NISTIR 5625

A Survey of Steel Moment-Resisting Frame Buildings Affected by the 1994 Northridge Earthquake

Nabih F.G Youssef
David Bonowitz
John L. Gross

April 1995
Building and Fire Research Laboratory
National Institute of Standards and Technology
Gaithersburg, MD 20899

U.S. Department of Commerce
Ronald H. Brown, *Secretary*
Technology Administration
Mary L. Good, *Under Secretary for Technology*
National Institute of Standards and Technology
Arati Prabhakar, *Director*

Acknowledgements

The survey forms used in this study were produced by Prof. Sami Masri, Rawn Nelson, David Bonowitz, Prof. Steve Mahin, Dr. Charles Thiel, Tom Sabol and Richard Holguin.

The engineering firms contributing survey responses as of October 20, 1994 are The Allen Company, Brandow & Johnston, Dames & Moore, EQE/San Francisco, Englekirk & Sabol,Forell/Elsesser Engineers, John A. Martin Associates, Kariotis & Associates, KPFF, Law/Crandall, Myers Nelson Houghton, Nabih Youssef & Associates, Skidmore, Owings & Merrill and Wiss Janney Elstner. The hard work and dedication of those who completed the survey forms under considerable time pressure are appreciated.

The technical review and assistance in preparing the report by Ann Bieniawski and careful review by Diana Todd are gratefully acknowledged.

Abstract

The January 1994 Northridge earthquake damaged a variety of building types throughout greater Los Angeles. Perhaps the most alarming pattern of structural damage involved brittle failures at beam-to-column connections in steel moment-resisting frames (MRF's). This damage has called into question the predictability of the behavior of steel MRF's and the reliability of conventional connections used in California buildings over the last two decades. In response to this damage, emergency changes to the Uniform Building Code now require specific test results in lieu of reliance on a prescribed detail.

This report presents results of a survey of MRF's inspected for connection damage since the earthquake. As a catalogue of inspected MRF's, both damaged and undamaged, the survey is intended to provide an overall view of the greater Los Angeles steel frame population, as well as a single-source building-specific record of observed conditions. Tabulated survey responses can help form a quantitative context for future research, hazard assessment, and policy making. A computerized database was developed to track submittals, compile basic survey data, and generate the summary tables shown in the report.

Principal conclusions from the survey data support the observation that MRF connection damage is not well correlated to any single structural characteristic. On the contrary, the survey data show that connection performance may be best understood in probabilistic, not deterministic, terms, with emphasis on construction and inspection quality. In other words, when the connection works, it works extremely well. But it might *not* work, if any link in the chain of design assumptions and construction procedures is weak.

It is essential to note, however, that current survey data does not include analysis results or estimates of actual seismic demands from the Northridge earthquake. Without these, any reading of survey results must remain open to the possibility that conventional MRF connections are flawed by their basic configuration and are simply incapable of ductile behavior at high strain rates [Skiles and Campbell, 1994]. This alternate theory, which would fundamentally change the way engineers think about steel MRF behavior, can only be discarded if analysis with recorded ground motions can show that damage did not correlate with demand. Survey results reported here show only that damage did not correlate well with design.

Preface

The survey of steel moment resisting frame buildings reported herein was undertaken by NIST in an effort to provide the engineering profession with an accurate characterization of the nature and extent of damage resulting from the Northridge earthquake. The motivation was to guide engineers and policy makers in hazard assessment and to provide a quantitative context for future research. The issues facing engineers and ploicy makers are indeed pressing and timely collection and reporting of survey data is deemed essential.

The data collected were available from a variety of sources including design drawings, specifications, engineer's reports and field measurements. Invariably the data collected were in English units. Conversion was required to the International System of Units (SI). Data are presented in SI units in all tables and both SI and English units in the text. Recorded data were often approximate (for example floor areas were recorded to the nearest 1000 ft^2) and conversions were made to preserve essentially the same level of accuracy.

The conversions shown below may prove useful is using this document and its appendices.

SI Unit Conversions

To convert from	to	multiply by
inch (in)	milimeter (mm)	25.4
foot (ft)	meter (m)	0.3048
ft^2	m^2	0.0929
kip/in^2 (ksi)	MPa	6.895
milimeter (mm)	inch (in)	0.0394
meter (m)	foot (ft)	3.2808
m^2	ft^2	10.764
MPa	kip/in^2 (ksi)	0.1450

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Abbreviations and Definitions

See also the Abbreviations and Definitions on the survey forms in Appendix B.

Building	Set of diaphragms laterally supported by the same set of frames or structurally separated from other diaphragms by seismic joints.
Connection	Intersection of one frame beam with one frame column, generally comprising a top flange connection, a bottom flange connection, and a web connection. A typical interior *joint* with a continuous column and beams on both sides constitutes *two* connections.
Damage Class	A set of damage types found in the same part of a connection.
TG	Damage to the beam flange at the top of the connection
BG	Damage to the beam flange at the bottom of the connection
TC	Damage to the column flange at the top of the connection
BC	Damage to the column flange at the bottom of the connection
TW	Damage to the beam flange weld at the top of the connection
BW	Damage to the beam flange weld at the bottom of the connection
S	Damage to the shear connection, including bolts, welds, and plates
PZ	Damage to panel zone continuity plates or welds, or ductile damage to column web or web doubler plate
CW	Cracking in column web or web doubler plate
Damage Ratio	For a given set of floor-frames and a given damage class, the number of floor-frames with the given damage class observed divided by the total number of floor-frames in the set, expressed as a decimal or percentage. See Section 4.2.2.
Damage Score	For a given set of floor-frames, a weighted sum of the number of floor-frames with each of the most common damage classes, divided by the total number of floor-frames in the set, expressed as a decimal. See Section 4.2.1.
Damage Type	A specific pattern of yielding, buckling, or cracking. See Figures 4-1, 4-2, and 4-3.
Floor-Frame	The set of connections in one frame at one level.
Floor Construction Types	
LC	Lightweight concrete with no metal deck
MC	Metal deck with normal weight concrete fill
MCL	Metal deck with lightweight concrete fill
W	Wood diaphragm with wood or metal floor joists

Frame	System of moment-connected beams and columns generally in a single vertical plane.
Geographic Zone	Geographic area selected for locating buildings in this survey such that buildings within each area would be expected to experience similar ground motions.
HAZ	Heat affected zone of a weld
Incipient Root Crack	A minor buried crack in the weld metal or HAZ, detectable by UT only. Possibly a pre-earthquake planar weld discontinuity. Interpreted by some survey engineers to include all rejectable weld discontinuities of any kind, or even all discontinuities whether rejectable by American Welding Society (AWS) criteria or not. See Section 4.1.1.
MRF	Moment-resisting frame. Also used to refer to an entire building whose lateral load resisting system includes MRF's.
WDR	Weld Damage Ratio. For a given building, the approximate portion of all reported weld damage that is thought or confirmed by the survey engineer to be incipient root cracking, expressed as a decimal. For a set of floor-frames, the average over all the defined floor-frames of WDR for the buildings from which those floor-frames come. In other words, while WDR is given for a building as a whole, for statistical purposes each floor-frame is assumed to have the same WDR. See Section 4.1.1.
Stories	The number of stories above ground for which the lateral load-resisting system in at least one direction is composed of steel MRF's (i.e., *does not* include stories below ground or stories above ground framed with concrete frames or walls, steel diagonal braces, etc.).
UT	Ultrasonic testing
VI	Visual inspection

Web Connection Types

B	Bolted connection
W	Welded connection
WB	A connection which is both welded and bolted

Weld Processes

FCAW	Flux-cored arc weld
SMAW	Shielded metal-arc weld

1.0 Introduction

The January 1994 Northridge earthquake damaged a variety of building types throughout greater Los Angeles. Perhaps the most alarming pattern of structural damage involved brittle failures at beam-to-column connections in steel moment-resisting frames (MRF's). This damage has called into question the predictability of steel MRF behavior and the reliability of conventional connections used in California buildings over the last two decades. In response to this damage, emergency changes to the Uniform Building Code (UBC) now require specific test results in lieu of reliance on a prescribed detail.

This report presents results of a survey of MRF's inspected for connection damage since the earthquake. As a catalogue of inspected MRF's, both damaged and undamaged, the survey is intended to provide an overall view of the greater Los Angeles steel frame population, as well as a single-source building-specific record of observed conditions. Tabulated survey responses can help form a quantitative context for future research, hazard assessment, and policy making.

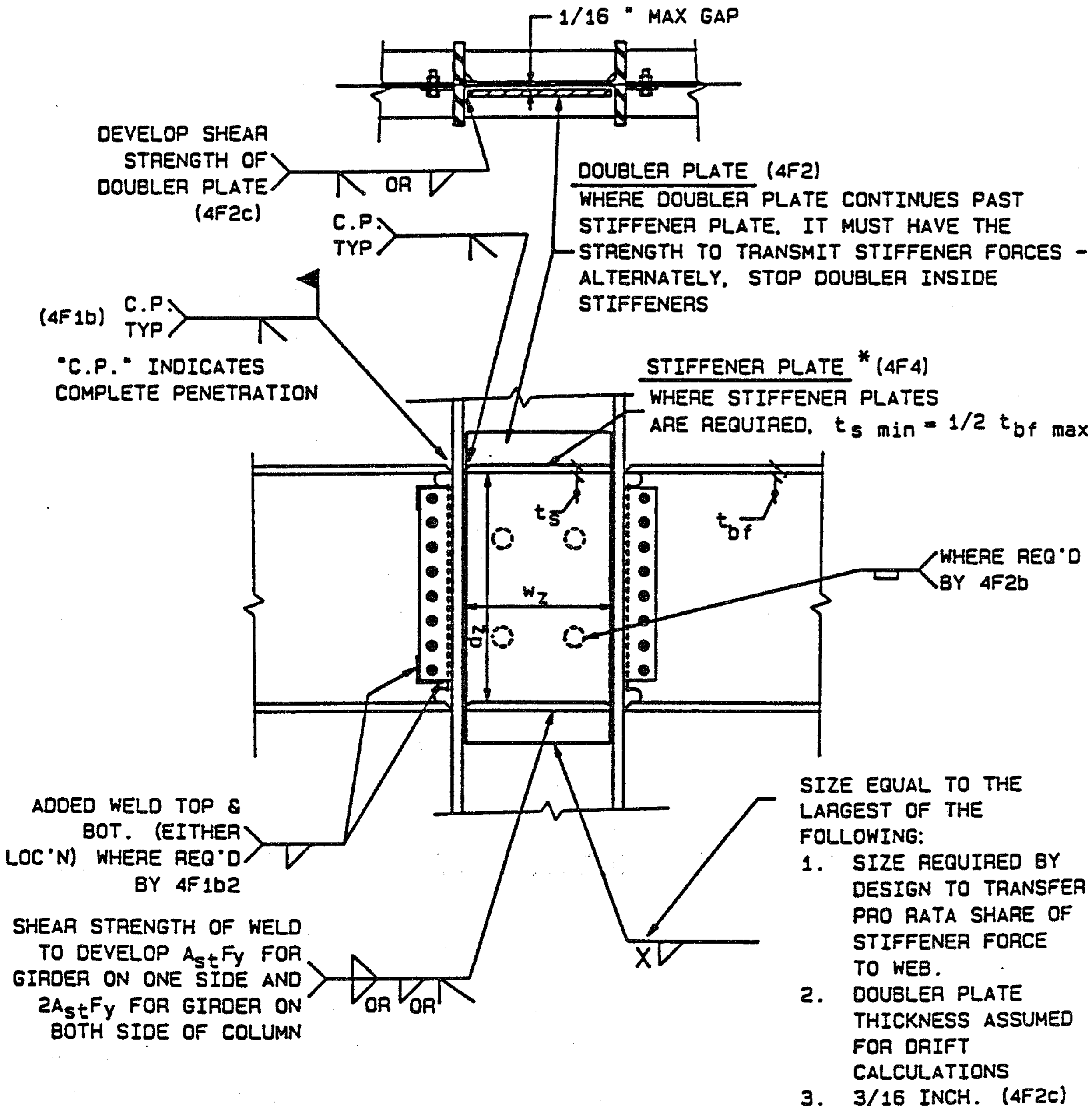
1.1 Damage to Moment-Resisting Frame Connections

Although the Northridge earthquake damaged other steel assemblies such as base plates and diagonal braces, the most common damage to steel structures was in the connections of moment-resisting frames. The seismic design philosophy for MRF's assumes that in large earthquakes frame elements will be stressed beyond their elastic range; inelastic behavior, which is useful for dissipating the energy of earthquake shaking, is allowed, but only in ductile elements. Since welds and bolts are not sufficiently ductile, the design philosophy does not allow connection failure. Instead, the role of the beam-to-column connection in a ductile MRF is to maintain its strength while adjacent beams and/or panel zones yield and deform inelastically [SEAOC, 1990].

The UBC, which is adopted with modifications by nearly all California jurisdictions as the standard for seismic design, codified this philosophy by requiring connection strength greater than beam strength. (While the UBC specified connection *strength*, it did not quantify a plastic rotation demand.) Since the 1988 Edition, the UBC also included a prescribed detail which could be used without supporting calculations or condition-specific testing. The prescribed detail required beam flanges welded to the column with complete penetration groove welds and beam webs connected with welds and/or high strength bolts [ICBO, 1988 & 1991]. In fact, this conventional detail was in wide use throughout California for years before the 1988 UBC. A generic version is shown in Figure 1-1. Recent Code changes have deleted the prescribed detail calling instead for test results or calculations to demonstrate specific connection capacity ["ICBO Board...," 1994].

1.1.1 Historical Performance

The prescribed or conventional detail was justified by tests from the early 1970's [SEAOC,



STIFFENER AND DOUBLER PLATES
FIGURE 4F-1

Figure 1-1. Conventional Steel MRF Beam-to-Column Joint
Source: SEAOC, 1990

1990]. These tests confirmed adequate strength and plastic rotation capacity for specific beam sizes and loading patterns. However, while most test programs on conventional connections were able to show impressive results with some specimens, all experienced some unacceptable behavior limited by non-ductile connection failures [Popov & Pinkney, 1969; Popov & Bertero, 1973; Popov et al, 1985; Popov & Tsai, 1987, Engelhardt & Husain, 1993]. A careful reading of journal articles from 1969 through 1993, benefitting from hindsight and the Northridge experience, reveals that weld defects, bolt slippage, or other diverse factors have in some cases made the connection the most critical part of the frame, directly violating the main precept of the ductile MRF design philosophy. Since the Northridge earthquake, some leading researchers have said that none of the observed MRF connection failures can really be called unexpected [Bertero et al, 1994].

While connection reliability can be questioned on the basis of historical test results, the performance of steel frames in earthquakes prior to Northridge has been thought to be excellent, and in practice, the steel MRF has long been considered perhaps the most reliable structural system for resisting seismic loads [Yanev et al, 1991]. Confidence in the prescribed connection detail has led to its use with a variety of member sizes, frame dimensions, shear connectors, flange weld processes, and lateral force resisting system configurations.

Many initial inspections of steel frame buildings following the Northridge earthquake found only minor non-structural damage. Based on prior earthquake experience, engineers had no reason to suspect cracked welds or fractured columns hidden behind soffits, ceilings, and fireproofing. Only after a few reports of steel damage began to circulate did engineers and owners revisit buildings to perform more complete inspections. In time, these inspections revealed several distinct damage types, a number of which (e.g. weld cracks, column flange tearing, and bolt failure) had been observed in past testing programs [Popov & Stephen, 1972; Popov & Bertero, 1973; Popov et al, 1985; Popov & Tsai, 1987; Engelhardt & Husain, 1993]. Within three months, fifty steel frames had been confirmed as damaged to some degree. By September 1994, eight months after the earthquake, the estimate had grown to over 100 damaged MRF buildings. (See Section 3.2.1 for a more detailed discussion of these estimates.)

1.1.2 Response to Observed Damage

As more damage was found, some building owners initiated systematic inspection and testing programs, and in many cases proceeded with engineered repairs, even in the absence of consensus standards and procedures. Other owners, whose buildings sustained little apparent damage and no substantial loss of function, have waited for government mandates to inspect their buildings. Given the number of damaged buildings reported and estimates of the total MRF population (see Section 3.2.1), it is likely that about 100 MRF buildings in heavily affected areas have not yet been inspected for connection damage.

Meanwhile, organizations and ad hoc committees in industry, academia, and government have begun studying the damage and developing new approaches to analysis, repair, strengthening, and design of steel MRF's [AISC,1994; SAC, *Advisory No. 3*]. A number of researchers and practitioners have speculated on the causes of observed damage, but there is no conclusive evidence that any one factor, whether related to design, construction, or unique ground motion, is consistently responsible [Sabol, 1994; Shipp et al, 1994; SEAOC Seismology Committee, 1994; Bertero et al, 1994]. Joint ventures of interested organizations have initiated testing programs to establish the causes of specific failures and the feasibility of proposed repairs. Local government responses have included emergency regulations and suspension of the Code-prescribed connection for new construction. Most significantly, the International Conference of Building Officials (ICBO) Board of Directors in September passed an emergency revision to the 1994 UBC deleting the prescribed detail and calling for test results or calculations to demonstrate both strength and inelastic rotation capacity ["ICBO Board...," 1994].

1.2 Survey of Available Data

Ten months after the Northridge earthquake, inspection, testing, preliminary research, and building-specific repair were ongoing. For the steel MRF population *as a whole*, the following issues were among those still unresolved:

- the quantitative extent of different damage types,
- the correlation between damage and site factors such as ground motion,
- the correlation between damage and design factors such as frame configuration,
- the correlation between damage and construction factors such as weld quality control.

To address these issues, the National Institute of Standards and Technology (NIST) contracted Nabih Youssef & Associates (NYA) to compile and analyze available data on steel MRF's inspected since the January 17 earthquake. A survey was developed for distribution to engineers who were already involved with the collection of data on the MRF connections. The goal was to make the results of this survey available to people working in all earthquake-related fields.

In the short term, the goal of this survey was to identify the nature and extent of observed damage, providing an accurate assessment of the situation as of November, 1994. In the long term, it is hoped that survey responses will provide insight or direction to researchers, practicing engineers, and policy makers studying the following issues, among others:

- the extent to which factors that correlated with damage also *caused* damage,
- the suitability of proposed repair and retrofit schemes,
- the nature of potential hazards remaining in unrepaired or undamaged frames,
- the relative merits of proposed code revisions and policy responses.

The survey was designed to address both the short term goal of quickly collecting damage data and the long term goal of supporting potential users with a comprehensive centralized database. The inherent conflicts between these two goals led to some revisions in survey scope midway through data collection. Eighteen buildings were submitted on the original survey form in the first three weeks of data collection; these responses formed the basis for the preliminary report presented at an industry workshop in September, 1994 [NYA, 1994]. A revised and shortened survey form was distributed to twenty-one survey engineers in mid-September. (Appendix B includes copies of both survey forms.) This report presents data from a total of 51 surveyed buildings submitted by October 21, 1994. Survey engineers have agreed to submit data on approximately 40 more buildings as test results become available.

A computerized database was developed to track submittals, compile basic survey data, and generate the summary tables discussed in this report. Not all survey items have been entered into the computerized database.

1.3 Scope of Report

The data reported here represents 51 inspected MRF buildings comprising 330 inspected frames, 1290 inspected floor-frames, and 5120 inspected beam-to-column connections. Survey forms were completed by 14 different engineering offices. A damage score is calculated for each building based on the types of damage found. These damage scores are used to examine various structural characteristics of the building to establish any correlations between these characteristics and the amount of damage to the building.

Section 2.0 of this report describes the survey effort in detail. Section 3.0 discusses the sources of available data and the distribution of reported buildings by location and type. Section 4.0 describes and quantifies observed connection damage. Section 5.0 discusses correlations between observed damage and factors such as building location and frame configuration. Section 6.0 presents conclusions drawn from the survey responses.

2.0 The Survey

2.1 Scope

The survey described in this report attempts, within the limits of available resources, to address both the short term goal of collecting damage data and the long term goal of supporting potential users with a comprehensive centralized database. It is beyond the current scope to collect all data of potential interest on every steel MRF affected by the Northridge earthquake. The short term survey goal requires data on building identification, basic description of construction and configuration, and a list of observed damage, perhaps keyed to frame elevations. The long term goal, however, requires specific structural descriptions.

When the survey effort began, five original contributing engineering firms had approximately 40 buildings with testing complete and approximately 10 more with testing in-progress. By October, 51 completed surveys had been submitted, and another 40 or so had been promised by 20 survey engineers, pending completion of testing and approval of building owners.

From the beginning, the survey scope was limited in order to facilitate response. Steps taken toward this end included:

- limiting the subject buildings to steel MRF's only, i.e. excluding braced frames, dual systems, and other steel assemblies damaged by the Northridge earthquake
- limiting the subject buildings to those with beam column joints visually inspected or tested, i.e. not collecting data on *potentially* damaged buildings
- requiring no inspection or testing beyond that which had already been completed
- requiring no analysis, calculation, or numerical design check
- accepting responses of "Unknown" to avoid additional research or interviews
- requesting information for each floor-frame instead of each connection
- eliminating survey sections not directly related to building description and earthquake response, e.g. sections on ground motion, costs, repair, or potential upgrade

In practice, the scope of survey responses was limited by the project schedule and a lack of available documents. In particular, because the survey engineers were generally not the original design engineers, most had no immediate access to original documents (e.g., steel mill certifications, weld specifications, structural calculations, etc.). As discussed below, the survey form was revised midway through data collection in response to these practical limitations.

2.2 Form

Due to limited time and availability of documents, initial responses were substantially incomplete on issues of building design history, non-structural detailing, steel and weld properties, and building performance in previous earthquakes. Reported damage was sometimes poorly labeled because the format for reporting it was time consuming and confusing. Additionally, the completeness of inspection, testing, and UT documentation used as the basis of survey responses seemed to vary widely.

For these reasons, and with the hope of improving response, the original survey form was modified. The substantive changes put less emphasis on building history and more emphasis on the nature of post-earthquake evaluations. The procedure for reporting damage (Survey Section V) was simplified into a tabular form. While information was still requested for each inspected floor-frame, the number of affected connections in each floor-frame was no longer reported. The potential effects of this loss of robustness are discussed briefly in Section 3.2.5.

Copies of the two survey forms are given in Appendix B. Eighteen buildings were surveyed with the original form, the rest with the revised form or a combination of the two.

2.3 Process

The survey process for each building involved distribution of survey forms, completion and submittal of forms, database entry, quality control by telephone, and revisions as needed. Each building survey progressed on its own schedule due to ongoing inspection in various stages and a constantly expanding list of participating engineers.

In most cases, survey engineers completed the forms themselves. In order to expedite submittal, however, NYA staff completed some survey forms based on interviews with and documents provided by the survey engineer.

Provisions were made to protect the confidentiality of building owners and survey engineer clients. A building ID Code was selected for each building and, in this report, buildings are identified by this code only. Building, owner, and tenant names were not reported on survey forms. Street addresses were generally given on the written survey form with instructions to keep confidential. If so noted, street addresses were not entered into the computerized database. Instead, each building was assigned to a geographic zone, and specific building location is given only in terms of zip codes, neighborhoods, or cross streets, if at all. Despite these measures, some owners of known damaged buildings declined to release information for this survey.

3.0 Characterizing the Data

3.1 Sources of Data

As of October 20, 1994, fourteen engineering firms had contributed survey data, and a total of twenty had agreed to participate. Firms were invited to participate based on their access to current building information, specifically reports of connection inspection and testing. In general, the survey engineer for a particular building had been retained by its owner to perform post-earthquake assessments and to design repairs or strengthening. In the typical case, the survey engineer was not the original engineer of record and was familiar with the building only from post-earthquake inspections. In all but a few cases, specialty contractors exposed the connections and performed the visual inspections and testing; typically, the engineer performed only a building walkthrough and visual inspection of some connections.

3.1.1 Documents

Though not listed in Appendix A or tracked in the current computer database, each completed survey form lists the sources of data used as the basis of response. Surveys completed on the revised form (see Appendix B) also list the documents available for future reference.

In general, the following documents were used as the basis of survey responses:

- Original structural design drawings
- Post-Northridge connection visual inspection reports
- Post-Northridge connection test reports
- Undocumented first-hand knowledge of the original building and observed damage

Occasionally, the following documents were also available and cited as the basis of response:

- Original architectural design drawings
- Post-Northridge building walkthrough notes or rapid assessment report
- Post-Northridge repair drawings based on connection test reports

Where the survey engineer was also the original engineer of record, some of the following documents may have been available as reference. In general, however, the following documents were not available to the survey engineer:

- Original structural calculations and design criteria
- Original soil/geotechnical reports
- Steel/Welding specifications
- Fabrication/Erection drawings
- Structural as-built drawings
- Weld or steel samples removed for testing

3.1.2 Testing

Inspection and test reports were typically prepared by the laboratory performing the tests, not by the survey engineers. Sample inspection criteria and report forms are included in Appendix C. Specific test locations were typically selected by the engineer on the basis of visible damage, recent experience, judgement, and access.

Connection inspection and testing generally involved the following basic steps: removal of finishes; removal of fireproofing to expose beam flange connections, beam web connections, column panel zone, and column flanges below the beam; cleaning of the connection, generally by wire brush only; visual inspection of members and connectors; and ultrasonic testing of beam flange welds and column flanges. Seven of the 51 survey responses were based on visual inspection only. Not counting these seven buildings, 94% of visually inspected connections were also tested.

