations
Rehabilitation Method 3	
Rehabilitation Method 4	
Rehabilitation Method 5	
Rehabilitation Method 6	
Non-seismic work included in construction cost:	
asbestos/hazardous material removal	No
disabled access	No
system improvements (arch., MEP)	No
repair of damage/deterioration	No
Condition of occupancy	vacant
Scope of seismic rehabilitation	
1 Structure	included in cost

2 Exterior falling hazards	evaluated and OK
3 Selected interior nonstructural	evaluated and OK
4 All interior nonstructural	not evaluated
STRUCTURAL COSTS (total of 1 & 2 including contractors overhead and profit)	309000.0
Estimate of uncertainty in data provided:	
Area	good (< 5%)
Total Construction Cost	poor (> 10%)
Structural Cost	poor (> 10%)
Non-Construction Project Costs:	
occupant relocation	$0.0
A & E fees, testing, permits	$47000.0
project management	$10000.0
Duration of construction (months)	6
Construction Costs:	
repair of damage or deterioration	$0.0
hazardous material removal	$0.0
disabled access	$0.0
system improvements	$0.0
nonstructural mitigation	$0.0
Plan shape	L-shaped
Base Dimensions	74.0 by 21.0
Typical Floor Plan Dimensions	74.0 by 21.0
Story Height	15.0
Total Height	15.0
Roof Framing (2nd Floor+)	steel beams
Floor Framing (2nd Floor+)	
Diaphragms	metal deck w/o concrete fill
Exterior Non-Load Bearing Cladding	N
Evidence of Settling?	No
Condition of Building?	good
Column Type	steel
Bearing Walls Type	reinforced masonry
Foundations	spread footings
Longitudinal Lateral System	shear walls
Tranverse Lateral System	shear walls
Code or Design Guideline Used for Rehabilitation	1991 UBC (I=1 25)
Special features (irregularities, interior partitions, etc)	
Rehabilitation Work Completed	

Fort Bragg Fire Station: Visual Deterioration/Danage from leaky roof


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