The revised survey form requested specific responses regarding the type and extent of testing; the original form did not (see Appendix B). For the 33 buildings surveyed with the revised form, typical testing involved UT only. In a few cases, magnetic particle testing and/or liquid dye penetrant testing were used to supplement the UT. Weld or base metal samples were generally not taken, and may not have been tested when they were. Despite some indications that effective UT requires removal of the backing bar and careful preparation of the weld [SAC, *Session Summaries*, Session 1], survey responses indicate that backing bars were seldom removed for inspection or testing.

Lack of access to the outside of perimeter connections and to the top surface of beam top flanges was a common constraint on full inspection and UT. The few buildings with exterior walls or slabs removed were either under construction, vacated due to heavy damage, or temporarily vacated to perform the work. By contrast, the typical surveyed building was occupied at the time of the earthquake, reoccupied shortly after the earthquake, and continuously occupied (with limited, temporary disruptions) during inspection and testing.

3.2 Sources of Error

3.2.1 Size of Sample

The number of surveyed buildings required for valid correlations is directly related to the number of buildings in the steel MRF population affected by the Northridge earthquake. Following the earthquake, the Los Angeles Department of Building & Safety conducted a search of Los Angeles building permit records since 1961 for Type I and II steel framed buildings. The search found about 1200 buildings in all of Los Angeles, including about 300 in heavily damaged San Fernando Valley and West Los Angeles. This does not include buildings in separate jurisdictions such as Beverly Hills or Santa Monica. As of October, 1994, the survey included data from 51 buildings, 46 of which are in the San Fernando Valley, West L.A., or nearby Santa Monica. Assuming a current total population of approximately 500 MRF buildings in the areas of strongest shaking, the survey represents about a 10% sample.

As for confirmed *damaged* buildings, the Los Angeles Department of Building & Safety *ad hoc* Steel Subcommittee identified about 50 buildings with damaged connections by April, 1994. By June, the Subcommittee had compiled a list of 77 buildings drawn mostly from the records of local testing firms [SAC, *Program...*]. In early August, five engineering firms participating in this survey indicated that they were involved with 62 buildings, most of which were not on the City's list of 77. The combination of these two numbers corroborates oft-cited estimates of "over 100" damaged steel MRF's [SEAOC Seismology Committee, 1994]. (This otherwise unconfirmed estimate was originally based on job records from the city's two largest testing firms.)

3.2.2 Nature of Sample

Local jurisdictions including the City of Los Angeles are developing inspection ordinances for steel MRF buildings [Holguin, *Ordinance...*]. As of October, 1994, however, all inspection and testing programs had been voluntary, usually motivated by visible frame damage, other structural damage, heavy non-structural damage, or observed MRF damage in similar nearby buildings. Since the present survey includes only inspected buildings, it is therefore likely that the sample represents the most-damaged subset of the MRF population. Mandatory inspections, however, will yield data on a broader range of MRF's, both damaged and undamaged.

3.2.3 Scope of Testing

Survey instructions specified no minimum scope of testing. Survey engineers were requested to report on any building with any level of connection inspection or testing, whether damaged or not. As noted above, many owners were not compelled to undertake substantial voluntary inspections in the absence of severe non-structural damage. Consequently, many buildings remain uninspected or only minimally inspected.

Among the surveyed buildings, the scope of inspection and testing varied. Thirteen of the 51 surveyed buildings had complete testing at every connection in every frame. As noted above, seven buildings had no testing, but six of these had thorough visual inspection. At building ESI2, preliminary visual inspection of only one floor-frame revealed cracking into the column web; results of further inspection were unavailable. Overall, of the 44 tested buildings, 25 had more than half of their floor-frames inspected and tested to some degree, and 32 buildings had at least a quarter inspected. Within each tested floor-frame, the number of tested connections also varied, but was generally high. Three quarters of all floor-frames had more than half of their connections tested.

The SEAOC Seismology Committee has recommended inspection and testing of at least 15% of all MRF connections in low-rise buildings [SEAOC Seismology Committee, 1994]. The scope of testing in nearly all of the surveyed buildings would meet this standard. Correlation of observed damage to scope of inspection is discussed in Section 5.3.

In addition to the number of connections tested, the scope of testing within a given connection may affect survey results slightly. In most cases, backing bars, slabs and finishes above the beam top flange, and exterior window wall obstructing the outside of perimeter frame connections were not removed. This limited the inspection and testing, especially at the beam top flange.

3.2.4 UT Error

Because weld damage was recorded much more frequently than any other damage class, and because most of that damage was detected only by UT, it is important to consider the reliability and consistency of ultrasonic testing. F. Robert Preece, in a monograph for the Steel Committee of California [Preece], has written that "the ultrasonic method is highly dependent on the skill and integrity of the operator." Preece and others have noted that this dependence, coupled with the pressure of a tight construction schedule, sometimes leads a technician to accept welds based on uncertain UT readings. A common situation involves readings near the mid-length of the beam flange weld where interference from the beam web makes both welding and UT difficult. A UT indication in this area is likely to be read unconservatively, ignored, or assumed to be just the edge of the backing bar [Benson]. After an earthquake, when real damage has already been observed, the opposite situation may prevail: technicians may feel pressure to find "damage" or indications, erring on the conservative side.

Reliability of UT and other testing is not merely a function of technician psychology, however. A root cause, say experts, is inadequate training and meaningless, inconsistent certification [SAC, *Advisory No. 3*]. Compounding the problem is a lack of training for engineers, who are largely unfamiliar with testing procedures or welding in general. In particular, engineers regularly reference AWS D1.1 [AWS] in project specifications, but many are not taught to distinguish quality workmanship from "fitness for purpose" or discontinuities from defects or earthquake damage.

Survey responses highlighted some of these uncertainties. In some cases, weld cracks went undetected by UT until backing bars were removed for a closer look. In other cases, UT suggested weld cracks, but none could be found when the backing bar was removed for repair.

The effect on survey results is largely limited to damage type W1: incipient root cracks detected by UT. As discussed in Section 4.1.1, different survey engineers reported different conditions as W1, sometimes reporting all indications found, other times reporting only what could clearly be identified as earthquake damage. For a given building, this variability is quantified by isolating the percentage of all weld damage that is type W1.

3.2.5 Completeness of Survey Responses

As previously noted, many of the responses on the original survey form were incomplete when original architectural drawings and construction phase documents were unavailable. Except for the many buildings with unknown flange weld processes, this did not affect the general structure or damage descriptions. Two of the 51 buildings surveyed to date reported damage by frame type, not by individual floor-frame. Consequently, that data is inconsistent and could not be used in characterizing and correlating the damage.

Another completeness issue involves the survey scope. As previously noted, damage data was collected for each floor-frame, not each connection. This was done to improve response, as a connection-by-connection survey would take too much time and effort to complete, but data for a whole building or frame would not be detailed enough. As a result, if a 3-bay (6-connection) floor-frame is indicated as having bottom weld damage, for example, the new survey form does not record whether one connection or all six are damaged. Further, if a floor-frame has both shear connection damage (class S) and damage to the bottom flange weld (class BW), for example, it's not clear from the survey if the two damage classes occurred in the same or different connections within the floor-frame. Finally, a 6-connection frame with three different damage types all in different connections will be represented three times in a list of damaged floor-frames even though only half its connections are affected, while a similar floor-frame with the same damage type in *all* its connections will be represented only once. (This last example is most significant in its effect on damage scores, defined later in the report.)

3.2.6 Quality of Survey Responses

Survey responses were checked for completeness and consistency. When questions arose, responses were checked by telephone interview with the survey engineer. In general, the responses were of high quality and consistency.

3.3 Data Distributions

Table 3-1 lists the 51 buildings surveyed, sorted by geographic zone. Heights and floor areas are listed to indicate building size, and the number of inspected or tested floor-frames is given to indicate the amount of data in the survey. Appendix A includes more detail on each building. The distribution of survey data by location, structural concept, and structural detailing is discussed below. Location data is directly related to the level of shaking experienced by each building; a given earthquake can be expected to impose similar demands on buildings in the same zone. Structural concept refers to building massing, redundancy, regularity, and other aspects of structural design usually addressed during a project's conceptual design phase. Structural detailing encompasses the balance of structural design decisions, including materials, member sizes, and connection types.

Building ID	Zone	Year Designed	MRF Stories	Lower Floor Area [m²]	Upper Floor Area [m²]	No of Inspected Floor-Frames
DM1	LAX	1970	15	5,600	2,000	5
SOM1	MW	1986	4	1,700	1,700	9
BJ05	NR	1990	11	2,700	2,300	55
BJ06	NR	1989	2	4,700	4,700	12
LCIB	NR	1990	4		2,900	3
LCIE	NR	1990	3	2,500	1,400	9
EQE1	SC	1991	4	2,000	2,000	16
EQE2	SC	1991	1	2,500	2,500	6
KPFF1A	SC	1981	2	900	900	4
BJ01	SM	1989	4	1,300	1,300	23
ESI2	SM	1990	5	2,000	2,000	1
ESI5	SM	1989	6	1,700	1,400	46
BAK	SO	1982	6	2,400	1,900	12
BJ04	SO	1981	4	1,000	1,000	16
ESI7	SO	1989	3	1,400	1,400	13
JAM7482	SO	1983	4	1,600	1,300	28
JAM7484	SO	1985	4	1,500	1,500	20
JAM7487	SO	1979	12	1,200	1,400	41
JAM7489	SO	1979	6	2,000	2,000	7
KAR3	SO		17			3
MNH04	SO	1981	6	3,000	3,000	12
NYA550	SO	1985	6	5,000	2,000	15
SOA	SO	1984	4	2,800	2,300	22
BJ02E	UC	1992	3	2,700	2,700	27
ESI3	UC	1984	8		700	1

Table 3-1. Characteristics of Surveyed Buildings[1]

[1] The following guidelines apply to all tables:

blank = not applicable or no response was recorded on the survey sheet
? = response was recorded on survey sheet as shown but the reporter was uncertain about the answer

Building ID	Zone	Year Designed	MRF Stories	Lower Floor Area [m^2]	Upper Floor Area [m^2]	No of Inspected Floor-Frames
WEA	UC	1979	4	700	1,700	24
BJ09	WH	1982	5	8,400	4,600	50
BJ10	WH	1990	5	4,600	4,600	13
BJ11	WH	1991	5	2,400	2,400	26
BJ18	WH	1987	3	2,000	2,000	24
ESI8	WH	1987	25	2,600	2,500	216
KAR2	WH	1978	4		2,600	12
MNH02	WH	1984	3		2,900	16
NYA539	WH	1984	3		2,600	14
NYA544	WH	1975	13	2,400	2,400	56
WJE1	WH		18	1,800	1,800	68
AC1	WLA	1984	3	1,700	1,700	19
ESI1	WLA	1993	5		1,100	50
ESI4	WLA	1988	27		1,300	10
FE1	WLA	1965	17	2,800	2,100	4
JAM7480	WLA	1983	11	3,000	2,100	14
JAM7485	WLA	1984	4	1,100	1,100	25
JAM7486	WLA	1983	13	1,900	1,500	44
MNH03AB	WLA	1978	3	1,000	1,000	38
MNH03CDE	WLA	1978	3	1,600	1,600	77
MNH03F	WLA	1978	3	500	500	17
MNH03G	WLA	1978	3	400	400	12
MNH03H	WLA	1978	3	700	700	9
NYA577	WLA	1980	14	3,000	1,600	20
NYA591	WLA	1970	28	2,200	2,200	16
NYA592	WLA	1969	20	2,300	2,300	10

Table 3-1. Characteristics of Surveyed Buildings (Continued)

3.3.1 Location

Each building is located in one of nine geographic zones, as listed in Table 3-1 and shown in Figure 3-1. The zones suggest themselves according to patterns of development and the clustered nature of the 51 buildings. Table 3-2 summarizes the data of Table 3-1 for each

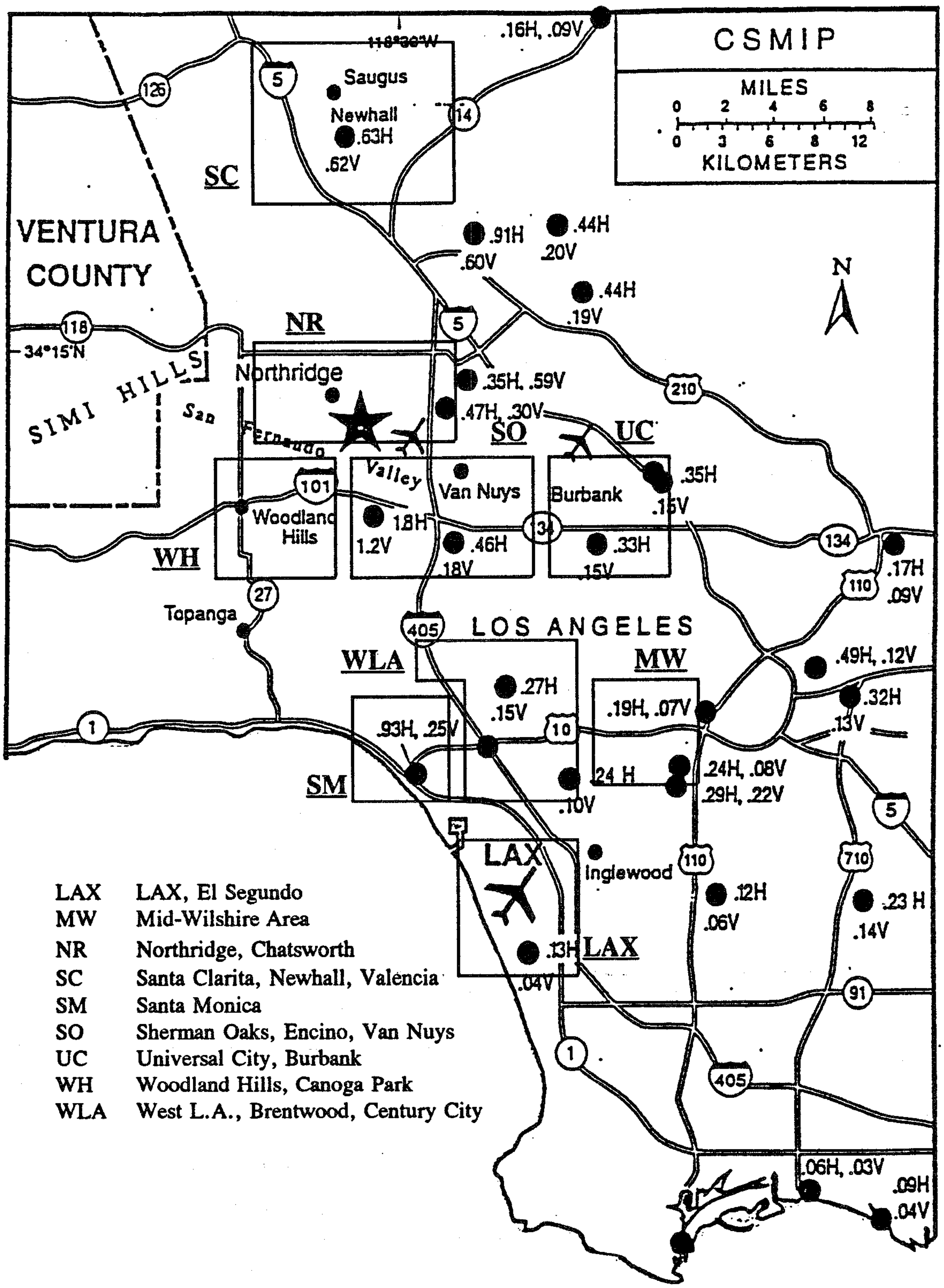


Figure 3-1. Location of Surveyed Buildings and Recorded Ground Accelerations
Source: CSMIP

zone. The 15 buildings in zone WLA are the most dispersed and can therefore be expected to represent the most diverse soil conditions and ground motions. The buildings in zones WLA and SM could be considered together based on their relative proximity, but are listed separately to indicate separate political jurisdictions. Three zones, SO, WH, and WLA, account for 36 of the 51 surveyed buildings, but five of the zone WLA buildings are separate superstructures on a shared site, and three of the zone WH buildings are structurally independent wings of a single complex.

Zone	No of Bldgs	Flr-Frms	Year Designed		Bldg Ht [stories]		Min Flr Area [m^2]	Max Flr Area [m^2]
			Oldest	Newest	Shortest	Tallest		
LAX	1	5	1970	1970	15	15	2,000	2,000
MW	1	9	1986	1986	4	4	1,700	1,700
NR	4	79	1989	1990	2	11	1,400	4,700
SC	3	26	1981	1991	1	4	900	2,500
SM	3	70	1989	1990	4	6	1,300	2,000
SO	11	189	1979	1989	3	17	1,000	3,000
UC	3	52	1979	1992	3	8	700	2,700
WH	10	495	1975	1991	3	25	1,800	4,600
WLA	15	365	1965	1993	3	28	400	2,300

Table 3-2. Summary of Survey Data by Geographic Zone

Figure 3-1 also shows recorded peak accelerations, as published by CSMIP [CSMIP]. The nearest recorded horizontal acceleration is less than 0.33g for only two zones, MW and LAX, which are represented in the survey by one building each. However, four buildings in the eastern portion of zone WLA are nearer to the station recording 0.27g peak horizontal acceleration than to the Santa Monica station recording 0.93g. Downtown Los Angeles, near recorded peak horizontal accelerations of 0.32g and 0.49g, currently has no buildings in the survey.

3.3.2 Structural Concept

Table 3-3 shows the distribution of survey data by building height. Three- to six-story buildings account for 33 of the 51 buildings surveyed, but they differ in size, with floor areas as small as 400 square meters (4500 square feet) and as large as 4600 square meters (50,000 square feet). Floor diaphragm size is more consistent among the taller buildings but any study of the tall buildings as a class will be dominated by building ESI8 whose 216 inspected and tested floor-frames represent the most of any surveyed building. The average floor diaphragm size for all buildings and floor-frames in the survey is about 2000 square meters (21,000 square feet), a figure which was practically law among office developers in the early 1980's [Garreau]. Thus, the surveyed buildings can be considered representative of the larger MRF population at least in terms of floorplate. Tables 3-1 and 3-3 show that this floor area can be found in buildings of almost any height. Table 3-4 shows the distribution of surveyed buildings and floor-frames by typical upper floor area.

MRF Stories	No of Bldgs	Flr-Frms	Min Flr Area [m²]	Max Flr Area [m²]
1	1	6	2,500	2,500
2	2	16	900	4,700
3	12	275	400	2,900
4	11	198	1,000	2,900
5	5	140	1,100	4,600
6	5	92	1,400	3,000
8	1	1	700	700
11	2	69	2,100	2,300
12	1	41	1,400	1,400
13	2	100	1,500	2,400
14	1	20	1,600	1,600
15	1	5	2,000	2,000
17	2	7	2,100	2,100
18	1	68	1,800	1,800
20	1	10	2,300	2,300
25	1	216	2,500	2,500
27	1	10	1,300	1,300
28	1	16	2,200	2,200

Table 3-3. Summary of Survey Data by Building Height

Structural redundancy is considered essential to reliable seismic behavior [Freeman, 1987; Naiem, 1989; SEAOC, 1990] and in the wake of observed Northridge damage, increased redundancy has been suggested as a method to improve connection performance [Malley and Saunders, 1994; SAC, *Session Summaries*, Session 4]. Redundancy can be achieved by using multi-bay frames, providing several frames in each principal direction, distributing the frames in plan to minimize the effects of irregularity and torsion, or by combining these and other measures.

Floor Area [m^2]	No of Bldgs	Flr-Frms	Bldg Ht [stories]	
			Shortest	Tallest
<700	3	38	3	3
700-1,500	14	324	2	27
1,500-2,200	16	359	3	18
2,200-3,000	13	479	1	28
≥3,000	4	87	2	6

Table 3-4. Summary of Survey Data by Upper Floor Area

For each building, the number of frames in each direction is given in Table 3-5. As shown, nearly all the surveyed buildings were reported as oriented with N-S and E-W principal directions. The number and average width of bays in each building was not compiled for this survey, but the overall distribution of *inspected* frames by number of bays and average bay width is given in Table 3-6. The 3-bay frame is most common, showing up in 31 of the 51 surveyed buildings, but bay widths range widely, from one to three times a typical story height of 3.7 meters (12 feet) .

Floor area tributary to a given frame or bay can be considered a quantitative measure of redundancy, but such detail was not compiled in this survey. For purposes of correlating observed damage to redundancy, the least redundant buildings can be identified as those with fewer than three frames in a given direction *and* only one or two bays in those frames. The buildings and floor-frames that meet these conditions are identified in Table 3-7.

Structural irregularities require special attention in design because they are at odds with the assumptions inherent in basic code procedures. Whether the irregularities in surveyed buildings were properly considered during design is unknown. For purposes of correlating observed damage to regularity, the irregular conditions in surveyed buildings are identified in Table 3-8. Twenty-nine of 51 buildings had irregularities of some kind; eight had both vertical and plan irregularities. The most common irregularities, reentrant corners and significant changes in mass from floor to floor, were due to setbacks in the building envelope, a common architectural design feature of 1980's office buildings [Garreau].

3.3.3 Structural Detailing

Table 3-9 shows the number of surveyed buildings and inspected floor-frames for different floor diaphragm types. Wood and concrete diaphragms are fundamentally different in terms of seismic behavior because wood floors are generally much lighter, do not act together with frame beams as composite members, and are less rigid and therefore much less prone to

Building ID	N-S	E-W	NE-SW	NW-SE	Remarks
DM1	2	2			
SOM1	3	3			
BJ05	4	2			
BJ06	2	3			
LCIB			6	8	
LCIE	8	11			
EQE1	2	2			
EQE2	3	3			
KPFF1A	2	2			
BJ01			2	5	
ESI2	3	4			
ESI5			4	2	At floors 1-4, 2 2-bay NWSE frames. At flrs 5-7, 4 1-bay NWSE frames.
BAK	2	3			
BJ04	2	2			
ESI7	3	3			
JAM7482	3	4			
JAM7484	2	2			
JAM7487	2	2			
JAM7489	4	5			
KAR3	2	2			Actual compass directions need to be confirmed.
MNH04	4	4			
NYA550	5	5			At floors 5-7(rf), 2 NS, 2 EW.
SOA	4	6			
BJ02E	6	4			
ESI3	1		1	1	
WEA	2	4			
BJ09	8	8			

Table 3-5. Number and Orientation of Frames in Surveyed Buildings

Building ID	N-S	E-W	NE-SW	NW-SE	Remarks
BJ10	4	4			
BJ11	4	4			
BJ18	3	3			
ES18	3	3	1	2	
KAR2					
MNH02	4	2			
NYA539	6	6			
NYA544	2	2			
WJE1	2	2			
AC1	4	4			
ESI1	5	5			
ESI4	2	2			NOTE: NS frames "bend" in plan, are not in single vertical plane. EW frames differ in orientation by about 40 degrees, but resultant is normal to resultant of NS frames.
FE1	0	2			NS direction is Shear Wall System.
JAM7480	4	4			
JAM7485	2	3			
JAM7486			2	2	
MNH03AB			6	8	
MNH03CDE			14	13	
MNH03F			3	4	
MNH03G			2	2	
MNH03H			2	3	
NYA577	6	2			At ground, including small frames under low roofs; 8 NS, 4 EW, 2 NWSE.
NYA591	0	2			
NYA592	2	2			

Table 3-5. Number and Orientation of Frames in Surveyed Buildings (Continued)

No of Bays	No of Bldgs Represented	Flr-Frms	Min Typ Bay Width [m]	Avg Typ Bay Width [m]	Max Typ Bay Width [m]
1	15	207	5.5	9.5	14.0
2	19	450	3.4	7.0	10.4
3	31	309	4.6	7.6	12.2
4	20	135	4.0	7.3	9.8
5	12	124	4.0	8.5	9.8
6	4	19	4.9	5.2	8.8
7	3	25	4.6	4.9	5.2
8	1	1	8.8	8.8	8.8
9	1	4	7.6	7.6	7.6
11	3	16	6.1	7.0	7.6

Table 3-6. Summary of Survey Data by Number of Bays per Frame

Building ID	Zone	Direction	Flr-Frms	No of Frms	No of Bays
KPFF1A	SC	NS	2	2	2
ESI5	SM	NWSE	10	2	2
BJ04	SO	EW	6	2	2
BJ04	SO	NS	6	2	2
JAM7484	SO	EW	10	2	1
JAM7484	SO	NS	10	2	1
WEA	UC	NS	8	2	1
WJE1	WH	EW	34	2	2
WJE1	WH	NS	34	2	2
JAM7485	WLA	NS	8	2	2

Table 3-7. List of Least Redundant Surveyed Buildings

Building ID	Vertical Irregularities	Plan Irregularities
DM1	Y possible soft story & geom irreg at setback above podium base.	N
BJ05	Y possible mass irreg at floor 9 setback.	Y out-of-plane offsets at floors 2 and 9.
BJ06	N	Y diaph discont at 15x30 m atrium opng.
LCIB	Unknown	Y apparent diaph discont at atrium, but reported as Unknown
LCIE	Unknown	Y apparent reent corners, but reported as Unknown
EQE2	N	Y reent corner: L-shaped floors.
ESI2	N	Y reent corners
ESI5	Y in plane discontinuity at floor 5.	Y out-of-plane offsets at floor 5.
BJ04	Y possible geom irreg at floor 3 frame 2 setback.	N
ESI7	N	Y reent corners: L-shaped floors.
JAM7482	N	Y possible reent corners
JAM7487	Y possible soft story at tall columns, floor 2 & 3 mezzanine/partial floor	Y reent corners & diaph discont @ partial floors 2 and 3.
JAM7489	N	Y reent corners: T-shape floors
NYA550	Y mass & geom irreg at floor 4 setback.	Y reentrant corner
SOA	N	Y reent corners
WEA	Y mass irreg	N
BJ09	Y possible mass irreg at floor 3 setback.	Y reent corners at floor 3 and above.
BJ18	N but note discontinuous top story columns landing midspan on floor 3 girders.	Y reent corner, L-shaped floors.
ESI8	N	Y reent corners.
MNH02	N	Y reent corners
NYA539	N	Y reentrant corner (L-shaped diaphragm)
AC1	Y possible geom irreg at setbacks.	Y possible reent corners
ESI1	Y mass irreg at floor setbacks.	Y torsional irreg, reent corners, diaph discontinuity reported.
ESI4	N	Y reent corners
FE1	N	Y out-of-plane offset at base
JAM7480	Y mass geom irregs due to many setbacks	Y possible reent corners
JAM7486	Y possible mass irreg at floor 6 setback/deck type change	N
MNH03CDE	N	Y reent corners
NYA577	Y mass & geom irreg at floor 2 & 3 low roof setbacks.	N

Table 3-8. Structural Irregularities in Surveyed Buildings

Floor Construction	No of Bldgs	Flr-Frms	Min Flr Area [m^2]	Max Flr Area [m^2]
LC	1	10	2,300	2,300
MC	19	673	1,300	4,700
MC or MCL?	3	48	1,700	2,400
MCL	19	299	700	4,600
MCL/MC	1	46	1,400	1,400
W	8	214	400	1,700

Table 3-9. Summary of Survey Data by Diaphragm Type

torsional response. Most of the buildings with metal deck and concrete fill also have steel studs at nominal spacings, probably intended for shear transfer only. Because of the variety of beam depths and deck orientations all using the same typical stud spacing, it is difficult without analysis to characterize beams as composite with any reliability.

Table 3-10 shows the distribution of survey data by specified column and beam yield strengths. Some engineers specify Grade 50 columns in combination with A36 beams to help ensure a "strong-column-weak-beam" design. However, the actual relative strengths of A36 and A572-Gr50 may vary widely, and the two steel grades have markedly different yield/tensile strength ratios [Hamburger and Frank, 1994]. These uncertainties can affect the states of stress and strain in frame members and welds. As shown in Table 3-10, the combination of A36 steel in both the columns and the beams is represented by more surveyed buildings, but the combination of A572-Gr50 steel in the columns and A36 steel in the beams is represented by more of the reported floor-frames. Both combinations appear in buildings of varying ages and heights, although the average building height of all floor-frames with the combination of A572-Gr50 steel in columns and A36 steel in beams is significantly higher than that of the floor-frames with the combination of A36 steel in both columns and beams.

Column Steel	Beam Steel	No of Bldgs	Flr-Frms	Year Designed		Bldg Height [stories]		
				Oldest	Newest	Shortest	Avg	Tallest
		2	5	1981	1984	2	3	8
	A36	1	14	1983	1983	11	11	11
A36	A36	28	540	1965	1991	1	6	28
A572-Gr50	A36	19	705	1970	1993	2	14	27
A572-Gr50?	A36?	1	26	1991	1991	5	5	5

Table 3-10. Summary of Survey Data by Nominal Steel Strength

Table 3-11 gives an approximate (member size data was not complete for some buildings) count of surveyed buildings and floor-frames with different types of exterior columns. The distribution of interior column types is similar, but with fewer box columns. The AISC [AISC,1989] Group 3 and 4 W14 sections dominate the survey. Table 3-12 gives approximate counts for each nominal beam depth (built-up beams are not included).

Typical Exterior Column	No of Bldgs	Flr-Frms	Year Designed		Bldg Height [stories]	
			Oldest	Newest	Shortest	Tallest
Box or Built-Up	4	118	1975	1984	3	13
W8	4	22	1978	1978	3	3
W12/14 Group 3	22	171	1970	1991	1	17
W12/14 Group 4	25	446	1970	1993	3	27
W14 Group 5	4	67	1981	1988	2	27
W21/24/27	5	91	1979	1992	2	11

Table 3-11. Summary of Survey Data by Exterior Column Type

Typical Girder	No of Bldgs	Flr-Frms	Year Designed		Min Bay [m]	Avg Bay [m]	Max Bay [m]
			Oldest	Newest			
W14/16	6	48	1978	1983	4.6	5.8	8.5
W18	9	46	1970	1990	3.7	6.1	12.2
W21	12	112	1970	1990	3.4	5.5	12.2
W24	23	135	1970	1992	4.0	7.0	10.4
W27	19	56	1970	1993	4.9	7.9	12.2
W30	20	106	1970	1992	4.0	7.6	12.8
W33	20	174	1970	1993	4.9	8.5	12.8
W36	30	533	1970	1993	4.6	7.9	14.0

Table 3-12. Summary of Survey Data by Girder Size (WF girders only)

Clearly, sections from 610 to 914 millimeters (24 to 36 inches) deep are used in a variety of conditions. As for combinations of column and beam sizes, Table 3-13 shows the different typical beams found in combination with Group 4 W14 columns. The W36x150-230 beams are most common.

Typical Girder	No of Bldgs	Flr-Frms
W14x26	3	13
W18x26	1	2
W21x?, W24x?, W27x?	1	2
W21x50	2	17
W21x83-W24x131	1	1
W24x146, W33x130	1	1
W24x162, W36x135	1	1
W24x62	1	1
W24x68	1	1
W24x76	1	2
W27x146	2	6
W27x84	2	3
W27x94	2	2
W30x108	3	3
W30x108, W30x116	1	2
W30x116	1	2
W30x124	1	2
W30x124, W30x132	1	4
W30x132	1	1
W30x191, W36x150	1	1
W30x99	3	11
W33x118	4	11

Typical Girder	No of Bldgs	Flr-Frms
W33x130	1	4
W33x141	2	2
W33x152	3	11
W33x201	2	5
W33x221	1	2
W33x241	2	12
W33x280	1	3
W36x135	3	5
W36x150	6	45
W36x160	4	24
W36x170	8	37
W36x182	6	35
W36x194	8	46
W36x194, BU36	1	1
W36x194, BU48	1	1
W36x210	5	48
W36x230	8	51
W36x245	4	24
W36x260	4	12
W36x280	3	8
W36x300	1	6

Table 3-13. Surveyed Girder Types with Group 4 W14 Columns

Table 3-14 shows the data distribution for different web connection types. The correlation with age is clear: the oldest buildings have all-welded beam webs, the newest have bolted webs with supplemental welds as required by the UBC since 1988, and most of the surveyed typical beams found in [illegible] 1970's [illegible] 1980's have bolts only. Note that the are most common.

recent buildings with WB type connections generally have supplemental welds *only where required by Code*, that is at the lightest sections within each beam depth group.

Web Conn Type	No of Bldgs	Flr-Frms	Year Designed	
			Oldest	Newest
B	37	1027	1975	1990
Unknown	2	26	1989	1989
W	4	35	1965	1970
WB	8	202	1988	1993

Table 3-14. Summary of Survey Data by Beam Web Connection Type

Flange Weld Process	No of Bldgs	Year Designed		Flr-Frms
		Oldest	Newest	
FCAW	8	1965	1993	389
SMAW	6	1978	1990	83
SMAW?	3	1984	1990	86
Unknown	34	1969	1992	732

Table 3-15. Summary of Survey Data by Girder Flange Weld Process

Table 3-15 shows the data distribution for different beam flange weld processes. Because weld processes are frequently not shown on structural drawings, 34 of the 51 survey responses either did not report a weld process or reported it as unknown.

4.0 Characterizing the Damage

4.1 Damage Classes and Types

The survey form described MRF connection damage with 24 different types, as shown in Figures 4-1 through 4-3. For reporting purposes, beam flange, column flange, and weld damage were further identified as occurring at either the top or bottom of the connection. (See Abbreviations and Definitions for damage class abbreviations.) In addition, narrative descriptions of non-structural damage and non-MRF structural damage were provided, and overall structural damage in each building was categorized by the survey engineers as None, Isolated, or Widespread. These descriptions are given for each building in Appendix A.

4.1.1 Incipient Root Cracks (Type W1)

The most commonly observed damage was in bottom flange welds (class BW), and a large portion of these conditions are small or incipient root cracks detected by UT (type W1). No descriptions or definitions beyond those in Figure 4-3 were provided to the survey engineers. Instead, many survey engineers relied on definitions provided by their testing lab, examples of which are given in Appendix C. Although procedures and acceptance criteria became more detailed and standardized as more buildings were inspected, UT results for many buildings were submitted without complete descriptions of the testing scope and findings.

If low rejection rates are achieved initially, a large project can have up to 75% of its flange welds not UT'd during construction; if rejectable welds exist, they may not be found. And, as discussed previously, UT procedures call for significant judgement, which may err on the unconservative side during construction but on the conservative side during post-earthquake inspections. Consequently, there is some question as to how many root discontinuities and rejectable welds were actually caused by the earthquake. For the survey, some engineers reported all discontinuity signals as W1 damage, even if they would normally be acceptable for new construction, on the theory that they could be "small root tears" worth investigating further (see Appendix C). Others reported only rejectable conditions. Still others reported only conditions clearly identified as earthquake damage. (Note that the typical standard for ultrasonic testing of welds, AWS D1.1 Chapter 8, is primarily intended to check workmanship, not "fitness for purpose.")

Because this damage type was so prevalent and variously defined, and because damage statistics are reported here by class not type, it was necessary to distinguish W1 conditions from other weld damage. To do this, the survey form asked survey engineers to estimate the percentage of all weld damage considered to be type W1. Although definitions of W1 "damage" varied among the many survey engineers, the amount of definite weld damage caused by the earthquake can be approximated by multiplying the number of floor frames in damage classes for top weld (TW) damage or bottom weld (BW) damage by the factor (1-WDR), where WDR is the weld damage ratio. This approach was used for computing damage scores.

SURVEY OF STEEL MRF BUILDINGS AFFECTED BY THE JANUARY 1994 NORTHRIDGE EARTHQUAKE	Building Name/ID: ______________ Survey Engr: ________ Firm: ________ Orig Date: ________ Revn Date: ________ Page: ________

SECTION V continued

REFERENCE SCHEDULE OF DAMAGE TYPES (See Reference Details below for pictorial description.)

G GIRDER DAMAGE
- G1 buckled flange
- G2 yielded flange
- G3 flange tearout near weld
- G4 flange crack outside HAZ

CF COLUMN FLANGE DAMAGE
- C1 incipient flange crack (detected by UT)
- C2 complete flange tearout or divot
- C3 full or partial cross-flange crack in HAZ
- C4 full or partial cross-flange crack outside HAZ
- C5 lamellar flange tearing

W FLANGE WELD DAMAGE
- W1 incipient crack, especially at weld root (detected by UT)
- W2 crack through weld metal, full or partial width of flange
- W3 fracture at girder interface
- W4 fracture at column interface

S SHEAR CONNECTION DAMAGE
- S1 column to web or column to shear tab weld crack
- S2 web to shear tab supplemental weld crack
- S3 web or shear tab crack, especially through bolt holes
- S4 web or shear tab deformation, especially at holes
- S5 loose, damaged, or missing bolts; faying surfaces out of contact

PZ PANEL ZONE DAMAGE
- P1 fracture, buckle, or yield of continuity plate
- P2 crack in continuity plate welds
- P3 buckle, yield, or ductile deformation of doubler plate or column web
- P4 crack in doubler plate welds

CW COLUMN WEB DAMAGE
- P5 partial depth crack in column web or doubler plate (extension of C3 or C4)
- P6 full or near full depth crack in column web or doubler plate

Figure 4-1. Survey Form Damage Types
(See Appendix B)

SURVEY OF STEEL MRF BUILDINGS AFFECTED BY THE JANUARY 1994 NORTHRIDGE EARTHQUAKE	Building Name/ID: ______________ Survey Engr: __________ Firm: __________ Orig Date: __________ Revn Date: __________ Page: ______

SECTION V continued

REFERENCE DETAIL (See Reference Schedule above for damage type descriptions.)

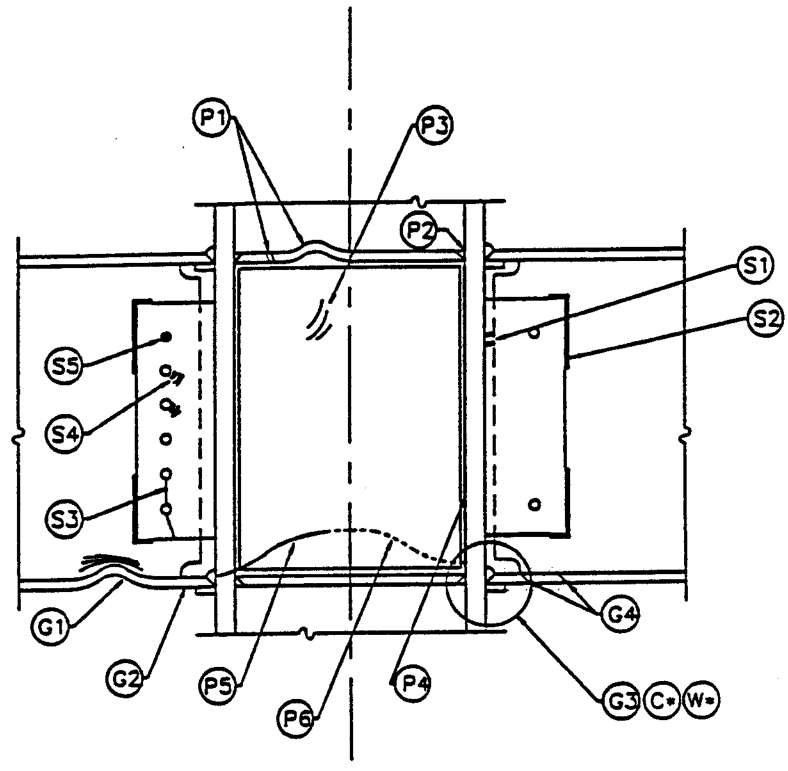


Figure 4-2. Survey Form Damage Types
(See Appendix B)

SURVEY OF STEEL MRF BUILDINGS AFFECTED BY THE JANUARY 1994 NORTHRIDGE EARTHQUAKE

Building Name/ID: ______________

Survey Engr: __________ Firm: ______________

Orig Date: ______________

Revn Date: ______________ Page: __________

SECTION V continued

REFERENCE DETAIL (See Reference Schedule above for damage type descriptions.)

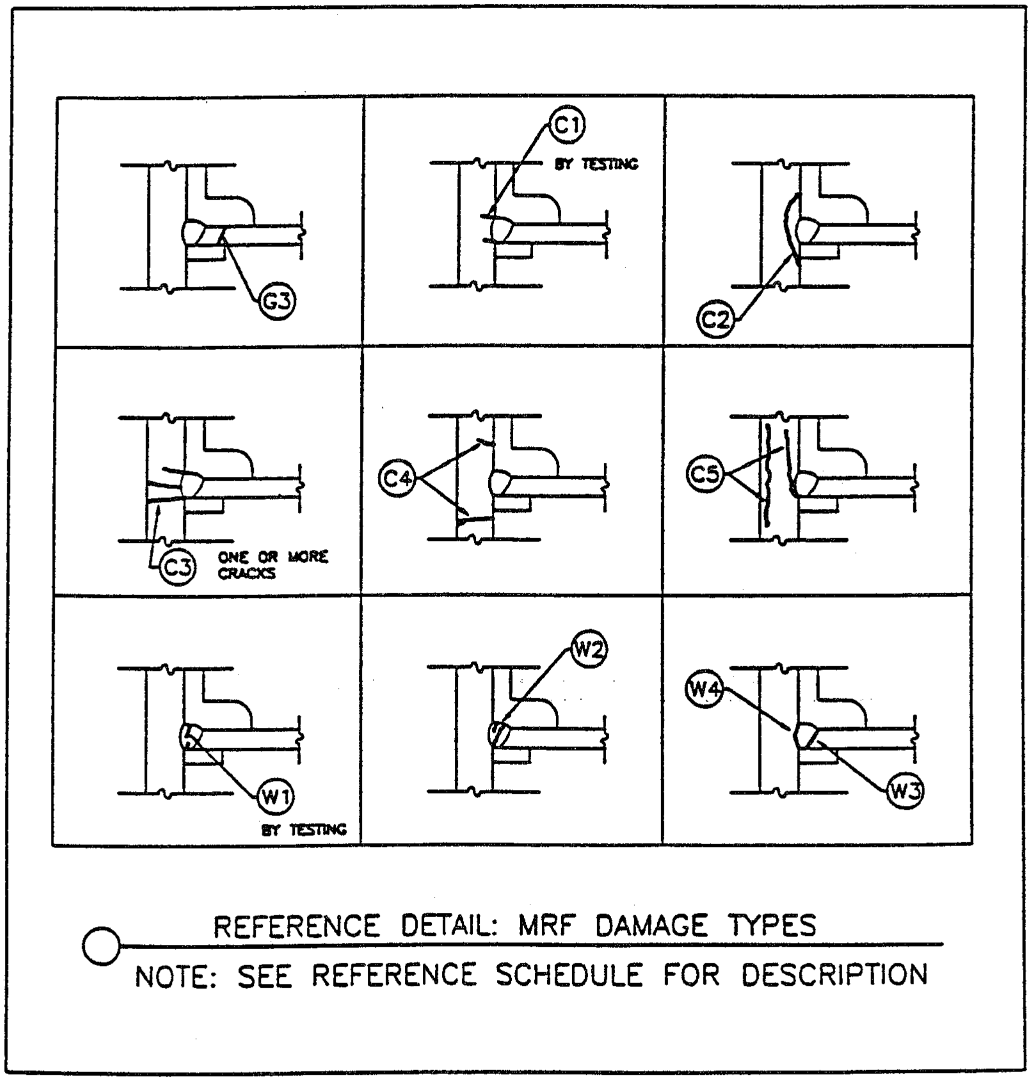


Figure 4-3. Survey Form Damage Types
(See Appendix B)

4.1.2 Fusion Zone Damage (Types W4 and C5)

The survey damage types shown in Figures 4-1 through 4-3 were grouped into classes according to the part of the connection most affected. Damage types W3 and W4 occur at the interface of weld and parent metal. These types were grouped with class W because damage at the weld interface is generally considered a function of inadequate welds, specifically poor fusion resulting from insufficient preheat or poor workmanship.

If damage near the interface is not visible, it is difficult to distinguish clearly by UT whether a crack occurs in the weld or parent metal. Consequently, damage types W4 and C5 can be confused with each other. In some cases, damage type C2, a tear in the parent material, can also be confused or combined with type W4 or C5. Different survey engineers may have reported this kind of damage differently; some reported uncertain or combined types as damage to both weld *and* column. For survey purposes, this may affect damage statistics compiled by class, as W4 and C5 damage are in different classes. However, the net effect on conclusions drawn is not expected to be significant.

4.1.3 Damage Class Combinations

Some damage classes always appear to occur together in the same connection. However, because the survey reports damage in each floor-frame, not each connection, these combinations cannot be quantitatively confirmed. The related damage classes include:

- Top weld (TW) damage occurs in 213 floor-frames in 25 buildings. About 75% of those floor-frames also have bottom weld (BW) damage. TW occurs by itself in only 48 floor-frames in six buildings.

- Shear (S) damage occurs in 44 floor-frames, always in combination with either bottom weld (BW) damage or bottom column flange (BC) damage, and about half the time with both.

- Column web (CW) damage, as expected, always occurs in combination with column flange cracking. In 46 of 47 cases, the crack is at the bottom of the connection. In 33 floor-frames, column web (CW) damage was observed without damage to the shear connection.

4.2 Damage Distributions

Table 4-1 summarizes the number of inspected floor-frames with each class of damage in each building. The buildings are listed by zone for comparison with Table 3-1. Table 4-2 summarizes the incidences of damage, showing the number of buildings and floor-frames in which each class was found at least once, as well as the range of conditions in which each class is represented. Clearly, each damage class is represented in buildings of various ages and heights and in frames with various numbers of bays and bay widths.

Building ID	Zone	WDR	Flr-Frms	Damage Class									Damage Score
				TG	BG	TC	BC	TW	BW	S	PZ	CW	
DM1	LAX		5	0	0	0	0	0	0	0	0	0	0.00
SOM1	MW	1.00	9		0		0		6	0	0	0	0.33
BJ05	NR	0.70	55	0	0	1	15	3	35	0	0	0	1.10
BJ06	NR	0.75	12	0	0	0	3	1	9	2	0	3	2.21
LCIB	NR	0.05	3	0	4	0	12	9	13	2	1	4	
LCIE	NR	0.00	9	0	0	0	6	2	13	0	1	3	
EQE1	SC	0.00	16	0	4	0	16	0	0	8	0	7	4.31
EQE2	SC	0.00	6	0	0	0	5	0	0	0	0	5	4.17
KPFF1A	SC	0.60	4	0	1	0	0	0	3	0	0	0	0.68
BJ01	SM	0.90	23	0	3	1	4	11	21	2	0	0	1.36
ESI2	SM	0.00	1	0	0		1		0	0	0	1	5.00
ESI5	SM	0.30	46	0	0	0	11	34	44	0	0	0	2.51
BAK	SO	0.00	12	0	0	0	0		10	0	0	0	1.25
BJ04	SO	0.30	16	0	0	0	1	1	14	0	0	0	1.25
ESI7	SO	0.00	13	0	0	0	0	0	3	2	0	0	0.65
JAM7482	SO	0.50	28	0	0	2	6	8	16	0	0	1	1.39
JAM7484	SO	0.50	20	0	0	1	3	15	16	4	0	1	2.40
JAM7487	SO	1.00	41	0	0	0	1	0	11	0	0	0	0.18
JAM7489	SO		7	0	0	0	0	0	0	0	0	0	0.00
KAR3	SO	0.00	3	0	0	0	3	0	0	0	0	0	2.00
MNH04	SO		12	0	0	0	0	0	0	0	0	0	0.00
NYA550	SO	1.00	15	0	0	0	0	0	4	0	0	0	0.13
SOA	SO	0.00	22	0	3	0	8	1	9	6	0	0	1.95
BJ02E	UC	0.50	27	0	0	1	16	11	23	4	7	5	3.30
ESI3	UC	1.00	1	0	0	0	1	0	1	1	0	0	4.50
WEA	UC	0.00	24	0	0	0	5	2	6	0	0	5	1.54
BJ09	WH	0.90	50	0	0	0	1	1	18	0	0	0	0.27

Table 4-1. Summary of Surveyed Damage By Building: Aggregate Damage Score & Number of Floor-Frames in Each Damage Class

Building ID	Zone	WDR	Flr-Frms	Damage Class									Damage Score
				TG	BG	TC	BC	TW	BW	S	PZ	CW	
BJ10	WH		13	0	0	0	0	0	0	0	0	0	0.00
BJ11	WH	1.00	26	0	0	2	7	8	15	0	0	0	0.98
BJ18	WH	0.75	24	0	0	0	2	1	14	0	0	0	0.64
ES18	WH	0.80	216	0	0	0	0	74	77	0	0	0	0.49
KAR2	WH	0.20	12	0	1	0	7	0	6	0	2	6	3.32
MNH02	WH	0.75	16	0	0	0	4	0	9	0	4	4	1.67
NYA539	WH	1.00	14	0	0	0	0	6	13	0	0	0	0.68
NYA544	WH	0.50	56	5	9	0	9	0	25	9	0	0	1.09
WJE1	WH	0.00	68	0	0	0	6	0	13	0	0	0	0.46
AC1	WLA	0.00	19	0	1	0	2	0	16	0	0	0	1.47
ESI1	WLA	0.00	50	0	0	0	3	1	7	2	0	0	0.44
ESI4	WLA	0.10	10	0	0	0	0	5	6	0	0	0	1.54
FE1	WLA		4	0	0	0	0	0	0	0	0	0	0.00
JAM7480	WLA	0.33	14	0	0	1	9	2	12	1	0	1	2.81
JAM7485	WLA	0.40	25	0	0	0	9	11	17	1	0	0	2.03
JAM7486	WLA	1.00	44	0	0	0	0	1	9	0	0	0	0.11
MNH03AB	WLA	0.00	38	0	0	0	0	2	5	0	0	0	0.28
MNH03CDE	WLA	0.00	77	0	0	0	1	0	8	0	0	1	0.22
MNH03F	WLA	0.00	17	0	0	0	0	0	3	0	0	0	0.26
MNH03G	WLA	0.00	12	0	0	0	0	0	1	0	0	0	0.13
MNH03H	WLA	0.00	9	0	0	0	0	0	0	0	0	0	0.00
NYA577	WLA	1.00	20	0	0	0	0	2	19	0	0	0	0.53
NYA591	WLA	1.00	16	0	0	0	0	1	2	0	0	0	0.09
NYA592	WLA		10	0	0	0	0	0	0	0	0	0	0.00

Table 4-1. Summary of Surveyed Damage By Building:
Aggregate Damage Score & Number of Floor-Frames in Each Damage Class (Continued)

4.2.1 Damage Score

The final column of Table 4-1 gives a rough damage "score" for each building. The ratios of damaged floor-frames to inspected floor-frames for the most common damage classes are weighted and summed as follows (FF = total inspected/tested floor-frames):

Damage Score =		(TW+BW)/FF	x 0.5
	+	(TW+BW)(1-WDR)/FF	x 1.0
	+	S/FF	x 2.0
	+	BC/FF	x 2.0
	+	CW/FF	x 3.0

Thus, a single floor-frame with no damage would score 0; with only incipient root cracking in bottom welds, 0.5; with complete bottom weld fracture only, 1.5; with incidences of all five of the most common damage classes, 10. For *groups* of floor-frames, the score reflects the ratios of damaged to inspected floor-frames, so that a building with widespread weld damage can score higher than one with isolated flange tears. Note that this scoring system takes no account of the number of inspected, tested, or damaged connections within a single floor-frame, nor the number of inspected floor-frames within a single frame. In particular, because data is available only for individual floor-frames, not individual connections, comparison of scores for different groups of floor-frames is only valid for sufficiently large groups. (See Section 3.2.5 regarding completeness of responses.) Also, note that the effective weights for shear (S) and column web (CW) damage are actually higher than they appear because shear (S) and column web (CW) damage always occur in combination with other classes, as noted above.

This scoring of observed damage is tentative, experimental, and intended only as a check on conclusions drawn from raw numbers of damaged floor-frames. The weights are based on engineering judgement as to the relative severity, structural and financial, of each damage class. Different weights may be equally valid. No study of statistical sensitivity has been made.

Damage scores for each building are given in Table 4-1. The scores for buildings LCIB and LCIE must be ignored, as their surveys reported damage for each frame type, not for each floor-frame. As shown in Table 4-1, the minimum score is 0, while the maximum is 5.0, reflecting the small number of inspected floor-frames in building ESI2. Among buildings with six or more inspected floor-frames (for example a 3-story building with one frame inspected in each direction), the minimum score is 0, while the maximum is 4.31.

Excluding LCIB and LCIE, the aggregate score for buildings with six or more inspected floor-frames is 0.98, or approximately 1.0, using a survey-wide average WDR of 0.50. The mean score for this subset of 43 buildings is 1.15, or rounded to 1.2, and the standard deviation is 1.14. Thus, any sufficiently large group of floor-frames with an aggregate damage score greater than 1.15+1.14=2.29, or roughly 2.3, has significantly more than average damage. Seven of the 43 "well-inspected" buildings meet this criterion.

4.2.2 Damage Ratios

Damage ratio, expressed in decimal or percentage form, is used here to mean the simple ratio of damaged floor-frames (or buildings) to total floor-frames (or buildings). From either a building or floor-frame perspective, the most common damage is seen from Table 4-2 to be in beam flange welds (classes TW and BW). Compared to the next most common damage class, column flange tearing, weld damage was observed in three times as many floor-frames. About 41% of all inspected floor-frames had some bottom weld (BW) damage, and about 17% reported top weld (TW) damage, although Table 4-1 suggests that perhaps half or more of this is incipient root cracking only. Cracking or tearing in the column flange at the bottom of the connection (class BC) also occurs in about 12% of inspected floor frames. Column flange cracks extended into the column web (class CW) in 47 floor-frames in 14 different surveyed buildings. The other damage types appear in far fewer floor-frames and buildings. Top beam and top column flange damage is reported most rarely; this may be due in part to limited access to the top surface of the beam top flange.

Damage Class	No of Bldgs	Flr-Frms	Year Designed		Bldg Ht [stories]		Min # Bays	Max # Bays	Min Bay Width[m]	Max Bay Width[m]
			Oldest	Newest	Shortest	Tallest				
Full Survey	51	1290	1966	1994	1	28	1	11	3.4	14.0
TG	1	5	1976	1976	13	13	5	5	9.8	9.8
BG	8	26	1976	1994	2	13	2	5	4.0	9.8
TC	7	9	1984	1994	3	11	1	4	5.2	11.9
BC	30	177	1976	1994	1	18	1	7	3.4	14.0
TW	25	213	1970	1994	2	28	1	11	3.4	14.0
BW	40	552	1970	1994	2	28	1	11	3.4	14.0
S	13	44	1976	1994	2	13	1	6	4.0	12.2
PZ	5	15	1985	1994	3	4	2	4	5.5	10.4
CW	14	47	1979	1994	1	11	1	6	3.4	11.9
Any Damage	44	629	1970	1994	1	28	1	11	3.4	14.0
No Damage	45	661	1966	1994	1	28	1	11	3.4	14.0
Weld Only	36	426	1970	1994	2	28	1	11	3.4	14.0
>Weld Only	32	186	1976	1994	1	18	1	7	3.4	14.0

Table 4-2. Summary of Surveyed Damage by Class

The damage classes labeled "No Damage" and "Weld Only" in Table 4-2 require some explanation. First, note that the "No Damage" statistics include floor-frames which may have been only minimally inspected - perhaps only one or two connections cleaned. With more complete inspection, some damage may be found. (Of the 661 undamaged floor-frames, 471 had at least half of their connections visually inspected *or* at least a quarter of them UT'd.) Second, the number of buildings in these two categories indicates the number in which *at least one floor-frame* had no damage or only weld damage. However, the number of buildings with no damage or only weld damage *in the entire building* can be derived from the table:

No. of buildings surveyed:		51
No. with any damage:		44 (86%)
No. with no damage at all:	51-44 =	7 (14%)
No. with more than weld damage:		32 (63%)
No. with weld damage only:	44-32 =	12 (24%)

On a floor-frame basis, the corresponding totals are taken directly from Table 4-2:

No. of floor-frames surveyed:	1290
No. with any damage:	629 (49%)
No. with no damage:	661 (51%)
No. with more than weld damage:	186 (14%)
No. with weld damage only:	426 (33%)

Discounting minor weld damage, the percentage of buildings with serious damage can be *estimated* as 63% with more than weld damage plus half (1-WDR using survey-wide average WDR of 0.50) of the 24% with weld damage only, or a total of 75%. Similarly, the percentage of floor frames with no serious damage can be estimated by taking 51% with no damage plus half of the 33% with weld damage only, or 67%. Thus, while most buildings (75%) had serious damage to welds or parent metal, most individual floor-frames (67%) did not. Another way of stating this is that only 33% (100%-67%) of floor frames had serious damage. And, because a damaged floor-frame can have several *un*damaged connections, it stands to reason that fewer that 33% of individual connections would have serious damage. (A database of individual connections, as opposed to floor-frames, would establish this percentage more reliably.)

This limited data suggests that damage estimates and reliability analyses can assume a *worst case* loss of about 33% of all MRF connections. In other words, an owner or engineer assessing a typical but as yet uninspected MRF in West L.A. (for example) can reasonably assume that no more than 30% of the building's connections are damaged and can plan inspections or changes in building use accordingly. Of course, this percentage must be tempered by the influences of various site and design factors discussed below. Furthermore, a reliability analysis must consider the likelihood that within a single floor-frame the loss of one connection may trigger damage in its neighbors, leading to the functional loss of the entire floor-frame. Such a study is beyond the scope of this survey.

4.2.3 No Damage

Table 4-3 isolates the seven buildings with no damage at all. Only four zones are represented, but they are the zones furthest from the epicenter and with the largest number of surveyed buildings. It is noteworthy that every zone with more than four surveyed buildings has at least one building with no damage. Recalling that the overall survey sample (as of October, 1994) probably represents the worst conditions within the MRF population, this suggests that broader inspection will reveal more and more buildings with limited or no damage. On the other hand, some of the buildings in Table 4-3 were only minimally inspected; although the survey data is not conclusive (see Section 5.3), it is reasonable to expect that more complete inspection could reveal more damage.

Building ID	Zone	Year Designed	MRF Stories	Upper Floor Area [m^2]	Floor Const	Flr-Frms	Insp'd Conns	Tested Conns
DM1	LAX	1970	15	2,000	MC	5	13	13
JAM7489	SO	1979	6	2,000	MCL	7	8	8
MNH04	SO	1981	6	3,000	MCL	12	31	31
BJ10	WH	1990	5	4,600	MCL	13	35	35
FE1	WLA	1965	17	2,100	MC	4	12	12
MNH03H	WLA	1978	3	700	W	9	32	0
NYA592	WLA	1969	20	2,300	LC	10	10	10

Table 4-3. Surveyed Buildings with No Damage

4.2.4 Weld Damage Only

Table 4-4 isolates the twelve buildings with weld damage only. As with the undamaged buildings, this subset represents a range of locations, ages, sizes, and materials. Again, note that each of the most-represented zones has buildings with weld damage only. Two of these buildings, BAK and ESI4, have weld damage so widespread that their damage scores approach those of buildings with more serious fractures.

4.2.5 Column Web Damage

Table 4-5 isolates the 12 buildings with the most serious damage: fracture through the column flange into the column web. (Buildings LCIB and LCIE also have column web (CW) damage but are not included here because of incompatible survey data.) Only the two zones furthest from Northridge, each of which has only one surveyed building, are not represented. The range of building ages and heights appears more narrow for these buildings, all of which are post-1978, and all but one of which is less than six stories. (However, note that BJ02E is

Building ID	Zone	Year Des'd	MRF Stories	Upper Flr Area [m^2]	Flr Cnst	Column Steel	Beam Steel	WDR	Flr-Frms	TW	BW	Damage Score
SOM1	MW	1986	4	1,700	W	A36	A36	1.00	9		6	0.33
BAK	SO	1982	6	1,900	MCL	A572-Gr50	A36	0.00	12		10	1.25
NYA550	SO	1985	6	2,000	MCL	A572-A36	A36	1.00	15	0	4	0.13
ESI8	WH	1987	25	2,500	MC	A572-Gr50	A36	0.80	216	74	77	0.49
NYA539	WH	1984	3	2,600	MC	A36	A36	1.00	14	6	13	0.68
ESI4	WLA	1988	27	1,300	MCL	A572-Gr50	A36	0.10	10	5	6	1.54
JAM7486	WLA	1983	13	1,500	MC	A572-Gr50	A36	1.00	44	1	9	0.11
MNH03AB	WLA	1978	3	1,000	W	A36	A36	0.00	38	2	5	0.28
MNH03F	WLA	1978	3	500	W	A36	A36	0.00	17	0	3	0.26
MNH03G	WLA	1978	3	400	W	A36	A36	0.00	12	0	1	0.13
NYA577	WLA	1980	14	1,600	MCL	A572-Gr50	A36	1.00	20	2	19	0.53
NYA591	WLA	1970	28	2,200	MCL	A36	A36	1.00	16	1	2	0.09

Table 4-4. Surveyed Buildings with Weld Damage Only

Building ID	Zone	Year Des'd	MRF Stories	Upper Flr Area [m^2]	Flr Cnst	Column Steel	Beam Steel	WDR	Flr-Frms	CW	Damage Score
BJ06	NR	1989	2	4,700	MC	A572-Gr50	A36	0.75	12	3	2.21
EQE1	SC	1991	4	2,000	MC	A572-Gr50	A36	0.00	16	7	4.31
EQE2	SC	1991	1	2,500	MC	A36	A36	0.00	6	5	4.17
ESI2	SM	1990	5	2,000	MCL	A572-Gr50	A36	0.00	1	1	5.00
JAM7482	SO	1983	4	1,300	W	A36	A36	0.50	28	1	1.39
JAM7484	SO	1985	4	1,500	MCL	A36	A36	0.50	20	1	2.40
BJ02E	UC	1992	3	2,700	MC	A572-Gr50	A36	0.50	27	5	3.30
WEA	UC	1979	4	1,700	W	A36	A36	0.00	24	5	1.54
KAR2	WH	1978	4	2,600	MC	A36	A36	0.20	12	6	3.32
MNH02	WH	1984	3	2,900	MC	A36	A36	0.75	16	4	1.67
JAM7480	WLA	1983	11	2,100	MC		A36	0.33	14	1	2.81
MNH03CDE	WLA	1978	3	1,600	W	A36	A36	0.00	77	1	0.22

Table 4-5. Surveyed Buildings with Column Web Damage

Building ID	Zone	Dir'n	Flr	No of Bays	Typ Bay Width [m]	Typ Ext Col	Typ Int Col	Typ Beam
BJ06	NR	NS	2	5	9.8	W21x364	W21x364	W36x230,260
BJ06	NR	NS	2	5	9.8	W21x333	W21x333	W36x230,260
BJ06	NR	NS	3	5	9.8	W21x364	W21x364	W36x135,150
LCIB	NR	NESW		3	9.5	W14x233-342	W14x233-342	W21,W24, W27
LCIB	NR	NWSE		3	6.1	na	W14x176-233	W21x62-W24x117
LCIE	NR	NS		2	9.5	W14x233	W14x233	W21x83-W24x131
EQE1	SC	NS	2	4	6.1		W14x159	W30x116
EQE1	SC	NS	2	4	6.1		W14x159	W30x116
EQE1	SC	NS	3	4	6.1		W14x145	W30x108
EQE1	SC	NS	3	4	6.1		W14x145	W30x108
EQE1	SC	EW	3	3	6.1		W14x211	W33x130
EQE1	SC	NS	4	4	6.1		W14x145	W27x94
EQE1	SC	NS	4	4	6.1		W14x145	W27x94
EQE2	SC	NS	1	2	7.3	W12x136		W24x76
EQE2	SC	NS	1	1	8.2	W12x190	na	W36x160
EQE2	SC	EW	1	2	7.3	W12x136		W24x76
EQE2	SC	EW	1	2	7.3	W12x136		W24x76
EQE2	SC	NS	1	2	6.1	W12x136		W30x99
ESI2	SM	EW	2	1	6.1	W14x193	na	W36x135
JAM7482	SO	NS	2	2	10.2	W14x398	W14x398	W36x210

Table 4-6. Surveyed Floor-Frames With Column Web Damage

Building ID	Zone	Dir'n	Flr	No of Bays	Typ Bay Width [m]	Typ Ext Col	Typ Int Col	Typ Beam
JAM7484	SO	NS	1	1	11.9	W14x311	na	W36x230
BJ02E	UC	NS	2	3	10.4	na	W24x162	W24x84, W36x210
BJ02E	UC	NS	2	3	10.4	na	W24x192	W36x135
BJ02E	UC	NS	2	3	10.4	na	W24x192	W36x135
BJ02E	UC	NS	3	3	10.4	na	W24x279	W36x210
BJ02E	UC	NS	3	3	10.4	na	W24x279	W36x210
WEA	UC	EW	2	1	7.3	W24x68	na	W24x76
WEA	UC	EW	2	1	7.3	W24x110	na	W33x118
WEA	UC	EW	2	1	7.3	W24x110	na	W33x118
WEA	UC	EW	2	1	9.1	W27x145	na	W36x160
WEA	UC	EW	3	1	7.3	W24x94	na	W30x108
KAR2	WH	NS	2	4	9.1	W14x136	W14x342	BU42
KAR2	WH	NS	2	4	9.1	W14x136	W14x370	BU42
KAR2	WH	NS	3	4	9.1	W14x95	W14x211	BU42
KAR2	WH	NS	3	4	9.1	W14x95	W14x211	BU42
KAR2	WH	NS	4	4	9.1	W14x84	W14x158	BU42
KAR2	WH	NS	4	4	9.1	W14x84	W14x158	BU42
MNH02	WH	NS	1	2	8.5	BU24	BU24	BU40
MNH02	WH	NS	1	2	8.5	BU24	BU24	BU40
MNH02	WH	NS	1	2	8.5	BU24	BU24	BU40
MNH02	WH	NS	1	2	8.5	BU24	BU24	BU40
JAM7480	WLA	EW	11	6	8.8			W36x150
MNH03CDE	WLA	NESW	2	2	3.4	W14x90		W21x50

Table 4-6. Surveyed Floor-Frames with Column Web Damage (Continued)

actually a 3-story MRF on top of a 6-story concrete structure.) Note that while buildings WEA and MNH02 have relatively many floor-frames with at least one cracked column web, their damage scores are close to the average building score of 1.15 (see Section 4.2.1). This suggests a deficiency in the scoring formula, since these buildings should be considered heavily damaged.

Column web cracking is serious and rare enough to warrant more full description. Table 4-6 lists characteristics of each floor-frame with column web (CW) damage. Additional information for each listed building can be found in Table 4-5 and in Appendix A. From Tables 4-5 and 4-6, it is clear that column web fractures have occurred in a variety of building locations, sizes, frame configurations, diaphragm types, and framing details.

5.0 Correlating the Damage

5.1 Method

Valid correlations between damage and building characteristics require data samples of reliable quality and comparability. The sources of survey error given in Section 3.2 must be considered in all of the discussions that follow.

For this report, correlations are studied by comparing damage scores or damage ratios of a specific subset of buildings or floor-frames to the aggregate scores and ratios of a larger subset, usually the complete set of surveyed conditions. It should be emphasized that the correlations cited are *not* based on statistics. For the survey as a whole, aggregate scores and ratios include the following rounded values, as discussed in Sections 4.2.1 and 4.2.2:

Damage Score:	average for buildings with 6 or more floor-frames	1.15
	building average plus one standard deviation	2.29
	floor-frame aggregate	0.98

Damage Ratios:	bottom weld	.41
	top weld	.16
	bottom column flange	.12

(Note that none of the correlations include data from buildings LCIB and LCIE, whose survey responses were not comparable to those of other buildings.)

5.2 Non-MRF Damage

Except in the most severe cases, MRF connection damage is impossible to identify without disruptive and costly inspection. It would be useful to know if the extent of MRF damage could be predicted on the basis of visible non-MRF damage. The survey forms recorded non-MRF damage only in qualitative, narrative form, as shown in the Appendix A summaries.

Most of the surveyed buildings reported some non-MRF structural damage, ranging from minor spalling around base plates to permanent lateral set and, in one case, near partial collapse. Eight buildings were found to have significant permanent lateral set, as summarized in Table 5-1. (Note that most surveyed buildings were not checked for plumbness. Also, note that buildings can experience substantial inelasticity without measurable lateral set.) The average damage score for these eight buildings is 2.2, significantly higher than the survey average.

Building ID	Zone	Stories	Damage Score	Non-MRF Structural Damage
BAK	SO	6	1.25	YES - Out of plumb 64 to 76 mm (2.5 to 3 in) in the N-S direction.
BJ05	NR	11	1.10	YES - Northerly 51 mm (2 in) permanent displacement @ roof (11th floor).
EQE1	SC	4	4.31	YES - 51 mm (2 in) perm. deflection to S at roof, 3.49 cm (1.375 in) at ground floor. 35 mm (1.375 in) perm. deflection to W at roof, 25 mm (1 in) at ground floor.
EQE2	SC	1	4.17	YES - 102 mm (4 in) perm. deflection to NW at roof. Crack across diaphragm with 51 mm (2 in) separation. Pullout failure of pre-cast attachments. Failure of non-moment beam connection at drop of roof about 102 mm (4 in). Pullout of roof from block walls. Pounding damage of block walls with roof diaphragm and with adjacent parking structure.
JAM7484	SO	4	2.40	YES - Distortion to beam web & shear tab in a few nonframe connections. 51-89 mm (2-3.5 in) out-of plumb, northerly, at 4th floor.
KAR3	SO	17	2.00	YES - Measured deflection of 89 mm (3.5 in) of the top relative to the base of 18-story N-S frame. All the deformation is within the top six stories.
SOA	SO	4	1.95	YES - Base plate anchors broke free from base plates. Large areas of spalled concrete around many column bases. One base shifted 19 mm (.75 in) north, another 10 mm (.375 in).
WJE1	WH	18	0.46	YES - 152 mm (6 in) perm. lateral displacement in height of 18 story building. Steel stair connections broken. Mechanical room block walls broken at connections to steel floor framing. Marble panel anchorages in lobby damaged.

Table 5-1. Surveyed Buildings with Reported Lateral Set

Table 5-2 shows the aggregate damage for the 202 inspected floor-frames in these eight buildings. Only the number of floor-frames with bottom column flange (BC) damage is significantly higher than average. The column web (CW) damage ratio of 0.06 represents 13 floor-frames, but twelve of these are in only two buildings. In summary, permanent lateral set appears to be only weakly related to significant MRF connection damage. In fact, building BAK sustained a permanent lateral set with weld damage only.

Current survey responses do not justify a correlation study between MRF connection damage and non-structural damage. First, non-structural damage is expected in large earthquakes. Second, although most surveyed buildings had some non-structural damage, the reported damage is highly varied, and much damage had already been repaired by the time MRF connection inspection began. Finally, there is strong anecdotal evidence that MRF damage can be present either with or without heavy non-structural damage [SEAOC Seismology Committee, 1994].

No of Bldgs	WDR	Flr-Frms	Damage Class					Damage Score
			BC	TW	BW	S	CW	
8	0.24	202	0.28	0.09	0.41	0.09	0.06	1.56

Table 5-2. Aggregate Damage Ratios and Score for Surveyed Buildings with Reported Lateral Set

5.3 Scope of Inspection

Even assuming reliable and consistent UT, a limited inspection program may fail to find widely scattered damage. A sufficient inspection scope is essential if damaged MRF's cannot be identified by outwardly visible damage (see above) or by geographic location (discussed below). With current survey data, a study of observed damage vs. scope of inspection can consider the number of inspected floor-frames within a building and the number of inspected connections within a floor-frame.

Since complete testing may have been motivated by visible connection damage, this correlation study should only include buildings in which damage could not be observed easily through fireproofing. The subset considered here consists of the 19 buildings with no damage or weld damage only. Of these 19, only one was fully inspected; that is, only building ESI8 had close to 100% of its floor-frames and connections tested. Only six of these buildings had at least 25% of their total floor-frames reported *and* 25% of the connections in those floor-frames tested. The average damage score for the 13 least-inspected buildings with no damage or weld damage only is 0.31; the average score for the other six more thoroughly tested buildings is 0.29. As this data is sparse, these averages are not especially meaningful, except to show that the survey data for this subset of buildings cannot conclusively show a link between damage and level of inspection.

A different subset of somewhat more damaged buildings is the set with column flange damage but *without* visible shear connection or column web damage. Ten buildings, with damage scores ranging from 0.2 to 2.5 and averaging 1.1, meet this criterion. Of these, five had testing of at least half of the connections in at least half of all floor-frames. (Note that this is a noticeably higher level of inspection than in buildings with no damage or weld damage only.) These five have an average score of 1.3, while the less inspected five averaged 0.9. Again, without robust data, the survey results are suggestive but not conclusive of a link between scope of inspection and observed damage.

In some buildings, structural analysis was used to locate connections for testing. If damage locations can be determined rationally, then there could be a *negative* correlation between damage and testing, as marginal testing will consider fewer and fewer critically stressed locations. Survey data is insufficient to test this hypothesis on a floor-frame level.

As noted in Section 3.1.2, access to the beam top flange and the outside of connections in perimeter frames was frequently limited. It is possible that the incidences of top column flange (TC) damage are so few because the inspection and testing there was limited, but the survey data is not complete enough to test such a hypothesis. Some engineers suspect that serious damage at the top of the connection would manifest as damage to the diaphragm above; if no evidence of diaphragm damage was seen, then limited inspection of the top flange is justified.

In addition, there are reasons to believe that damage at the top of the connection *should* be more rare than at the bottom: at the top, the extreme flange fiber is at the toe of the weld, not at the root/backing bar notch; for a beam acting compositely with a concrete slab, the imposed bending is resisted in part by the slab; and in composite members, the neutral axis is shifted from the steel mid-depth up toward the top flange, leading to higher strains at the bottom weld and lower strains at the top. Given these explanations, it is reasonable to look for top column flange (TC) damage and top flange weld (TW) damage at non-composite beams. However, the eight buildings and 214 floor-frames with wood diaphragms showed no higher incidence of these damage classes than did those with metal deck and concrete fill.

5.4 Location

5.4.1 Zone

Table 4-1 gives damage data for the surveyed buildings sorted by geographic zone. Each zone represents a range of damage levels, showing that buildings subjected to similar ground motions exhibited markedly different performance, even though their steel MRF structures were probably designed to similar criteria. There is not a direct correlation between geographic location and extent of MRF damage.

Tables 4-3, 4-4, and 4-5 give the zones represented by three different damage levels. Table 5-3 summarizes the damage for each zone, giving the ratio of damaged floor-frames in each class and the aggregate damage score for the entire zone. By damage score, Santa Clarita (SC), Universal City (UC), and Santa Monica (SM) are significantly above the survey average of 1.0, although these zones all have small samples of only three buildings each. This supports the suggestion from Section 4.2.3 that the survey's limited sample has captured the worst damage in each zone and that further inspection and testing within a given zone will reveal some buildings with minor or no damage.

5.4.2 Adjacent Buildings

A study of neighboring but otherwise very different buildings requires greater detail than the current survey provides. Three sets of buildings, however, are on adjacent sites and are constructed from similar details as distinct but related parts of larger projects: BJ10 & 11, BJ05 & 06, and MNH03AB, CDE, F, G, & H. Table 4-1 is sufficient to show that the extent of damage can vary greatly, even in these similar adjacent buildings. In particular, BJ10 is undamaged while BJ11 has column flange tears in one fourth of its floor-frames. The

MNH03 buildings have similar low damage scores, but note that the only non-weld damage in all five buildings is in the irregular (U-shaped) MNH03CDE.

Zone	No of Bldgs	Flr-Frms	WDR	Damage Class					Damage Score
				BC	TW	BW	S	CW	
LAX	1	5		0.00	0.00	0.00	0.00	0.00	0.00
MW	1	9	1.00	0.00	0.00	0.67	0.00	0.00	0.33
NR	2	67	0.71	0.27	0.06	0.66	0.03	0.04	1.30
SC	3	26	0.09	0.81	0.00	0.12	0.31	0.46	3.78
SM	3	70	0.49	0.23	0.64	0.93	0.03	0.01	2.14
SO	11	189	0.50	0.12	0.13	0.44	0.06	0.01	0.96
UC	3	52	0.28	0.42	0.25	0.58	0.10	0.19	2.63
WH	10	495	0.66	0.07	0.18	0.38	0.02	0.02	0.72
WLA	15	365	0.27	0.07	0.07	0.29	0.01	0.01	0.61

Table 5-3. Damage Ratios and Scores by Zone

Direction	No of Bldgs	Flr-Frms	WDR	Damage Class					Damage Score
				BC	TW	BW	S	CW	
EW	37	449	0.54	0.11	0.14	0.36	0.02	0.02	0.80
NESW	10	156	0.34	0.08	0.19	0.37	0.01	0.01	0.87
NS	38	481	0.53	0.20	0.15	0.52	0.06	0.06	1.35
NWSE	10	192	0.44	0.02	0.19	0.30	0.00	0.00	0.55

Table 5-4. Damage Ratios and Scores by Frame Direction

5.4.3 Directionality

Table 5-4 separates the reported floor-frames by compass direction, clearly showing greater damage in North-South frames. Table 5-5 breaks the data down further by geographic zone, ignoring zones LAX and MW which have only one building each. (Note that at this level, a number of zone-direction combinations are represented by only one or two buildings and relatively few floor-frames.) Data from zones SO, WH, and WLA show that the N-S directionality is strongest north of the Santa Monica Mountains and weakest in Santa Monica and West L.A. It should be noted that strong motion records in the Santa Monica area showed a stronger E-W component than N-S component.

Zone	Direction	No of Bldgs	WDR	Flr-Frms	Damage Class					Damage Score
					BC	TW	BW	S	CW	
NR	EW	2	0.71	30	0.20	0.07	0.70	0.00	0.00	1.00
NR	NS	2	0.71	37	0.32	0.05	0.62	0.05	0.08	1.54
SC	EW	3	0.09	13	0.77	0.00	0.08	0.31	0.23	2.95
SC	NS	3	0.09	13	0.85	0.00	0.15	0.31	0.69	4.60
SM	EW	1	0.00	1	1.00	0.00	0.00	0.00	1.00	5.00
SM	NESW	2	0.42	30	0.40	0.77	1.00	0.07	0.00	2.84
SM	NWSE	2	0.56	39	0.08	0.56	0.90	0.00	0.00	1.53
SO	EW	9	0.61	84	0.05	0.13	0.36	0.00	0.00	0.53
SO	NS	11	0.41	105	0.17	0.13	0.50	0.11	0.02	1.33
UC	EW	2	0.21	28	0.25	0.14	0.50	0.04	0.14	1.83
UC	NS	3	0.35	24	0.63	0.38	0.67	0.17	0.25	3.53
WH	EW	10	0.63	204	0.05	0.19	0.29	0.01	0.00	0.54
WH	NESW	1	0.80	24	0.00	0.17	0.25	0.00	0.00	0.29
WH	NS	10	0.64	219	0.12	0.17	0.52	0.03	0.05	1.02
WH	NWSE	1	0.80	48	0.00	0.21	0.25	0.00	0.00	0.32
WLA	EW	8	0.33	82	0.13	0.12	0.44	0.01	0.01	0.98
WLA	NESW	7	0.21	102	0.01	0.03	0.22	0.00	0.01	0.37
WLA	NS	7	0.37	76	0.16	0.09	0.49	0.04	0.00	1.05
WLA	NWSE	7	0.22	105	0.00	0.05	0.10	0.00	0.00	0.18

Table 5-5. Damage Ratios and Scores by Zone and Frame Direction

N-S directionality in the five northernmost zones is corroborated by reports of permanent lateral set, given in Table 5-1, and by the damage data in Tables 5-6 and 5-7. In 3-bay frames with bay widths of 9.1 to 12.2 meters (30 to 40 feet), there are 100 surveyed floor-frames overall. As can be determined from Tables 5-6 and 5-7, all of the shear (S) and column web (CW) damage and 14 of 16 bottom column flange (BC) damage cases are in the N-S direction.

Typ Bay Width [m]	No of Bldgs	Flr-Frms	WDR	Damage Class					Damage Score
				BC	TW	BW	S	CW	
4.6-5.8	9	114	0.29	0.09	0.11	0.18	0.01	0.00	0.54
6.1-8.8	15	87	0.45	0.14	0.13	0.43	0.05	0.01	0.98
9.1-12.2	15	100	0.82	0.16	0.09	0.38	0.03	0.05	0.85

Table 5-6. Damage Ratios and Scores for 3-Bay Frames by Bay Width

Typ Bay Width [m]	No of Bldgs	Flr-Frms	WDR	Damage Class					Damage Score
				BC	TW	BW	S	CW	
4.6-5.8	2	16	0.70	0.00	0.00	0.06	0.00	0.00	0.05
6.1-8.8	5	33	0.59	0.06	0.15	0.61	0.00	0.00	0.81
9.1-12.2	5	49	0.81	0.29	0.14	0.43	0.06	0.10	1.39

Table 5-7. Damage Ratios and Scores for 3-Bay Frames by Bay Width: North-South Frames, 1 to 14-Story, Zones NR, SC, SO, UC, WH

5.5 Concept Design

5.5.1 Height

As shown in Table 4-5, column web (CW) damage is mostly limited to buildings shorter than six stories. Overall, the average damage score for 34 surveyed buildings less than seven stories tall is 1.2, about the same as the average for the entire survey. Damage ratios for these buildings are also close to overall survey averages: bottom weld (BW) damage, 0.44; top weld (TW) damage, 0.16; bottom column flange (BC) damage, 0.16. Damage in the 14 taller buildings (excluding ESI8, whose 216 floor-frames skew the sample) is somewhat lower than average, but not significantly so. Thus, short buildings do not appear significantly more prone to MRF damage than tall buildings.

The location of damage within a building's height may indicate that damage is associated with certain modes of vibration. Table 5-8 shows damage characteristics for frames at each level of 3 to 5 story buildings. (Floor #1 data may be anomalous, since ground floor conditions vary greatly depending on column fixity and basement structure. Roof data may also reflect various loading and penthouse framing conditions.) In 3- and 4-story buildings, Table 5-8 shows a clear trend: more damage at lower stories, notably bottom column flange (BC) damage, bottom weld (BW) damage and column web (CW) damage. This reflects the story drift and shear distribution of a flexible frame in its first vibration mode. The trend does not show in the 5-story buildings, although the data there is relatively sparse.

Stories	Floor # or Roof	No of Bldgs	Flr-Frms	WDR	Damage Class					Damage Score
					BC	TW	BW	S	CW	
3	1	3	24	0.88	0.17	0.25	0.71	0.00	0.17	1.43
3	2	11	95	0.17	0.13	0.09	0.47	0.04	0.04	1.22
3	3	10	78	0.15	0.08	0.05	0.31	0.01	0.03	0.74
3	Roof	9	69	0.12	0.04	0.01	0.13	0.01	0.00	0.32
4	1	3	19	0.21	0.21	0.42	0.58	0.21	0.05	2.29
4	2	10	47	0.38	0.53	0.28	0.68	0.17	0.19	3.05
4	3	10	49	0.40	0.31	0.22	0.55	0.14	0.12	2.12
4	4	10	48	0.39	0.23	0.19	0.54	0.02	0.08	1.56
4	Roof	7	32	0.33	0.13	0.25	0.47	0.03	0.00	1.15
5	1	3	16	0.98	0.19	0.06	0.31	0.00	0.00	0.57
5	2	5	37	0.62	0.05	0.05	0.43	0.00	0.03	0.62
5	3	4	27	0.57	0.11	0.15	0.30	0.00	0.00	0.63
5	4	4	22	0.48	0.14	0.09	0.27	0.05	0.00	0.73
5	5	2	20	0.45	0.05	0.05	0.20	0.05	0.00	0.46
5	Roof	2	18	0.40	0.00	0.00	0.06	0.00	0.00	0.06

Table 5-8. Damage Ratios and Scores in 3 to 5-Story Buildings by Floor Level

Table 5-9 gives data characteristics for different portions of six 11- to 14-story mid-rise buildings. Bottom weld (BW) damage is observed at about the same rate at lower and upper levels. Greater bottom column flange (BC) damage leads to higher ratios and scores around mid-height and at top floors, but this may be an artifact of limited sample sizes. For the six surveyed mid-rise buildings, there is no clear correlation between damage and floor number.

Limited data (see Table 3-3) prohibits useful studies of damage vs. floor number for high-rise buildings.

Stories	Floor #	No of Bldgs	Flr-Frms	WDR	Damage Class					Damage Score
					BC	TW	BW	S	CW	
11-14	2 - 4	5	50	0.79	0.12	0.00	0.46	0.1	0.00	0.73
11-14	5 - 7	6	63	0.75	0.22	0.06	0.51	0.1	0.00	1.00
11-14	8 -10	5	57	0.80	0.07	0.04	0.53	0.0	0.00	0.57
11-14	11-15	6	40	0.70	0.20	0.05	0.48	0.0	0.03	0.95

Table 5-9. Damage Ratios and Scores in 11 to 14-Story Buildings by Floor Level

5.5.2 Frame Configuration

With reference to Table 3-6, Tables 5-10 and 5-11 give damage characteristics according to the number of bays per frame. Both tables exclude frames of more than five bays, which are not as well represented.

Table 5-10 considers all surveyed buildings (except LCIB and LCIE). Note that the 2-bay frame data is dominated by 216 floor-frames from building ESI8. As a group, 1-bay frames have the highest damage score and bottom weld (BW) and top weld (TW) damage ratios, but they do not stand out from the other groups as significantly more prone to damage. Survey wide, there does not appear to be a correlation between observed damage and the number of bays per frame.

Bays	No of Bldgs	Flr-Frms	WDR	Damage Class					Damage Score
				BC	TW	BW	S	CW	
1	13	205	0.33	0.11	0.24	0.53	0.04	0.04	1.32
2	18	448	0.50	0.08	0.23	0.38	0.00	0.02	0.84
3	29	301	0.50	0.13	0.11	0.32	0.03	0.02	0.79
4	20	135	0.56	0.19	0.08	0.47	0.05	0.09	1.27
5	12	124	0.53	0.18	0.02	0.39	0.14	0.02	1.10

Table 5-10. Damage Ratios and Scores by Number of Bays per Frame

Table 5-11 considers the same data for a subset of floor-frames: North-South (NS) oriented frames in low- and mid-rise buildings (1 to 14 stories), located north of West L.A. in zones that showed predominant NS directionality (see Table 5-3). As NS frames have already been shown to have more damage in these zones, the high scores and ratios in Table 5-11 are not surprising. One- and 2-bay frames have the highest weld damage ratios, but 4- and 5-bay frames have very high ratios of column flange cracking and the highest damage scores overall.

In light of observed Northridge damage, the use of 1-bay frames has been questioned because each connection represents half of a frame's energy dissipation capacity, and with only two connections per floor, the loss of one could greatly increase demand on the other. Although the data is limited for this narrow subset of floor-frames, Table 5-11 shows that 1-bay frames experienced only average damage. Despite this finding, one bay frames continue to present a concern for Engineers due to their lack of redundancy. Because 4- and 5-bay frames are highly redundant, the severity of high scores shown in Table 5-11 depends on the number of damaged connections within each frame, but those numbers were not tracked by the survey.

Bays	No of Bldgs	Flr-Frms	WDR	Damage Class					Damage Score
				BC	TW	BW	S	CW	
1	7	44	0.41	0.07	0.25	0.55	0.14	0.07	1.48
2	7	37	0.56	0.30	0.14	0.70	0.00	0.19	1.95
3	11	98	0.71	0.16	0.12	0.43	0.03	0.05	0.97
4	7	40	0.55	0.43	0.03	0.43	0.10	0.30	2.38
5	4	50	0.37	0.36	0.04	0.56	0.28	0.06	2.14

Table 5-11. Damage Ratios and Scores by Number of Bays per Frame: North-South Frames, 1 to 14-Story, Zones NR, SC, SO, UC, WH

Tables 5-6 and 5-7 show the damage in the most common frame configuration, 3 bays, broken down by typical bay width. Table 5-6 considers all surveyed floor-frames; Table 5-7 considers only NS floor-frames in 1-14 story buildings north of West L.A. Surprisingly, the subset of North-South data shows less overall damage than the survey as a whole. Both tables show somewhat less damage in frames with shorter bays, though the Table 5-7 data is sparse. At best, there is a weak correlation between damage and long bays.

5.5.3 Redundancy

As described in Section 3.3.2, Table 3-7 lists the least redundant frames in the survey: those with only one or two bays in directions with only two frames. For the seven buildings represented, damage scores range from 0.46 to 2.51, averaging 1.55, somewhat greater than the overall survey average.

Table 5-12 gives the aggregate damage for these least redundant floor-frames. All the damage ratios and scores are close to the survey-wide averages. By this measure, at least, there is no correlation between observed damage and lack of structural redundancy. Surveyed buildings that are least redundant *and* irregular are discussed in the next section.

No of Bldgs	Flr-Frms	WDR	Damage Class					Damage Score
			BC	TW	BW	S	CW	
7	128	0.16	0.13	0.22	0.44	0.03	0.02	1.25

Table 5-12. Aggregate Damage Ratios and Scores for Least Redundant Buildings (Ref. Table 3-7)

5.5.4 Irregularity

Table 3-8 lists potential irregularities in surveyed buildings. The 27 buildings listed represent both the lowest and highest damage scores in the survey. Their average score is 1.2, the same as the survey average. The average damage score for the eight buildings with both plan and vertical irregularities is 1.1. Note that the scope and severity of listed irregularities varies from building to building and that some or all of a building's irregularities may have been adequately addressed during design.

Table 5-13 gives aggregate damage characteristics by type of irregularity. While buildings with both vertical and plan irregularities have slightly higher bottom weld (BW) damage ratios, the 22 surveyed buildings with *no* irregularities have the highest column web (CW) damage ratio and the highest damage score. Clearly, there is no correlation between damage and structural irregularity.

Irregularity	No of Bldgs	Flr-Frms	WDR	Damage Class					Damage Score
				BC	TW	BW	S	CW	
Both	8	290	0.54	0.14	0.14	0.51	0.01	0.00	0.94
Neither	22	429	0.35	0.19	0.14	0.39	0.07	0.04	1.25
Plan	22	740	0.55	0.10	0.19	0.42	0.02	0.02	0.87
Vertical	13	399	0.58	0.12	0.12	0.49	0.01	0.02	0.86

Table 5-13. Damage Ratios and Scores by Building Irregularity (Ref. Table 3-8)

Of the seven least redundant structures discussed above, three also have some irregularity: ESI5, BJ04, and WEA. Although hardly a robust sample, these three buildings have an aggregate bottom weld (BW) damage ratio of 0.74, a top weld (TW) damage ratio of 0.43, a bottom column flange (BC) damage ratio of 0.20, and an average damage score of 1.8, all well above survey-wide averages.

An interesting comparison is provided by the five MNH03 buildings, all fairly redundant and all built from identical details on a shared foundation. Though only visually inspected, four of the five experienced no damage or just weld damage. With a C-shaped plan, Building MNH03CDE is the only irregular building of the five and also the only one with observed bottom column flange (BC) damage and column web (CW) damage.

5.6 Detail Design

5.6.1 Yield Strength

With reference to Table 3-10, Table 5-14 presents damage characteristics for the two main column steel grades. Based on nominal strengths, there is no clear correlation between observed damage and column material strength. With survey data on nominal strengths only, however, it is difficult to draw any conclusions regarding observed damage and material properties, since the variation of actual yield strength in A36 and multi-certified steel is well documented [Hamburger and Frank, 1994].

Column Steel	No of Bldgs	Flr-Frms	WDR	Damage Class					Damage Score
				BC	TW	BW	S	CW	
A36	26	528	0.36	0.12	0.09	0.35	0.0	0.04	0.96
A572-Gr50	19	705	0.58	0.11	0.21	0.44	0.0	0.02	0.94

Table 5-14. Damage Ratios and Scores by Nominal Column Strength

5.6.2 Member Size

Without original criteria and calculations, it is difficult to tell which issues controlled the member design for surveyed buildings. However, with bay widths of 7.6 meters (25 feet) or greater (Table 3-6) and only a handful of bays in each direction (Tables 3-5 and 3-6), it is possible that many of the surveyed buildings, even those only three or four stories tall, were controlled by stiffness concerns, their members selected mainly to meet maximum code drift limits. For a given story drift, frame geometry, and constant relative member stiffness, beam curvatures at the column face are known, and for a given curvature, deeper wide flange beams experience greater strains in their flanges and flange welds. These large strains may be related to observed MRF connection damage.

To test this hypothesis, the following subset of floor-frames is considered: buildings 3 stories or taller with concrete diaphragms, floor-frames with typical bay widths between 7.3 and 11.0 meters (24 and 36 feet), Group 4 W14 columns (see Table 3-11), and wide flange beams of different nominal depths (see Tables 3-12 and 3-13). Table 5-16 shows the damage in these floor-frames. No consistent pattern is apparent, although the data is sparse for W30 and smaller beams.

In Table 5-15, the bay widths (beam spans) are limited because for similar story drifts, longer spans yield lower beam flange stresses. This fact can also be used to test the relation between damage and beam flange strain. Tables 5-6 and 5-7 show overall damage patterns by bay width. Confining the study to floor-frames with W36 beams meeting the conditions of Table 5-15 yields the damage data in Table 5-16. Again, there is no recognizable pattern relating damage to beam span in this subset of floor-frames.

Without at least a simplified analysis, survey data are not sufficient to relate damage to design details. And without much more robust data, it may require time-history analysis with recorded ground motions to reveal any valid correlations.

Typ Girder	No of Bldgs	Flr-Frms	WDR	Damage Class					Damage Score
				BC	TW	BW	S	CW	
W24	1	2		0.00	0.00	0.00	0.00	0.00	0.00
W27	3	3	0.65	0.00	0.00	0.33	0.00	0.00	0.28
W30	4	18	0.50	0.00	0.00	0.67	0.00	0.00	0.67
W33	6	47	0.63	0.02	0.00	0.17	0.00	0.00	0.19
W36	14	176	0.72	0.06	0.10	0.44	0.01	0.01	0.56

Table 5-15. Damage Ratios and Scores by WF Girder Depth: Buildings > 3 Stories, Concrete Diaphragms, Group 4 W14 Columns, and 7.3- to 11.0-m Bay Widths

Typ Bay [m]	No of Bldgs	Flr-Frms	WDR	Damage Class					Damage Score
				BC	TW	BW	S	CW	
4.6-6.1	7	103	0.75	0.07	0.34	0.34	0.02	0.00	0.68
6.1-7.6	6	116	0.75	0.03	0.27	0.41	0.03	0.00	0.63
7.6-9.1	10	78	0.76	0.00	0.00	0.01	0.00	0.00	0.01
9.1-10.7	12	88	0.65	0.00	0.00	0.01	0.00	0.00	0.01
10.7-12.2	2	19	0.26	0.11	0.37	0.58	0.26	0.05	2.07
12.2-15.2	3	20	0.29	0.20	0.40	0.50	0.05	0.00	1.59

Table 5-16. Damage Ratios and Scores for W36 Girders by Bay Width: Buildings > 3 Stories, Concrete Diaphragms, Group 4 W14 Columns

5.6.3 Other

The current survey data cannot support meaningful studies of damage correlations by shear connection type, weld process, or composite beam behavior. Data shown in Section 3.3.3 indicates that damage to floor-frames in buildings with wood diaphragms was not significantly different from damage patterns overall; the aggregate damage score for the 214 floor-frames is 0.58, slightly lower than average.

As noted above, buildings with similar details can have various levels of damage, even when situated on adjacent sites.

5.7 Material & Construction Quality

The lack of measurable correlation in this set of data between observed damage and basic design characteristics suggests that correlations be sought in either demand-based or reliability-based parameters. Predictability of damage may be a function of either local rotations and strains or a function of material and construction quality. These cases are not related to the set of concerns typically addressed by practicing engineers and the design criteria of building codes.

This alone is a valuable conclusion. Still, it requires confirmation with studies beyond the scope of the current survey. Among the possible demand-based damage indicators are:

- plastic rotation demand at the connection
- weld stress due to beam overstrength
- weld strain
- strain rate
- panel zone deformation causing local kinks at the flange welds
- through-thickness stresses in the column flange

Among the possible reliability-based damage indicators are:

- base metal quality
- weld metal quality
- weld quality and workmanship, including preheat, deposition rate, interpass temperature, wind shielding, etc.
- inspection and testing quality, including rejection of end dams, UT reliability, etc.
- fabrication and fit-up, including size and shape of weld access holes, flange preparation, and root opening

6.0 Conclusions and Recommendations

6.1 Conclusions

Current survey data comprises 1290 inspected floor-frames from 51 steel MRF buildings. The floor-frames represent a variety of locations, building sizes, frame configurations, and construction types. The principal conclusions drawn from this data are:

- Observed damage ranges from none to complete column web fracture. The most common damage found is partial or complete fracture of beam flange groove welds. About 40% of all reported floor-frames have some cracking in the bottom weld; about 15% have some cracking in the top weld. Three quarters of the floor-frames with top weld damage also have bottom weld damage. Overall, about half of all the reported weld damage is limited to UT-rejectable discontinuities or incipient root cracking, some of which certainly predates the Northridge earthquake.

- Damage to base metal occurs most frequently as fracture of the column flange adjacent to the beam bottom flange weld: about 15% of floor-frames have one or more incidences of this type of fracture. Similar damage at the top of the connection was reported in only 9 floor-frames, but the low number may be partly due to obstruction of inspection by floor diaphragms above.

- The most serious damage types, column web cracking and shear connection damage, each occurred in about 4% of reported floor frames, and always in combination with weld or column flange fracture. Column web fracture was observed in a variety of building locations, sizes, frame configurations, diaphragm types, and framing details.

- On a floor-frame basis, about half of all floor-frames reported no damage, and another third reported weld damage only. Considering that about half of all reported weld damage was "incipient root cracking" only, it can be concluded that about two thirds of all reported floor-frames had nothing more than root cracks. However, while root cracks and weld discontinuities may be relatively easy to repair or even acceptable, observed column flange and weld fracture patterns suggest strongly that serious damage is related to the condition at the weld root.

Survey data was studied for correlations between observed damage and basic structural characteristics. Only two clear patterns were found. Specifically, studies of correlations between observed damage and surveyed building characteristics found that:

- North of the Santa Monica Mountains, North-South oriented frames were more damaged than others. No strong directionality was found in Santa Monica, West Los Angeles, or Universal City.

- In low-rise buildings (3 to 5 stories), lower floor levels were more damaged than upper floor levels. No similar patterns were apparent for mid-rise or high-rise buildings.

- Structural or non-structural non-MRF damage did not correlate with damage ratios and/or damage scores.

- Building height and floor diaphragm area did not correlate with damage ratios and/or damage scores.

- Frame configuration (bay length and number of bays per frame) did not correlate with damage ratios and/or damage scores.

- Structural redundancy (number of frames and bays in a given direction) did not correlate with damage ratios and/or damage scores.

- Structural regularity (principally building line setbacks and reentrant corners) did not correlate with damage ratios and/or damage scores.

- Member size and nominal yield strength did not correlate with damage ratios and/or damage scores.

6.2 Considerations

In drawing these conclusions, it is essential to remember that:

- The database sample is limited and perhaps unrepresentative (though probably conservatively so). The most serious damage types were reported in each of the geographic zones represented by more than one building. In the three zones with more than four surveyed buildings, buildings with no damage at all or weld damage only were also reported. This suggests that the survey may have captured the worst damage in each zone and that inspection of more buildings will find a greater percentage with little or no damage.

- The scope of inspection within each building varied, and in some cases was extremely limited. More inspection will obviously give a more accurate picture, but there is no strong evidence that more inspection within a building will find more or less damage.

- No estimates of true structural demands from the Northridge earthquake were available for correlation with observed damage.

- No estimates of the impact of observed damage on building performance were available, and none are implied by this report.

6.3 Implications

The conclusions listed previously - especially the lack of correlation between damage and structural characteristics - yield some lessons for engineers, researchers, and others studying the effects of major earthquakes on steel frame buildings:

- Design standards for new construction should consider the likelihood and potential impact of brittle connection failure in the conventional welded-flange MRF connection. In response to observed Northridge earthquake damage the ICBO, in an emergency Code change, has deleted the prescribed connection from the 1994 UBC ["ICBO Board...," 1994].

- Studies of the limited survey data suggest that damage is not related to building and frame configuration, or structural detailing. Engineers and researchers studying the cause of damage and potential repair or upgrade schemes should therefore consider that MRF performance may be a function of issues not typically considered by practicing designers. That is, performance may be related to peculiar ground motions (including vertical accelerations), unique localized demands, or the reliability of material and construction quality.

- Pre-earthquake evaluation of existing steel MRF buildings should consider the likelihood and potential impact of brittle connection failure. Survey data show that approaches limited to document review and simplified analysis (e.g. FEMA 178 [FEMA, 1992]) will not account for observed behavior.

- Post-earthquake evaluation should include visual inspection and testing of some portion of MRF connections. Survey data show that assessments based on building walkthroughs (e.g. ATC-20 Rapid Evaluation Method [ATC]) may not find significant MRF damage, and that follow-up evaluations limited to visual inspection and drawing review (e.g. ATC-20 Detailed Evaluation Method [ATC]) may not uncover partially fractured welds and frame members.

6.4 Recommendations

The value of current survey data can be enhanced by correlating observed damage with specific estimates of local ground motion and resulting frame forces, and by experimental studies to determine the effects of weld discontinuities, root cracks, and other damage patterns on connection and frame performance. Recommended future efforts directly related to this survey include:

- Continued collection of data with the current scope and format.

- Continued use and improvement of the survey form developed in this effort both as a tool for data collection and as an indicator of useful information types and formats.

- Collection of recorded ground motion parameters for each zone or neighborhood.

- Analysis of specific or generic buildings to generate demands for damage correlation studies. Both elastic and inelastic analysis, using code lateral forces and recorded ground motions, should be used to assess the efficacy of simplified methods.

- Maintenance of the existing database and coordination with potential users, including designers, researchers, and building officials.

- Collection of more detailed data, especially regarding actual steel strength and weld properties.

- Development of a separate database for individual connections, as opposed to floor-frames.

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Appendix A: Survey Summaries

Survey Form : new

Survey Date : 10/12/94

Building ID: **AC1**

Pre Nridge Status : OC

Status as of 10/12/94 OC

Inspection/Testing: IP

Repair/Retrofit: NS

Geographic Zone: WLA

Northridge Tag : N

Non-MRF Structural Damage?
NO "None so far. Pin-based columns not yet inspected."

Non-Structural Damage?
Life Safety related:

Other: YES "Brick veneer deformed out-of-plane relative to original position."

Design Code : LABC

Year Designed : 1984

Year Built : 1984

MRF Stories Above Ground: 3

MRF Stories Below Ground: 0

Ground Floor Area [sf]: 18,000

Upper Floor Area [sf]: 18,000

Plan Irregularities?
Y possible reent corners

Vertical Irregularities?
Y possible geom irreg at setbacks.

Column Fy [ksi]: 36

Girder Fy [ksi]: 36

Floor Construction Type: MC/L?

Web Connection Type: B

Flange Weld Process: SMAW?

Number of Frames in Each Direction:
N-S 4 NE-SW
E-W 4 NW-SE
Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 128

No of Connections Inspected: 31

No of Connections Tested: 31

No of Inspected Floor-Frames: **19**

%W1 : 0.0 %

Damage Score :**1.47**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
10	EW	4	30	1	0	1	0	0	0	1	0	0	0
14	EW	3	30	3	0	0	0	2	0	3	0	0	0
2	EW	3	30	3	0	0	0	0	0	2	0	0	0
6	EW	3	30	3	0	0	0	0	0	2	0	0	0
AN	NS	4	30	3	0	0	0	0	0	3	0	0	0
AS	NS	4	30	3	0	0	0	0	0	3	0	0	0
GN	NS	3	30	2	0	0	0	0	0	1	0	0	0
GS	NS	4	30	1	0	0	0	0	0	1	0	0	0

Survey Form : new
Survey Date : 10/11/94
Building ID: **BAK**

Pre Nridge Status : OC
Status as of 10/11/94 OC
Inspection/Testing: C
Repair/Retrofit: C
Geographic Zone: SO

Northridge Tag : Y

Non-MRF Structural Damage?
YES "out of plumb 2.5 to 3 inches in the north-south direction."

Non-Structural Damage?
Life Safety related: YES "Anchors for exterior precast panels 'badly deformed.' Cracking of 1st story masonry walls."

Other:

Design Code : UBC 1979?
Year Designed : 1982
Year Built :

MRF Stories Above Ground: 6
MRF Stories Below Ground: 1

Ground Floor Area [sf]: 26,000
Upper Floor Area [sf]: 20,000

Plan Irregularities?
N

Vertical Irregularities?
N

Column Fy [ksi]: 50
Girder Fy [ksi]: 36
Floor Construction Type: MCL
Web Connection Type: B
Flange Weld Process: U

Number of Frames in Each Direction:
N-S 2 NE-SW
E-W 3 NW-SE
Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 72
No of Connections Inspected: 72
No of Connections Tested: 0

No of Inspected Floor-Frames: **12**
%W1 : 0.0 %
Damage Score :**1.25**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
13	NS	3	28	6	0	0	0	0		5	0	0	0
3	NS	3	28	6	0	0	0	0		5	0	0	0

Survey Form : old
Survey Date : 8/31/94
Building ID: **BJ01**

Pre Nridge Status : OC
Status as of 8/31/94 OC
Inspection/Testing: C
Repair/Retrofit:
Geographic Zone: SM

Northridge Tag : N
Non-MRF Structural Damage?

Non-Structural Damage?
Life Safety related:

Other: YES "Glass block feature wall damage. Ceilings & Partitions & Shelving."

Design Code : UBC 1988
Year Designed : 1989
Year Built : 1990
MRF Stories Above Ground: 4
MRF Stories Below Ground:
Ground Floor Area [sf]: 13,550
Upper Floor Area [sf]: 13,550

Plan Irregularities?
N

Vertical Irregularities?
N

Column Fy [ksi]: 50
Girder Fy [ksi]: 36
Floor Construction Type: MC
Web Connection Type:
Flange Weld Process:

Number of Frames in Each Direction:
N-S
E-W
NE-SW 2
NW-SE 5
Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 110
No of Connections Inspected: 110
No of Connections Tested: 110
No of Inspected Floor-Frames: **23**
%W1 : 90.0 %
Damage Score :**1.36**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
3	NESW	4		3	0	1	1	2	3	3	2	0	0
6	NESW	4		3	0	2	0	2	1	3	0	0	0
B	NWSE	3		4	0	0	0	0	4	2	0	0	0
C	NWSE	1		3	0	0	0	0	0	3	0	0	0
D	NWSE	1		3	0	0	0	0	0	3	0	0	0
E	NWSE	1		3	0	0	0	0	0	3	0	0	0
G	NWSE	3		4	0	0	0	0	3	4	0	0	0

Survey Form : comb   Survey Date : 10/13/94

Building ID: **BJ02E**

Pre Nridge Status : UC   Status as of 8/31/94   UC
Inspection/Testing: C
Repair/Retrofit: C

Geographic Zone: UC

Northridge Tag : N

Non-MRF Structural Damage?
YES "Minor cracks in stair and elevator enclosure. CMU walls in concrete parking structure below. Minor fillet weld cracks in misc. connections to MRF columns (non-MRF members)."

Non-Structural Damage?
Life Safety related: na: building under construction

Other: na: building under construction

Design Code : UBC 1991
Year Designed : 1992
Year Built : 1994

MRF Stories Above Ground: 3
MRF Stories Below Ground: 0

Ground Floor Area [sf]: 29,000
Upper Floor Area [sf]: 29,000

Plan Irregularities?
N

Vertical Irregularities?
N

Column Fy [ksi]: 50
Girder Fy [ksi]: 36
Floor Construction Type: MC
Web Connection Type: WB
Flange Weld Process: U

Number of Frames in Each Direction:
N-S 6   NE-SW
E-W 4   NW-SE
Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 135
No of Connections Inspected: 121
No of Connections Tested: 121

No of Inspected Floor-Frames: **27**
%W1 : 50.0 %
Damage Score :**3.30**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
22C	NS	3	34	1	0	0	0	1	1	1	0	1	1
22N	NS	3	34	3	0	0	1	3	1	3	1	2	1
22S	NS	3	34	3	0	0	0	2	1	3	2	2	1
29C	NS	3	34	3	0	0	0	2	2	2	0	0	1
29N	NS	3	34	2	0	0	0	2	0	2	0	1	0
29S	NS	3	34	3	0	0	0	3	2	2	0	0	1
A	EW	3	18	3	0	0	0	1	1	3	0	0	0
D	EW	3	18	3	0	0	0	1	1	3	1	0	0
G	EW	4	18	3	0	0	0	0	1	3	0	1	0
K	EW	3	18	3	0	0	0	1	1	1	0	0	0

Survey Form : new
Survey Date : 9/29/94

Building ID: **BJ04**

Pre Nridge Status : OC
Status as of 9/29/94 OC
Inspection/Testing: C
Repair/Retrofit: IP

Geographic Zone: SO

Northridge Tag : Y

Non-MRF Structural Damage?
YES "At 2nd floor, bolts in non-frame beams spanning N-S were sheared, 5 locations total: Note that A307 bolts were used in error. Cracks/spalls in first floor concrete near most frame column base plates." NOTE: Yellow tag was based on this and LS-related non-struc damage, not on MRF damage, which was unseen. Tag was removed after preliminary repairs. Building was not retagged after discovery of MRF damage.

Non-Structural Damage?
Life Safety related: YES "Stud wall (exterior building enclosure) separated from floor @ 2nd and 3rd floors. NE corner stair post (steel TS) had lost anchorage to supporting block wall."

Other:

Design Code : LABC 1980
Year Designed : 1981
Year Built : 1981

MRF Stories Above Ground: 4
MRF Stories Below Ground: 0

Ground Floor Area [sf]: 10,600
Upper Floor Area [sf]: 10,600

Plan Irregularities?
N

Vertical Irregularities?
Y possible geom irreg at floor 3 frame 2 setback.

Column Fy [ksi]: 36
Girder Fy [ksi]: 36
Floor Construction Type: MCL
Web Connection Type: B
Flange Weld Process: U

Number of Frames in Each Direction:
N-S 2 NE-SW
E-W 2 NW-SE
Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 74
No of Connections Inspected: 73
No of Connections Tested: 73

No of Inspected Floor-Frames: **16**
%W1 : 30.0 %
Damage Score :**1.25**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
2	NS	3	21	4	0	0	0	1	1	4	0	0	0
6	NS	2	27	4	0	0	0	0	0	3	0	0	0
B	EW	2	29	4	0	0	0	0	0	4	0	0	0
E	EW	2	29	4	0	0	0	0	0	3	0	0	0

Survey Form : new
Survey Date : 10/6/94
Building ID: **BJ05**

Pre Nridge Status : OC
Status as of 10/6/94 OC
Inspection/Testing: IP
Repair/Retrofit: NS
Geographic Zone: NR

Northridge Tag : N
Non-MRF Structural Damage?
YES "Northerly 2" permanent displacement @ roof (11th floor)."

Non-Structural Damage?
Life Safety related: NO

Other: YES "Ceilings, furnishings, floor tiles, lobby stonework damaged."

Design Code : LABC 1988
Year Designed : 1990
Year Built : 1991
MRF Stories Above Ground: 11
MRF Stories Below Ground: 1
Ground Floor Area [sf]: 29,000
Upper Floor Area [sf]: 25,000

Plan Irregularities?
Y out-of-plane offsets at floors 2 and 9.

Vertical Irregularities?
Y possible mass irreg at floor 9 setback.

Column Fy [ksi]: 50
Girder Fy [ksi]: 36
Floor Construction Type: MC
Web Connection Type: WB
Flange Weld Process: SMAW?

Number of Frames in Each Direction:
N-S 4 NE-SW
E-W 2 NW-SE
Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 548
No of Connections Inspected: 361
No of Connections Tested: 361
No of Inspected Floor-Frames: **55**
%W1 : 70.0 %
Damage Score :**1.10**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
16	NS	6	18	10	0	0	0	5	0	9	0	0	0
18	NS	3	16	6	0	0	0	0	0	0	0	0	0
5	NS	3	16	7	0	0	0	0	0	1	0	0	0
7	NS	6	18	10	0	0	1	4	1	9	0	0	0
D	EW	7	16	8	0	0	0	2	0	8	0	0	0
F.5	EW	3	32	3	0	0	0	0	0	2	0	0	0
I.5	EW	3	32	4	0	0	0	0	0	0	0	0	0
L	EW	7	16	7	0	0	0	4	2	6	0	0	0

Survey Form : new

Survey Date : 10/7/94

Building ID: **BJ06**

Pre Nridge Status : OC

Status as of 10/7/94 OC

Inspection/Testing: IP

Repair/Retrofit: IP

Geographic Zone: NR

Northridge Tag : N

Non-MRF Structural Damage?
YES "Insignificant (1/4") lateral set determined by survey."

Non-Structural Damage?
Life Safety related:

Other: YES "spalling at precast connections;" damage/breakage to "floor tiles, partitions, windows, ceilings;" "furnishings fell over."

Design Code : LABC 1988

MRF Stories Above Ground: 2

Ground Floor Area [sf]: 51,000

Year Designed : 1989

MRF Stories Below Ground: 0

Upper Floor Area [sf]: 51,000

Year Built : 1991

Plan Irregularities?
Y diaph discont at 50x100 ft atrium opng.

Vertical Irregularities?
N

Column Fy [ksi]: 50

Girder Fy [ksi]: 36

Floor Construction Type: MC

Web Connection Type: WB

Flange Weld Process: SMAW?

Number of Frames in Each Direction:
N-S 2 NE-SW
E-W 3 NW-SE
Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 84

No of Inspected Floor-Frames: **12**

No of Connections Inspected: 54

%W1 : 75.0 %

No of Connections Tested: 54

Damage Score :**2.21**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
1	NS	5	32	2	0	0	0	2	1	2	1	0	2
14	NS	5	32	2	0	0	0	1	0	2	1	0	1
A	EW	1	32	1	0	0	0	0	0	0	0	0	0
C	EW	1	32	1	0	0	0	0	0	0	0	0	0
E	EW	3	32	2	0	0	0	0	0	2	0	0	0
L	EW	4	32	2	0	0	0	0	0	2	0	0	0
S	EW	3	32	2	0	0	0	0	0	1	0	0	0

Survey Form : new

Survey Date : 10/21/94

Building ID: **BJ09**

Pre Nridge Status : OC

Status as of 10/21/94 OC

Inspection/Testing: IP

Repair/Retrofit: NS

Geographic Zone: WH

Northridge Tag : N

Non-MRF Structural Damage?
NO "none"

Non-Structural Damage?
Life Safety related: YES "Piping, conduit, mechanical system damage -- for Hospital, this was Life-Safety related."

Other: YES "partitions, ceilings, expansion joint material/flashing at adjacent buildings damaged."

Design Code : T24 CBC 1979

Year Designed : 1982

Year Built : 1983

MRF Stories Above Ground: 5

MRF Stories Below Ground: 0

Ground Floor Area [sf]: 90,000

Upper Floor Area [sf]: 50,000

Plan Irregularities?
Y reent corners at floor 3 and above.

Vertical Irregularities?
Y possible mass irreg at floor 3 setback.

Column Fy [ksi]: 50

Girder Fy [ksi]: 36

Floor Construction Type: MC

Web Connection Type: B

Flange Weld Process: U

Number of Frames in Each Direction:

N-S 8 NE-SW

E-W 8 NW-SE

Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 516

No of Connections Inspected: 133

No of Connections Tested: 133

No of Inspected Floor-Frames: 50

%W1 : 90.0 %

Damage Score : .27

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
12E	EW	4	17	4	0	0	0	1	0	1	0	0	0
12W	EW	4	20	3	0	0	0	0	0	1	0	0	0
1E	EW	4	17	3	0	0	0	0	0	1	0	0	0
1W	EW	4	20	4	0	0	0	0	1	1	0	0	0
5E	EW	7	17	3	0	0	0	0	0	2	0	0	0
5W	EW	6	19	1	0	0	0	0	0	1	0	0	0
8E	EW	7	17	4	0	0	0	0	0	1	0	0	0
8W	EW	6	19	2	0	0	0	0	0	1	0	0	0
A	NS	3	24	4	0	0	0	0	0	0	0	0	0
CN	NS	4	25	4	0	0	0	0	0	2	0	0	0
CS	NS	4	25	4	0	0	0	0	0	0	0	0	0
EN	NS	4	25	1	0	0	0	0	0	0	0	0	0
ES	NS	4	25	2	0	0	0	0	0	1	0	0	0
GN	NS	4	25	2	0	0	0	0	0	2	0	0	0
GS	NS	4	25	4	0	0	0	0	0	1	0	0	0
K	NS	11	25	5	0	0	0	0	0	3	0	0	0

Survey Form : new
Survey Date : 10/4/94
Building ID: **BJ10**

Pre Nridge Status : OC
Status as of 10/4/94 OC
Inspection/Testing: C
Repair/Retrofit: na
Geographic Zone: WH

Northridge Tag : N

Non-MRF Structural Damage?
NO "None."

Non-Structural Damage?
Life Safety related:

Other: YES "partitions, plumbing, piping, no life safety impact."

Design Code : Unknown
Year Designed : 1990
Year Built : 1991

MRF Stories Above Ground: 5
MRF Stories Below Ground: 1

Ground Floor Area [sf]: 50,000
Upper Floor Area [sf]: 50,000

Plan Irregularities?
N

Vertical Irregularities?
N

Column Fy [ksi]: 50
Girder Fy [ksi]: 36
Floor Construction Type: MCL
Web Connection Type: B
Flange Weld Process: U

Number of Frames in Each Direction:
N-S 4 NE-SW
E-W 4 NW-SE
Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 86
No of Connections Inspected: 35
No of Connections Tested: 35

No of Inspected Floor-Frames: 13
%W1 :
Damage Score : 0.00

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
1	EW	4	20	1	0	0	0	0	0	0	0	0	0
12	EW	4	20	2	0	0	0	0	0	0	0	0	0
9	EW	4	20	1	0	0	0	0	0	0	0	0	0
AN	NS	3	30	3	0	0	0	0	0	0	0	0	0
GN	NS	3	30	1	0	0	0	0	0	0	0	0	0
GS	NS	3	30	2	0	0	0	0	0	0	0	0	0
J	NS	3	24	3	0	0	0	0	0	0	0	0	0

Survey Form : new
Survey Date : 9/30/94
Building ID: **BJ11**

Pre Nridge Status : UC
Status as of 9/30/94 UC
Inspection/Testing: IP
Repair/Retrofit: IP
Geographic Zone: WH

Northridge Tag : N
Non-MRF Structural Damage?
NO "None"

Non-Structural Damage?
Life Safety related:

Other: YES "Required miscellaneous repairs to paint, plumbing, etc."

Design Code :T24 CBC
Year Designed : 1991
Year Built : 1992

MRF Stories Above Ground: 5
MRF Stories Below Ground: 1

Ground Floor Area [sf]: 26,000
Upper Floor Area [sf]: 26,000

Plan Irregularities?
N

Vertical Irregularities?
N

Column Fy [ksi]: 50?
Girder Fy [ksi]: 36?
Floor Construction Type: MC/L?
Web Connection Type: WB
Flange Weld Process: U

Number of Frames in Each Direction:
N-S 4 NE-SW
E-W 4 NW-SE
Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 156
No of Connections Inspected: 138
No of Connections Tested: 138

No of Inspected Floor-Frames: **26**
%W1 : 100.0 %
Damage Score :**.98**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
1	EW	3	17	3	0	0	0	2	1	1	0	0	0
12	EW	3	17	4	0	0	1	1	1	3	0	0	0
5	EW	3	17	3	0	0	1	2	1	1	0	0	0
8	EW	3	17	3	0	0	0	0	1	1	0	0	0
CCN	NS	3	25	3	0	0	0	1	0	2	0	0	0
CCS	NS	3	25	3	0	0	0	0	0	0	0	0	0
YN	NS	3	25	3	0	0	0	1	1	3	0	0	0
YS	NS	3	25	4	0	0	0	0	3	4	0	0	0

Survey Form : new
Survey Date : 10/13/94
Building ID: **BJ18**

Pre Nridge Status : OC
Status as of 10/13/94 OC
Inspection/Testing: C
Repair/Retrofit: NS
Geographic Zone: WH

Northridge Tag : N

Non-MRF Structural Damage?
YES "Possible settlement of soil adjacent to basement wall. Block wall minor cracking."

Non-Structural Damage?
Life Safety related:

Other: YES "Exterior cladding cracked. Ceiling damage. Mechanical units shifted off isolators."

Design Code : LABC? 1985?
MRF Stories Above Ground: 3
Ground Floor Area [sf]: 21,000
Year Designed : 1987
MRF Stories Below Ground: 0
Upper Floor Area [sf]: 21,000
Year Built : 1989

Plan Irregularities?
Y reent corner, L-shaped floors.

Vertical Irregularities?
N but note discontinuous top story columns landing midspan on floor 3 girders.

Column Fy [ksi]: 50
Girder Fy [ksi]: 36
Floor Construction Type: MCL
Web Connection Type: B
Flange Weld Process: U

Number of Frames in Each Direction:
N-S 3 NE-SW
E-W 3 NW-SE
Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 68
No of Connections Inspected: 68
No of Connections Tested: 68
No of Inspected Floor-Frames: **24**
%W1 : 75.0 %
Damage Score :**.64**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
1	NS	1	30	4	0	0	0	0	0	3	0	0	0
3	NS	2	30	4	0	0	0	1	0	2	0	0	0
6	NS	1	36	4	0	0	0	0	0	3	0	0	0
A	EW	1	30	4	0	0	0	0	0	1	0	0	0
C	EW	3	30	4	0	0	0	0	1	1	0	0	0
G	EW	1	36	4	0	0	0	1	0	4	0	0	0

Survey Form : new
Survey Date : 10/10/94
Building ID: **DM1**

Pre Nridge Status : OC
Status as of 10/10/94 OC
Inspection/Testing: C
Repair/Retrofit: C
Geographic Zone: LAX

Northridge Tag : N

Non-MRF Structural Damage?
NO "None"

Non-Structural Damage?
Life Safety related: YES "Stair system worked as non-structural building braces and showed damage."

Other: YES "Drywall and plaster in stairwells cracked at each floor."

Design Code : UBC 1969
Year Designed : 1970
Year Built : 1971

MRF Stories Above Ground: 15
MRF Stories Below Ground: 2

Ground Floor Area [sf]: 60,000
Upper Floor Area [sf]: 21,000

Plan Irregularities?
N

Vertical Irregularities?
Y possible soft story & geom irreg at setback above podium base.

Column Fy [ksi]: 50
Girder Fy [ksi]: 36
Floor Construction Type: MC
Web Connection Type: W
Flange Weld Process: U

Number of Frames in Each Direction:
N-S 2 NE-SW
E-W 2 NW-SE
Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 62
No of Connections Inspected: 13
No of Connections Tested: 13

No of Inspected Floor-Frames: **5**
%W1 :
Damage Score :**0.00**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
4	EW	5	30	2	0	0	0	0	0	0	0	0	0
A	NS	7	15	1	0	0	0	0	0	0	0	0	0
H	NS	7	15	2	0	0	0	0	0	0	0	0	0

Survey Form : new

Survey Date : 9/29/94

Pre Nridge Status : OC

Status as of 9/29/94 OC

Inspection/Testing: C

Repair/Retrofit: C

Building ID: **EQE1**

Geographic Zone: SC

Northridge Tag : YG

Non-MRF Structural Damage?
YES "2" permanent deflection to south at roof, 1-3/8" at ground floor. 1-3/8" permanent deflection to west at roof, 1" at ground floor."

Non-Structural Damage?
Life Safety related:

Other: YES "Buckled single angle out-of-plane braces for precast panels. Chipped corners and minor cracking of some precast panels. Some broken glass, dropped ceiling tiles, and partition wall damage."

Design Code : UBC 1988

Year Designed : 1991

Year Built : 1992

MRF Stories Above Ground: 4

MRF Stories Below Ground: 0

Ground Floor Area [sf]: 21,200

Upper Floor Area [sf]: 21,500

Plan Irregularities?
N

Vertical Irregularities?
N

Column Fy [ksi]: 50

Girder Fy [ksi]: 36

Floor Construction Type: MC

Web Connection Type: WB

Flange Weld Process: FCAW

Number of Frames in Each Direction:
N-S 2 NE-SW
E-W 2 NW-SE
Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 112

No of Connections Inspected: 112

No of Connections Tested: 112

No of Inspected Floor-Frames: **16**

%W1 : 0.0 %

Damage Score :**4.31**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
1	NS	4	20	4	0	0	0	4	0	0	2	0	3
10	NS	4	20	4	0	2	0	4	0	0	2	0	3
B	EW	3	23	4	0	1	0	4	0	0	2	0	0
M	EW	3	20	4	0	1	0	4	0	0	2	0	1

Survey Form : new | Survey Date : 9/29/94 | Building ID: **EQE2**

Pre Nridge Status : OC | Status as of 9/29/94 OC
Inspection/Testing: C
Repair/Retrofit: C
Geographic Zone: SC

Northridge Tag : YG
Non-MRF Structural Damage?
YES "4" permanent deflection to Northwest at roof. Crack across diaphragm with 2" separation. Pullout failure of pre-cast attachments. Failure of non-moment beam connection at drop of roof about 4". Pullout of roof from block walls. Pounding damage of block walls with roof diaphragm and with adjacent parking structure."

Non-Structural Damage?
Life Safety related:

Other: YES "Extensive partition wall, ceiling, and glass damage. Cracked precast panels."

Design Code : UBC 1988
Year Designed : 1991
Year Built : 1992

MRF Stories Above Ground: 1
MRF Stories Below Ground: 0

Ground Floor Area [sf]: 27,000
Upper Floor Area [sf]: 27,000

Plan Irregularities?
Y reent corner: L-shaped floors.

Vertical Irregularities?
N

Column Fy [ksi]: 36
Girder Fy [ksi]: 36
Floor Construction Type: MC
Web Connection Type: WB
Flange Weld Process: FCAW

Number of Frames in Each Direction:
N-S 3 NE-SW
E-W 3 NW-SE
Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 20
No of Connections Inspected: 20
No of Connections Tested: 20

No of Inspected Floor-Frames: **6**
%W1 : 0.0 %
Damage Score :**4.17**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
2L	NS	2	24	1	0	0	0	1	0	0	0	0	1
6L	NS	1	27	1	0	0	0	1	0	0	0	0	1
KL	EW	1	30	1	0	0	0	0	0	0	0	0	0
ML	EW	2	24	1	0	0	0	1	0	0	0	0	1
RL	EW	2	24	1	0	0	0	1	0	0	0	0	1
XX	NS	2	20	1	0	0	0	1	0	0	0	0	1

Survey Form : old

Survey Date : 8/23/94

Pre Nridge Status : UC

Status as of 8/23/94 UC

Inspection/Testing: C

Repair/Retrofit: IP

Building ID: **ESI1**

Geographic Zone: WLA

Northridge Tag : N

Non-MRF Structural Damage?
YES "Slip connections reached end of travel at lowest level of bldg. & angles bolted to web were slightly bent."

Non-Structural Damage?
Life Safety related: NO "Building not occupied."

Other: NO "None. Cladding not on."

Design Code : UBC 1991

Year Designed : 1993

Year Built : 1994

MRF Stories Above Ground: 5

MRF Stories Below Ground: 0

Ground Floor Area [sf]:

Upper Floor Area [sf]: 11,800

Plan Irregularities?
Y torsoinal irreg, reent corners, diaph discontinuity reported.

Vertical Irregularities?
Y mass irreg at floor setbacks.

Column Fy [ksi]: 50

Girder Fy [ksi]: 36

Floor Construction Type: MCL

Web Connection Type: WB

Flange Weld Process: FCAW

Number of Frames in Each Direction:
N-S 5 NE-SW
E-W 5 NW-SE
Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 100

No of Connections Inspected: 100

No of Connections Tested: 100

No of Inspected Floor-Frames: **50**

%W1 : 0.0 %

Damage Score :**.44**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
A	NS	1	20	5	0	0	0	0	0	1	1	0	0
B	NS	1	40	5	0	0	0	0	0	2	0	0	0
C	NS	1	40	5	0	0	0	0	0	1	0	0	0
D	NS	1	40	5	0	0	0	2	1	2	1	0	0
E	EW	1	20	5	0	0	0	1	0	1	0	0	0
F	EW	1	20	5	0	0	0	0	0	0	0	0	0
G	NS	1	20	5	0	0	0	0	0	0	0	0	0
H	EW	1	40	5	0	0	0	0	0	0	0	0	0
I	EW	1	40	5	0	0	0	0	0	0	0	0	0
J	EW	1	40	5	0	0	0	0	0	0	0	0	0

Survey Form : old
Pre Nridge Status : UC

Survey Date : 8/19/94
Status as of 8/19/94 V
Inspection/Testing:
Repair/Retrofit:

Building ID: **ESI2**

Geographic Zone: SM

Northridge Tag : N
Non-MRF Structural Damage?
YES "Buckled rod braces in penthouse. Cracks in non-structural masonry walls."

Non-Structural Damage?
Life Safety related: NO "None."

Other: YES "Cracks in non-structural masonry walls."

Design Code : UBC 1989?
Year Designed : 1990
Year Built : 1993

MRF Stories Above Ground: 5
MRF Stories Below Ground: 0

Ground Floor Area [sf]: 21,000
Upper Floor Area [sf]: 21,000

Plan Irregularities?
Y reent corners

Vertical Irregularities?
N

Column Fy [ksi]: 50
Girder Fy [ksi]: 36
Floor Construction Type: MCL
Web Connection Type: B
Flange Weld Process: SMAW

Number of Frames in Each Direction:
N-S 3 NE-SW
E-W 4 NW-SE
Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 2
No of Connections Inspected: 2
No of Connections Tested:

No of Inspected Floor-Frames: **1**
%W1 : 0.0 %
Damage Score :**5.00**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
A	EW	1	20	1	0	0		1		0	0	0	1

Survey Form : new
Survey Date : 10/3/94
Building ID: **ESI3**

Pre Nridge Status : OC
Status as of OC
Inspection/Testing: IP
Repair/Retrofit: IP
Geographic Zone: UC

Northridge Tag : N

Non-MRF Structural Damage?
YES "Diagonal braces at Mechanical Penthouse above Main Roof had caused beam web to tear and beam bolts to shear off."

Non-Structural Damage?
Life Safety related: YES "Mechanical equipment at Penthouse had damaged isolators. Exterior stucco tore away from studs @ Penthouse."

Other: YES "Cracked non-structural interior partitions."

Design Code : UBC 1982
Year Designed : 1984
Year Built :

MRF Stories Above Ground: 8
MRF Stories Below Ground: 2

Ground Floor Area [sf]:
Upper Floor Area [sf]: 8,000

Plan Irregularities?
N

Vertical Irregularities?
N

Column Fy [ksi]:
Girder Fy [ksi]:
Floor Construction Type: MCL
Web Connection Type: B
Flange Weld Process: U

Number of Frames in Each Direction:
N-S 1
NE-SW 1
E-W
NW-SE 1
Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 12
No of Connections Inspected: 12
No of Connections Tested: 3

No of Inspected Floor-Frames: **1**
%W1 : 100.0 %
Damage Score :**4.50**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
A	NS	6	20	1	0	0	0	1	0	1	1	0	0

Survey Form : old
Survey Date : 8/25/94
Building ID: **ESI4**

Pre Nridge Status : LM?
Status as of 6/1/94 LM
Inspection/Testing: U
Repair/Retrofit: U
Geographic Zone: WLA

Northridge Tag : N
Non-MRF Structural Damage?
NO "None reported."

Non-Structural Damage?
Life Safety related: NO "None."

Other: YES "May have been some drywall separation &/or cracks."

Design Code : UBC 1985
Year Designed : 1988
Year Built : 1991
MRF Stories Above Ground: 27
MRF Stories Below Ground: 2
Ground Floor Area [sf]:
Upper Floor Area [sf]: 13,500

Plan Irregularities?
Y reent corners

Vertical Irregularities?
N

Column Fy [ksi]: 50
Girder Fy [ksi]: 36
Floor Construction Type: MCL
Web Connection Type: WB
Flange Weld Process: U

Number of Frames in Each Direction:
N-S 2 NE-SW
E-W 2 NW-SE
Notes: NOTE: NS frames "bend" in plan, are not in single vertical plane. EW frames differ in orientation by about 40 degrees, but resultant is normal to resultant of NS frames.

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 72
No of Connections Inspected: 20
No of Connections Tested: 14
No of Inspected Floor-Frames: **10**
%W1 : 10.0 %
Damage Score :**1.54**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
A	NWSE	4	20	4	0	0	0	0	2	2	0	0	0
B	NWSE	3	26	2	0	0	0	0	2	2	0	0	0
C	NESW	4	19	3	0	0	0	0	0	1	0	0	0
D	NESW	4	19	1	0	0	0	0	1	1	0	0	0

Survey Form : comb

Survey Date : 10/7/94

Building ID: **ESI5**

Pre Nridge Status : OC

Status as of 9/6/94 OC

Inspection/Testing: C

Repair/Retrofit: NS

Geographic Zone: SM

Northridge Tag : G

Non-MRF Structural Damage?
NO "None"

Non-Structural Damage?
Life Safety related: "Unknown"

Other: "Unknown"

Design Code : UBC 1985

Year Designed : 1989

Year Built : 1990

MRF Stories Above Ground: 6

MRF Stories Below Ground: 0

Ground Floor Area [sf]: 18,000

Upper Floor Area [sf]: 15,000

Plan Irregularities?
Y out-of-plane offsets at floor 5.

Vertical Irregularities?
Y in plane discontinuity at floor 5.

Column Fy [ksi]: 50

Girder Fy [ksi]: 36

Floor Construction Type: MCL/MC

Web Connection Type: B

Flange Weld Process: SMAW

Number of Frames in Each Direction:

N-S

NE-SW 4

E-W

NW-SE 2

Notes: At floors 1-4, 2 2-bay NWSE frames. At flrs 5-7, 4 1-bay NWSE frames.

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 112

No of Connections Inspected: 105

No of Connections Tested: 105

No of Inspected Floor-Frames: **46**

%W1 : 30.0 %

Damage Score :**2.51**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
1A	NWSE	2	20	5	0	0	0	2	5	5	0	0	0
1B	NWSE	1	20	3	0	0	0	0	1	2	0	0	0
1C	NWSE	1	20	3	0	0	0	0	2	3	0	0	0
2A	NWSE	2	20	5	0	0	0	1	4	4	0	0	0
2B	NWSE	1	20	3	0	0	0	0	2	3	0	0	0
2C	NWSE	1	20	3	0	0	0	0	1	3	0	0	0
3	NESW	1	28	6	0	0	0	2	6	6	0	0	0
4	NESW	1	28	6	0	0	0	1	2	6	0	0	0
5	NESW	1	28	6	0	0	0	2	5	6	0	0	0
6	NESW	1	28	6	0	0	0	3	6	6	0	0	0

Survey Form : new

Survey Date : 9/24/91

Building ID: **ESI7**

Pre Nridge Status : OC

Status as of 6/21/94 OC

Inspection/Testing: C

Repair/Retrofit: C

Geographic Zone: SO

Northridge Tag : N

Non-MRF Structural Damage?
YES "75' CMU block wall on property line & part of exterior enclosure for building had expansion bolts which tie wall to building shear off. Wall pulled away from building at top (42' above ground floor) approximately 2"."

Non-Structural Damage?
Life Safety related: YES "Exterior plaster soffit above main street entrance considerable cracking (sic). Access to this entrance limited."

Other:

Design Code : LABC 1988

Year Designed : 1989

Year Built : 1990

MRF Stories Above Ground: 3

MRF Stories Below Ground: 0

Ground Floor Area [sf]: 15,500

Upper Floor Area [sf]: 15,500

Plan Irregularities?
Y reent corners: L-shaped floors.

Vertical Irregularities?
N

Column Fy [ksi]: 50

Girder Fy [ksi]: 36

Floor Construction Type: MC

Web Connection Type: B

Flange Weld Process: FCAW

Number of Frames in Each Direction:
N-S 3 NE-SW
E-W 3 NW-SE
Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 26

No of Connections Inspected: 26

No of Connections Tested: 12

No of Inspected Floor-Frames: **13**

%W1 : 0.0 %

Damage Score :**.65**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
1	NS	1	30	3	0	0	0	0	0	1	1	0	0
2	NS	1	30	3	0	0	0	0	0	1	1	0	0
3	NS	1	36	2	0	0	0	0	0	0	0	0	0
4	EW	1	44	3	0	0	0	0	0	1	0	0	0
5	EW	1	30	1	0	0	0	0	0	0	0	0	0
6	EW	1	30	1	0	0	0	0	0	0	0	0	0

Survey Form : new
Survey Date : 9/24/91

Pre Nridge Status : VAC
Status as of 9/24/94 VAC
Inspection/Testing: C
Repair/Retrofit: NS

Building ID: **ESI8**

Geographic Zone: WH

Northridge Tag : N

Non-MRF Structural Damage?
YES "Same location on 4-5 floors, non frame beam connection at a diagonal corner has weld cracks at shear tab to column."

Non-Structural Damage?
Life Safety related:

Other: YES "No damage except one pane of glass broke on 2nd floor. NOTE: Interior spaces not built out."

Design Code : LABC 1985
Year Designed : 1987
Year Built : 1990

MRF Stories Above Ground: 25
MRF Stories Below Ground: 0

Ground Floor Area [sf]: 27,500
Upper Floor Area [sf]: 26,500

Plan Irregularities?
Y reent corners.

Vertical Irregularities?
N

Column Fy [ksi]: 50
Girder Fy [ksi]: 36
Floor Construction Type: MC
Web Connection Type: B
Flange Weld Process: FCAW

Number of Frames in Each Direction:
N-S 3 NE-SW 1
E-W 3 NW-SE 2
Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 864
No of Connections Inspected: 864
No of Connections Tested: 829

No of Inspected Floor-Frames: **216**
%W1 : 80.0 %
Damage Score :**.49**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
1	NS	2	23	24	0	0	0	0	14	16	0	0	0
2	NS	2	19	24	0	0	0	0	11	13	0	0	0
3	NS	2	24	24	0	0	0	0	6	10	0	0	0
4	EW	2	24	24	0	0	0	0	7	7	0	0	0
5	EW	2	19	24	0	0	0	0	11	5	0	0	0
6	EW	2	23	24	0	0	0	0	11	8	0	0	0
7	NWSE	2	19	24	0	0	0	0	5	4	0	0	0
8	NWSE	2	19	24	0	0	0	0	5	8	0	0	0
9	NESW	2	24	24	0	0	0	0	4	6	0	0	0

Survey Form : new

Survey Date : 10/12/94

Building ID: **FE1**

Pre Nridge Status : OC

Status as of 10/12/94 OC

Inspection/Testing: C

Repair/Retrofit: na

Geographic Zone: WLA

Northridge Tag : N

Non-MRF Structural Damage?
YES "Some minor cracks in shear walls. (Landers EQ [1992] caused more cracks than Northridge EQ.)"

Non-Structural Damage?
Life Safety related:

Other: YES "Some ceiling tiles fell. other damage unknown by FE [survey engineer firm]."

Design Code : LABC? 1964

Year Designed : 1965

Year Built : 1966

MRF Stories Above Ground: 17

MRF Stories Below Ground: 0

Ground Floor Area [sf]: 30,000

Upper Floor Area [sf]: 23,000

Plan Irregularities?
Y out-of-plane offset at base

Vertical Irregularities?
N

Column Fy [ksi]: 36

Girder Fy [ksi]: 36

Floor Construction Type: MC

Web Connection Type: W

Flange Weld Process: FCAW

Number of Frames in Each Direction:
N-S 0 NE-SW
E-W 2 NW-SE
Notes: NS direction is Shear Wall System

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 88

No of Connections Inspected: 12

No of Connections Tested: 12

No of Inspected Floor-Frames: **4**

%W1 :

Damage Score :**0.00**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
P	EW	11	25	2	0	0	0	0	0	0	0	0	0
U	EW	11	25	2	0	0	0	0	0	0	0	0	0

Survey Form : new

Survey Date : 9/28/94

Pre Nridge Status : OC

Status as of 9/28/94 OC

Inspection/Testing: IP

Repair/Retrofit: NS

Building ID: **JAM7480**

Geographic Zone: WLA

Northridge Tag : N

Non-MRF Structural Damage?

YES Per EQE letter of 2/2/94: "some horizontal cracks at concrete covering of a steel column along the east wall of the DWP vault ... at the steel beam connection to the column."

Non-Structural Damage?

Life Safety related: YES Per EQE letter 2/2/94: "Three elevators were shut down. No additional damage to building support equipment reported. A few supports were lost at some sprinkler lines in the parking garage. Cracks in the drywall ... in various stairway locations as well as glass damage at the front door ... cracking to non-bearing cmu block walls in stairway #1."

Other:

Design Code : LABC

Year Designed : 1983

Year Built : 1984

MRF Stories Above Ground: 11

MRF Stories Below Ground: 0

Ground Floor Area [sf]: 32,000

Upper Floor Area [sf]: 23,000

Plan Irregularities?

Y possible reent corners

Vertical Irregularities?

Y mass geom irregs due to many setbacks

Column Fy [ksi]:

Girder Fy [ksi]: 36

Floor Construction Type: MC

Web Connection Type: B

Flange Weld Process: U

Number of Frames in Each Direction:

N-S 4 NE-SW

E-W 4 NW-SE

Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 116

No of Connections Inspected: 83

No of Connections Tested: 83

No of Inspected Floor-Frames: **14**

%W1 : 33.0 %

Damage Score :**2.81**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
2	EW	4	29	2	0	0	0	2	0	1	0	0	0
6	EW	4	29	2	0	0	0	0	0	2	0	0	0
9	EW	7	29	2	0	0	0	1	0	2	0	0	1
C	NS	4	30	2	0	0	0	2	1	2	0	0	0
E	NS	4	29	2	0	0	1	2	1	2	1	0	0
H	NS	4	30	2	0	0	0	1	0	2	0	0	0
M	NS	3	29	2	0	0	0	1	0	1	0	0	0

Survey Form : new

Survey Date : 9/27/94

Building ID: **JAM7482**

Pre Nridge Status : OC

Status as of 9/27/94

Inspection/Testing: C

Repair/Retrofit: IP

Geographic Zone: SO

Northridge Tag : Y

Non-MRF Structural Damage?
YES "Base pl's set flush into ground floor slab, supported by RC cols below: concrete around inset PL typically spalled."

Non-Structural Damage?
Life Safety related:

Other:

Design Code : LABC 1980

MRF Stories Above Ground: 4

Ground Floor Area [sf]: 17,000

Year Designed : 1983

MRF Stories Below Ground: 0

Upper Floor Area [sf]: 14,200

Year Built : 1984

Plan Irregularities?
Y possible reent corners

Vertical Irregularities?
N

Column Fy [ksi]: 36

Girder Fy [ksi]: 36

Floor Construction Type: W

Web Connection Type: B

Flange Weld Process: U

Number of Frames in Each Direction:
N-S 3
E-W 4
NE-SW
NW-SE
Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 88

No of Connections Inspected: 88

No of Connections Tested: 88

No of Inspected Floor-Frames: **28**

%W1 : 50.0 %

Damage Score :**1.39**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
1	EW	1	24	4	0	0	1	1	2	1	0	0	0
3	EW	1	26	4	0	0	0	0	0	2	0	0	0
4	EW	2	26	4	0	0	0	0	0	1	0	0	0
7	EW	2	28	4	0	0	0	1	1	4	0	0	0
A	NS	1	22	4	0	0	0	0	0	0	0	0	0
B	NS	2	33	4	0	0	1	1	2	4	0	0	0
E	NS	2	33	4	0	0	0	3	3	4	0	0	1

Survey Form : new

Survey Date : 9/26/94

Pre Nridge Status : OC

Status as of 9/26/94 VAC

Inspection/Testing: C

Repair/Retrofit: IP

Building ID: **JAM7484**

Geographic Zone: SO

Northridge Tag : Y

Non-MRF Structural Damage?
YES "Distortion to beam web & shear tab in a few nonframe connections. 2-3.5" out-of plumb, northerly, at 4th floor."

Non-Structural Damage?
Life Safety related:

Other:

Design Code :

Year Designed : 1985

Year Built : 1985

MRF Stories Above Ground: 4

MRF Stories Below Ground: 0

Ground Floor Area [sf]: 15,900

Upper Floor Area [sf]: 15,900

Plan Irregularities?
N

Vertical Irregularities?
N

Column Fy [ksi]: 36

Girder Fy [ksi]: 36

Floor Construction Type: MCL

Web Connection Type: B

Flange Weld Process: U

Number of Frames in Each Direction:

N-S 2 NE-SW

E-W 2 NW-SE

Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 40

No of Connections Inspected: 40

No of Connections Tested: 40

No of Inspected Floor-Frames: **20**

%W1 : 50.0 %

Damage Score :**2.40**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
1	NS	1	39	5	0	0	1	1	4	5	3	0	1
6	NS	1	39	5	0	0	0	0	3	4	1	0	0
A	EW	1	41	5	0	0	0	0	4	3	0	0	0
D	EW	1	46	5	0	0	0	2	4	4	0	0	0

Survey Form : new

Survey Date : 9/26/94

Building ID: **JAM7485**

Pre Nridge Status : OC

Status as of 9/26/94

Inspection/Testing: C

Repair/Retrofit:

Geographic Zone: WLA

Northridge Tag : NY

Non-MRF Structural Damage?
NO "per EQE, 'no structural damage' as of 1/29/94 walk-through"

Non-Structural Damage?
Life Safety related: YES "Per EQE letter 1/29: 'drywall cracked inside the stairway, and an architectural facade was cracked. Instances of broken glass were also noted.'"

Other:

Design Code : LABC 1980

Year Designed : 1984

Year Built : 1984

MRF Stories Above Ground: 4

MRF Stories Below Ground: 0

Ground Floor Area [sf]: 12,200

Upper Floor Area [sf]: 12,200

Plan Irregularities?
N

Vertical Irregularities?
N

Column Fy [ksi]: 36

Girder Fy [ksi]: 36

Floor Construction Type: MCL

Web Connection Type: B

Flange Weld Process: U

Number of Frames in Each Direction:
N-S 2 NE-SW
E-W 3 NW-SE
Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 103

No of Connections Inspected: 103

No of Connections Tested: 103

No of Inspected Floor-Frames: **25**

%W1 : 40.0 %

Damage Score :**2.03**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
1E	EW	2	16	5	0	0	0	3	3	4	1	0	0
1W	EW	2	16	5	0	0	0	1	1	2	0	0	0
4	EW	2	32	5	0	0	0	1	4	5	0	0	0
A	NS	2	20	5	0	0	0	3	1	3	0	0	0
G	NS	2	20	5	0	0	0	1	2	3	0	0	0

Survey Form : new

Survey Date : 10/14/94

Pre Nridge Status : OC

Status as of 10/21/94 OC

Inspection/Testing: C

Repair/Retrofit: na

Building ID: **JAM7486**

Geographic Zone: WLA

Northridge Tag : N

Non-MRF Structural Damage?
NO "none"

Non-Structural Damage?
Life Safety related:

Other: YES "Per EQE letter report, cracking in stairway drywall."

Design Code : LABC 1980
Year Designed : 1983
Year Built : 1984

MRF Stories Above Ground: 13
MRF Stories Below Ground: 0

Ground Floor Area [sf]: 20,000
Upper Floor Area [sf]: 16,000

Plan Irregularities?
N

Vertical Irregularities?
Y possible mass irreg at floor 6 setback/deck type change

Column Fy [ksi]: 50
Girder Fy [ksi]: 36
Floor Construction Type: MC
Web Connection Type: B
Flange Weld Process: U

Number of Frames in Each Direction:
N-S
E-W
NE-SW 2
NW-SE 2
Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 294
No of Connections Inspected: 114
No of Connections Tested: 114

No of Inspected Floor-Frames: **44**
%W1 : 100.0 %
Damage Score :**.11**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
1	NESW	3	30	12	0	0	0	0	0	2	0	0	0
10	NESW	4	30	9	0	0	0	0	0	2	0	0	0
A	NWSE	3	29	13	0	0	0	0	1	4	0	0	0
G	NWSE	3	29	10	0	0	0	0	0	1	0	0	0

Survey Form : new

Survey Date : 10/12/94

Pre Nridge Status : OC

Status as of 10/21/94 OC

Inspection/Testing: C

Repair/Retrofit: na

Building ID: **JAM7487**

Geographic Zone: SO

Northridge Tag : N

Non-MRF Structural Damage?
NO "none" noted by EQE or JAMA, but not out-of-plumb 2" northerly at top, possibly pre-Northridge and not associated with any other damage.

Non-Structural Damage?
Life Safety related:

Other: YES "Per EQE letter report, minor only, cracking in stairway drywall."

Design Code : LABC 1976

Year Designed : 1979

Year Built :

MRF Stories Above Ground: 12

MRF Stories Below Ground: 0

Ground Floor Area [sf]: 12,500

Upper Floor Area [sf]: 15,500

Plan Irregularities?
Y reent corners & diaph discont @ partial floors 2 and 3.

Vertical Irregularities?
Y possible soft story at tall columns, floor 2 & 3 mezzanine/partial floor

Column Fy [ksi]: 36

Girder Fy [ksi]: 36

Floor Construction Type: MCL

Web Connection Type: B

Flange Weld Process: U

Number of Frames in Each Direction:

N-S 2 NE-SW

E-W 2 NW-SE

Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 326

No of Connections Inspected: 94

No of Connections Tested: 94

No of Inspected Floor-Frames: **41**

%W1 : 100.0 %

Damage Score :**.18**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
1	EW	5	30	12	0	0	0	0	0	2	0	0	0
4	EW	5	30	11	0	0	0	0	0	3	0	0	0
B	NS	3	30	12	0	0	0	1	0	4	0	0	0
G	NS	3	30	6	0	0	0	0	0	2	0	0	0

Survey Form : new

Survey Date : 10/14/94

Building ID: **JAM7489**

Pre Nridge Status : OC

Status as of 10/21/94 OC

Inspection/Testing: C

Repair/Retrofit: na

Geographic Zone: SO

Northridge Tag : N

Non-MRF Structural Damage?
NO "none"

Non-Structural Damage?
Life Safety related:

Other: YES "Per EQE letter report, cracking in stairway drywall, planter (on grade?) slightly settled."

Design Code : LABC 1976

Year Designed : 1979

Year Built : 1979

MRF Stories Above Ground: 6

MRF Stories Below Ground: 0

Ground Floor Area [sf]: 21,000

Upper Floor Area [sf]: 21,000

Plan Irregularities?
Y reent corners: T-shape floors

Vertical Irregularities?
N

Column Fy [ksi]: 36

Girder Fy [ksi]: 36

Floor Construction Type: MCL

Web Connection Type: B

Flange Weld Process: U

Number of Frames in Each Direction:
N-S 4 NE-SW
E-W 5 NW-SE
Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 54

No of Connections Inspected: 8

No of Connections Tested: 8

No of Inspected Floor-Frames: 7

%W1 :

Damage Score :**0.00**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
5	EW	5	29	1	0	0	0	0	0	0	0	0	0
8	EW	5	20	1	0	0	0	0	0	0	0	0	0
A	NS	3	16	1	0	0	0	0	0	0	0	0	0
C	NS	4	18	2	0	0	0	0	0	0	0	0	0
J	NS	3	16	2	0	0	0	0	0	0	0	0	0

Survey Form : old

Survey Date : 9/3/94

Building ID: **KAR2**

Pre Nridge Status : OC

Status as of 9/3/94 OC

Inspection/Testing: C

Repair/Retrofit: IP

Geographic Zone: WH

Northridge Tag : N

Non-MRF Structural Damage?
YES "Broken H.S. bolts in tie beam @ roof level."

Non-Structural Damage?
Life Safety related: NO

Other: YES "Damaged masonry veneer @ corners of bldg on exterior."

Design Code : LABC 1976

Year Designed : 1978

Year Built :

MRF Stories Above Ground: 4

MRF Stories Below Ground: 0

Ground Floor Area [sf]:

Upper Floor Area [sf]: 27,600

Plan Irregularities?

Vertical Irregularities?

Column Fy [ksi]: 36

Girder Fy [ksi]: 36

Floor Construction Type: MC

Web Connection Type: B

Flange Weld Process: SMAW

Number of Frames in Each Direction:

N-S

NE-SW

E-W

NW-SE

Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 102

No of Connections Inspected: 102

No of Connections Tested: 102

No of Inspected Floor-Frames: **12**

%W1 : 20.0 %

Damage Score :**3.32**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
2	EW	5	30	3	0	0	0	0	0	1	0	0	0
8	EW	4	30	3	0	0	0	1	0	0	0	0	0
A	NS	4	30	3	0	1	0	3	0	2	0	1	3
F	NS	4	30	3	0	0	0	3	0	3	0	1	3

Survey Form : old

Survey Date : 8/18/94

Pre Nridge Status :

Status as of
Inspection/Testing: IP
Repair/Retrofit:

Building ID: **KAR3**

Geographic Zone: SO

Northridge Tag :

Non-MRF Structural Damage?
YES "...measured deflection of 3-1/2" of the top relative to the base [of 18-story N-S frame. All the deformation is within the top six stories.]"

Non-Structural Damage?
Life Safety related:

Other:

Design Code :
Year Designed :
Year Built :

MRF Stories Above Ground: 17
MRF Stories Below Ground:

Ground Floor Area [sf]:
Upper Floor Area [sf]:

Plan Irregularities?
N

Vertical Irregularities?
N

Column Fy [ksi]: 36
Girder Fy [ksi]: 36
Floor Construction Type: MC/L?
Web Connection Type:
Flange Weld Process:

Number of Frames in Each Direction:
N-S 2 NE-SW
E-W 2 NW-SE
Notes: Actual compass directions need to be confirmed.

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's:
No of Connections Inspected:
No of Connections Tested:

No of Inspected Floor-Frames: 3
%W1 : 0.0 %
Damage Score :**2.00**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
20	NS	3		1	0	0	0	1	0	0	0	0	0
5	NS	3	28	2	0	0	0	2	0	0	0	0	0

Survey Form : old
Survey Date : 8/22/94

Building ID: **KPFF1A**

Pre Nridge Status : OC
Status as of 8/22/94 OC
Inspection/Testing: IP
Repair/Retrofit: NS

Geographic Zone: SC

Northridge Tag : N
Non-MRF Structural Damage?

Non-Structural Damage?
Life Safety related:

Other: YES "glazing, ceilings"

Design Code : Title 24
Year Designed : 1981
Year Built :

MRF Stories Above Ground: 2
MRF Stories Below Ground: 0

Ground Floor Area [sf]: 9,700
Upper Floor Area [sf]: 9,700

Plan Irregularities?
N

Vertical Irregularities?
N

Column Fy [ksi]:
Girder Fy [ksi]:
Floor Construction Type: MCL
Web Connection Type: B
Flange Weld Process: U

Number of Frames in Each Direction:
N-S 2 NE-SW
E-W 2 NW-SE
Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 20
No of Connections Inspected: 14
No of Connections Tested: 14

No of Inspected Floor-Frames: **4**
%W1 : 60.0 %
Damage Score :**.68**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
A	EW	4	32	1	0	0	0	0	0	1	0	0	0
B	EW	4	32	1	0	0	0	0	0	0	0	0	0
C	NS	2	28	1	0	0	0	0	0	1	0	0	0
D	NS	2	28	1	0	1	0	0	0	1	0	0	0

Survey Form : old

Survey Date : 8/23/94

Pre Nridge Status : UC

Status as of 8/23/94 OC

Inspection/Testing: IP

Repair/Retrofit: IP

Building ID: **LCIB**

Geographic Zone: NR

Northridge Tag : R

Non-MRF Structural Damage?
YES "sheared bolts in moment-frame seated beam connection."

Non-Structural Damage?
Life Safety related: NO "None observed"

Other: YES "Extensive damage to interior gypsum board finishes and exterior stucco, buckled parapet copings and displaced seismic joints."

Design Code : Unknown 1988

Year Designed : 1990

Year Built : 1994

MRF Stories Above Ground: 4

MRF Stories Below Ground: 0

Ground Floor Area [sf]:

Upper Floor Area [sf]: 31,050

Plan Irregularities?
Y apparent diaph discont at atrium, but reported as Unknown

Vertical Irregularities?
Unknown

Column Fy [ksi]: 36

Girder Fy [ksi]: 36

Floor Construction Type: MCL

Web Connection Type: B

Flange Weld Process: SMAW

Number of Frames in Each Direction:
N-S NE-SW 6
E-W NW-SE 8
Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 240

No of Connections Inspected: 240

No of Connections Tested: 240

No of Inspected Floor-Frames:

%W1 : 5.0 %

Damage Score :

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
A	NESW	3	31	1	0	4	0	4	0	4	1	1	1
B	NESW	1	31	1	0	0	0	0	1	1	0	0	0
C	NWSE	3	20	1	0	0	0	8	8	8	1	0	3

Survey Form : old
Survey Date : 9/1/94
Building ID: **LCIE**

Pre Nridge Status : UC
Status as of 9/1/94 OC
Inspection/Testing: IP
Repair/Retrofit: IP

Geographic Zone: NR

Northridge Tag : R

Non-MRF Structural Damage?
NO "None observed."

Non-Structural Damage?
Life Safety related: NO "None observed."

Other: YES "Extensive damage to interior gypsum board finishes and exterior stucco. Brick tile finishes adjacent to west stair support damaged due to movement."

Design Code : Unknown 1988
Year Designed : 1990
Year Built : 1994

MRF Stories Above Ground: 3
MRF Stories Below Ground: 0

Ground Floor Area [sf]: 26,640
Upper Floor Area [sf]: 15,300

Plan Irregularities?
Y apparent reent corners, but reported as Unknown

Vertical Irregularities?
Unknown

Column Fy [ksi]: 36
Girder Fy [ksi]: 36
Floor Construction Type: MCL
Web Connection Type: B
Flange Weld Process: SMAW

Number of Frames in Each Direction:
N-S 8
NE-SW
E-W 11
NW-SE
Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 164
No of Connections Inspected: 164
No of Connections Tested: 164

No of Inspected Floor-Frames: **2**
%W1 : 0.0 %
Damage Score :

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
A	NS	2	31	1	0	0	0	1	0	3	0	0	0
B	NS	2	31	1	0	0	0	4	2	4	0	1	3
C	EW	3	20	1	0	0	0	0	0	0	0	0	0
D	EW	3	20	1	0	0	0	0	0	0	0	0	0
E	EW	3	20	1	0	0	0	0	0	2	0	0	0
F	EW	3	20	1	0	0	0	0	0	0	0	0	0
G	EW	3	20	1	0	0	0	0	0	1	0	0	0
H	EW	3	20	1	0	0	0	0	0	2	0	0	0
J	EW	1	20	1	0	0	0	1	0	1	0	0	0

Survey Form : old

Survey Date : 8/18/94

Pre Nridge Status : OC

Status as of 8/17/94 OC

Inspection/Testing: IP

Repair/Retrofit: NS

Building ID: **MNH02**

Geographic Zone: WH

Northridge Tag : G

Non-MRF Structural Damage?
NO "As of yet, no other structural damage has been observed."

Non-Structural Damage?
Life Safety related: NO

Other: YES Loss of glazing at first and second floors, stucco cracking around windows and corners (slight to moderate), dropped ceiling tiles,overturned furniture & bookcases.

Design Code : LABC 1980

Year Designed : 1984

Year Built : 1985

MRF Stories Above Ground: 3

MRF Stories Below Ground: 0

Ground Floor Area [sf]:

Upper Floor Area [sf]: 30,900

Plan Irregularities?
Y reent corners

Vertical Irregularities?
N

Column Fy [ksi]: 36

Girder Fy [ksi]: 36

Floor Construction Type: MC

Web Connection Type: B

Flange Weld Process: FCAW

Number of Frames in Each Direction:

N-S 4 NE-SW

E-W 2 NW-SE

Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 88

No of Connections Inspected: 56

No of Connections Tested: 56

No of Inspected Floor-Frames: **16**

%W1 : 75.0 %

Damage Score :**1.67**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
A	NS	2	28	3	0	0	0	1	0	3	0	1	1
B	EW	5	28	2	0	0	0	0	0	0	0	0	0
C	NS	2	28	3	0	0	0	1	0	2	0	1	1
D	NS	2	28	3	0	0	0	1	0	2	0	1	1
E	EW	5	28	2	0	0	0	0	0	0	0	0	0
F	NS	2	28	3	0	0	0	1	0	2	0	1	1

Survey Form : comb
Survey Date : 10/4/94
Building ID: **MNH03AB**

Pre Nridge Status : OC
Status as of 8/1/94 OC
Inspection/Testing: C
Repair/Retrofit: C
Geographic Zone: WLA

Northridge Tag : N

Non-MRF Structural Damage?
YES "Minor spalling of concrete @ expansion joints for subterranean parking. Corbel at joint provides vertical support for 14' trib 2-way slab. Concrete spalled from corbel causing partial loss of support."

Non-Structural Damage?
Life Safety related: YES "All common exits remained open and unobstructed; however, ... overturned filing cabinets, bookcases, cubicle partitions, etc. blocked hallways and corridors in tenant spaces."
Other: YES "Drywall/steel stud walls out of plumb, numerous falling T-bar track and tiles, minor window cracking, HVAC cooling towers spring isolators broke." ALSO: see LS-related damage regarding overturned furnishings.

Design Code : LABC 1976
Year Designed : 1978
Year Built : 1979
MRF Stories Above Ground: 3
MRF Stories Below Ground: 0
Ground Floor Area [sf]: 11,200
Upper Floor Area [sf]: 11,200

Plan Irregularities?
N

Vertical Irregularities?
N

Column Fy [ksi]: 36
Girder Fy [ksi]: 36
Floor Construction Type: W
Web Connection Type: B
Flange Weld Process: U

Number of Frames in Each Direction:
N-S
E-W
NE-SW 6
NW-SE 8
Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 148
No of Connections Inspected: 76
No of Connections Tested: 0
No of Inspected Floor-Frames: **38**
%W1 : 0.0 %
Damage Score :**.28**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
1	NWSE	3	18	3	0	0	0	0	0	0	0	0	0
2	NWSE	3	18	3	0	0	0	0	0	0	0	0	0
3	NWSE	3	18	3	0	0	0	0	0	0	0	0	0
4	NWSE	2	12	1	0	0	0	0	0	0	0	0	0
5	NWSE	3	18	3	0	0	0	0	0	0	0	0	0
6	NWSE	3	18	3	0	0	0	0	0	0	0	0	0
7	NWSE	3	18	3	0	0	0	0	0	0	0	0	0
8	NWSE	2	12	1	0	0	0	0	0	0	0	0	0
A	NESW	2	11	3	0	0	0	0	0	1	0	0	0
B	NESW	2	11	3	0	0	0	0	1	1	0	0	0
C	NESW	2	11	3	0	0	0	0	1	1	0	0	0
D	NESW	2	11	3	0	0	0	0	0	1	0	0	0
E	NESW	2	11	3	0	0	0	0	0	1	0	0	0
F	NESW	2	11	3	0	0	0	0	0	0	0	0	0

Survey Form : comb

Survey Date : 10/4/94

Building ID: **MNH03CDE**

Pre Nridge Status : OC

Status as of 8/1/94 OC

Inspection/Testing: C

Repair/Retrofit: C

Geographic Zone: WLA

Northridge Tag : N

Non-MRF Structural Damage?

YES "Minor spalling of concrete @ expansion joints for subterranean parking. Corbel at joint provides vertical support for 14' trib 2-way slab. Concrete spalled from corbel causing partial loss of support."

Non-Structural Damage?

Life Safety related: YES "All common exits remained open and unobstructed; however, ... overturned filing cabinets, bookcases, cubicle partitions, etc. blocked hallways and corridors in tenant spaces."

Other: YES "Drywall/steel stud walls out of plumb, numerous falling T-bar track and tiles, minor window cracking, HVAC cooling towers spring isolators broke." ALSO: see LS-related damage regarding overturned furnishings.

Design Code : LABC 1976

Year Designed : 1978

Year Built : 1979

MRF Stories Above Ground: 3

MRF Stories Below Ground: 0

Ground Floor Area [sf]: 17,000

Upper Floor Area [sf]: 17,000

Plan Irregularities?

Y reent corners

Vertical Irregularities?

N

Column Fy [ksi]: 36

Girder Fy [ksi]: 36

Floor Construction Type: W

Web Connection Type: B

Flange Weld Process: U

Number of Frames in Each Direction:

N-S

E-W

NE-SW 14

NW-SE 13

Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 304

No of Connections Inspected: 154

No of Connections Tested: 0

No of Inspected Floor-Frames: 77

%W1 : 0.0 %

Damage Score : .22

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
10	NWSE	3	18	3	0	0	0	0	0	0	0	0	0
11	NWSE	3	18	3	0	0	0	0	0	0	0	0	0
12	NWSE	3	18	3	0	0	0	0	0	0	0	0	0
13	NWSE	3	18	3	0	0	0	0	0	0	0	0	0
14	NWSE	2	11	3	0	0	0	0	0	1	0	0	0
15	NWSE	2	11	3	0	0	0	0	0	0	0	0	0
16	NWSE	2	11	3	0	0	0	0	0	0	0	0	0
17	NWSE	2	11	3	0	0	0	0	0	0	0	0	0
18	NWSE	3	18	3	0	0	0	0	0	0	0	0	0
19	NWSE	3	18	3	0	0	0	0	0	0	0	0	0
20	NWSE	3	18	3	0	0	0	0	0	0	0	0	0
21	NWSE	3	18	3	0	0	0	0	0	0	0	0	0
9	NWSE	2	11	3	0	0	0	0	0	0	0	0	0
G	NESW	2	11	3	0	0	0	0	0	1	0	0	0
H	NESW	2	11	3	0	0	0	0	0	1	0	0	0
I	NESW	2	11	3	0	0	0	0	0	1	0	0	0

NIST Survey of Steel MRF Buildings
Affected by the Northridge Earthquake

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
J	NESW	2	11	3	0	0	0	1	0	1	0	0	1
K	NESW	2	11	3	0	0	0	0	0	1	0	0	0
L	NESW	2	11	3	0	0	0	0	0	1	0	0	0
M	NESW	3	18	3	0	0	0	0	0	0	0	0	0
N	NESW	3	18	3	0	0	0	0	0	0	0	0	0
O	NESW	3	18	3	0	0	0	0	0	0	0	0	0
P	NESW	3	18	3	0	0	0	0	0	0	0	0	0
Q	NESW	2	18	1	0	0	0	0	0	0	0	0	0
R	NESW	2	18	1	0	0	0	0	0	0	0	0	0
S	NESW	3	18	3	0	0	0	0	0	0	0	0	0
T	NESW	3	18	3	0	0	0	0	0	1	0	0	0

Survey Form : comb   Survey Date : 10/4/94

Pre Nridge Status : OC   Status as of 8/1/94   OC

Inspection/Testing: C

Repair/Retrofit: C

Building ID: **MNH03F**

Geographic Zone: WLA

Northridge Tag : N

Non-MRF Structural Damage?
YES "Minor spalling of concrete @ expansion joints for subterranean parking. Corbel at joint provides vertical support for 14' trib 2-way slab. Concrete spalled from corbel causing partial loss of support."

Non-Structural Damage?
Life Safety related: YES "All common exits remained open and unobstructed; however, ... overturned filing cabinets, bookcases, cubicle partitions, etc. blocked hallways and corridors in tenant spaces."
Other: YES "Drywall/steel stud walls out of plumb, numerous falling T-bar track and tiles, minor window cracking, HVAC cooling towers spring isolators broke." ALSO: see LS-related damage regarding overturned furnishings.

Design Code : LABC 1976   MRF Stories Above Ground: 3   Ground Floor Area [sf]: 5,600
Year Designed : 1978   MRF Stories Below Ground: 0   Upper Floor Area [sf]: 5,600
Year Built : 1979

Plan Irregularities?
N

Vertical Irregularities?
N

Column Fy [ksi]: 36
Girder Fy [ksi]: 36
Floor Construction Type: W
Web Connection Type: B
Flange Weld Process: U

Number of Frames in Each Direction:
N-S   NE-SW 3
E-W   NW-SE 4
Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 86   No of Inspected Floor-Frames: **17**
No of Connections Inspected: 44   %W1 : 0.0 %
No of Connections Tested: 0   Damage Score : **.26**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
22	NWSE	3	15	2	0	0	0	0	0	0	0	0	0
23	NWSE	3	15	2	0	0	0	0	0	0	0	0	0
24	NWSE	3	15	2	0	0	0	0	0	0	0	0	0
25	NWSE	3	15	2	0	0	0	0	0	0	0	0	0
U	NESW	3	23	3	0	0	0	0	0	1	0	0	0
V	NESW	3	23	3	0	0	0	0	0	1	0	0	0
W	NESW	3	23	3	0	0	0	0	0	1	0	0	0

Survey Form : comb
Survey Date : 10/4/94
Pre Nridge Status : OC
Status as of 8/1/94 OC
Inspection/Testing: C
Repair/Retrofit: C

Building ID: **MNH03G**

Geographic Zone: WLA

Northridge Tag : N

Non-MRF Structural Damage?
YES "Minor spalling of concrete @ expansion joints for subterranean parking. Corbel at joint provides vertical support for 14' trib 2-way slab. Concrete spalled from corbel causing partial loss of support."

Non-Structural Damage?
Life Safety related: YES "All common exits remained open and unobstructed; however, ... overturned filing cabinets, bookcases, cubicle partitions, etc. blocked hallways and corridors in tenant spaces."
Other: YES "Drywall/steel stud walls out of plumb, numerous falling T-bar track and tiles, minor window cracking, HVAC cooling towers spring isolators broke." ALSO: see LS-related damage regarding overturned furnishings.

Design Code : LABC 1976
Year Designed : 1978
Year Built : 1979

MRF Stories Above Ground: 3
MRF Stories Below Ground: 0

Ground Floor Area [sf]: 4,500
Upper Floor Area [sf]: 4,500

Plan Irregularities?
N

Vertical Irregularities?
N

Column Fy [ksi]: 36
Girder Fy [ksi]: 36
Floor Construction Type: W
Web Connection Type: B
Flange Weld Process: U

Number of Frames in Each Direction:
N-S
NE-SW 2
E-W
NW-SE 2
Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 72
No of Connections Inspected: 32
No of Connections Tested: 0

No of Inspected Floor-Frames: **12**
%W1 : 0.0 %
Damage Score :**.13**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
26	NWSE	4	17	3	0	0	0	0	0	0	0	0	0
27	NWSE	4	17	3	0	0	0	0	0	0	0	0	0
X	NESW	3	23	3	0	0	0	0	0	1	0	0	0
Y	NESW	3	23	3	0	0	0	0	0	0	0	0	0

Survey Form : comb

Survey Date : 10/4/94

Building ID: **MNH03H**

Pre Nridge Status : OC

Status as of 8/1/94 OC

Inspection/Testing: C

Repair/Retrofit: C

Geographic Zone: WLA

Northridge Tag : N

Non-MRF Structural Damage?
YES "Minor spalling of concrete @ expansion joints for subterranean parking. Corbel at joint provides vertical support for 14' trib 2-way slab. Concrete spalled from corbel causing partial loss of support."

Non-Structural Damage?
Life Safety related: YES "All common exits remained open and unobstructed; however, ... overturned filing cabinets, bookcases, cubicle partitions, etc. blocked hallways and corridors in tenant spaces."
Other: YES "Drywall/steel stud walls out of plumb, numerous falling T-bar track and tiles, minor window cracking, HVAC cooling towers spring isolators broke." ALSO: see LS-related damage regarding overturned furnishings.

Design Code : LABC 1976

MRF Stories Above Ground: 3

Ground Floor Area [sf]: 7,000

Year Designed : 1978

MRF Stories Below Ground: 0

Upper Floor Area [sf]: 7,000

Year Built : 1979

Plan Irregularities?
N

Vertical Irregularities?
N

Column Fy [ksi]: 36

Girder Fy [ksi]: 36

Floor Construction Type: W

Web Connection Type: B

Flange Weld Process: U

Number of Frames in Each Direction:
N-S
NE-SW 2
E-W
NW-SE 3
Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 52

No of Connections Inspected: 32

No of Connections Tested: 0

No of Inspected Floor-Frames: **9**

%W1 : 0.0 %

Damage Score :**0.00**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
28	NWSE	3	28	1	0	0	0	0	0	0	0	0	0
29	NWSE	3	28	1	0	0	0	0	0	0	0	0	0
30	NWSE	3	31	1	0	0	0	0	0	0	0	0	0
AA	NESW	4	15	3	0	0	0	0	0	0	0	0	0
Z	NESW	4	15	3	0	0	0	0	0	0	0	0	0

Survey Form : new
Survey Date : 9/29/94
Building ID: **MNH04**

Pre Nridge Status : OC
Status as of 9/29/94 OC
Inspection/Testing: C
Repair/Retrofit: na
Geographic Zone: SO

Northridge Tag : U
Non-MRF Structural Damage?
NO "None"

Non-Structural Damage?
Life Safety related:

Other: YES "Minor ceiling tile displacement. Minor cracking of interior partitions."

Design Code : UBC 1979
Year Designed : 1981
Year Built : 1981
MRF Stories Above Ground: 6
MRF Stories Below Ground: 0
Ground Floor Area [sf]: 32,000
Upper Floor Area [sf]: 32,000

Plan Irregularities?
N

Vertical Irregularities?
N

Column Fy [ksi]: 36
Girder Fy [ksi]: 36
Floor Construction Type: MCL
Web Connection Type: B
Flange Weld Process: SMAW

Number of Frames in Each Direction:
N-S 4 NE-SW
E-W 4 NW-SE
Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 54
No of Connections Inspected: 31
No of Connections Tested: 31
No of Inspected Floor-Frames: **12**
%W1 :
Damage Score :**0.00**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
2	EW	2	34	3	0	0	0	0	0	0	0	0	0
6	EW	2	34	3	0	0	0	0	0	0	0	0	0
A2	NS	2	30	1	0	0	0	0	0	0	0	0	0
C	NS	2	30	2	0	0	0	0	0	0	0	0	0
E	NS	3	30	3	0	0	0	0	0	0	0	0	0

Survey Form : old
Survey Date : 8/21/94
Building ID: **NYA539**

Pre Nridge Status : OC
Status as of 8/21/94 OC
Inspection/Testing: C
Repair/Retrofit: NS
Geographic Zone: WH

Northridge Tag : U

Non-MRF Structural Damage?

Non-Structural Damage?
Life Safety related:

Other:

Design Code : LABC 1980
Year Designed : 1984
Year Built : 1985

MRF Stories Above Ground: 3
MRF Stories Below Ground: 0

Ground Floor Area [sf]:
Upper Floor Area [sf]: 28,000

Plan Irregularities?
Y reentrant corner (L-shaped diaphragm)

Vertical Irregularities?
N

Column Fy [ksi]: 36
Girder Fy [ksi]: 36
Floor Construction Type: MC
Web Connection Type: B
Flange Weld Process: U

Number of Frames in Each Direction:
N-S 6 NE-SW
E-W 6 NW-SE
Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 54
No of Connections Inspected: 33
No of Connections Tested: 33

No of Inspected Floor-Frames: **14**
%W1 : 100.0 %
Damage Score :.68

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
3	EW	1	34	1	0	0	0	0	0	1	0	0	0
5	EW	1	34	1	0	0	0	0	0	1	0	0	0
7	EW	1	34	1	0	0	0	0		1	0	0	0
9	EW	1	34	1	0	0	0	0	1	1	0	0	0
D	NS	3	20	1	0	0	0	0	1	1	0	0	0
G	NS	4	20	1		0		0		1	0	0	0
X10	NS	1	34	1		0		0		1	0	0	0
X12	NS	1	34	1	0	0	0	0	1	1	0	0	0
X5	NS	1	34	2	0	0	0	0	1	2	0	0	0
X8	NS	1	34	1	0	0	0	0	0	1	0	0	0
Y1	EW	3	20	1	0	0	0	0	1	1	0	0	0
Y5	EW	4	20	2	0	0	0	0	1	1	0	0	0

Survey Form : old
Survey Date : 8/17/94
Building ID: **NYA544**

Pre Nridge Status : OC
Status as of 8/17/94 OC
Inspection/Testing: C
Repair/Retrofit: NS
Geographic Zone: WH

Northridge Tag : U
Non-MRF Structural Damage?
U

Non-Structural Damage?
Life Safety related:

Other:

Design Code : LABC
Year Designed : 1975
Year Built : 1976

MRF Stories Above Ground: 13
MRF Stories Below Ground: 1

Ground Floor Area [sf]: 25,600
Upper Floor Area [sf]: 25,600

Plan Irregularities?
N

Vertical Irregularities?
N

Column Fy [ksi]: 36
Girder Fy [ksi]: 36
Floor Construction Type: MC
Web Connection Type: B
Flange Weld Process: U

Number of Frames in Each Direction:
N-S 2 NE-SW
E-W 2 NW-SE
Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 560
No of Connections Inspected: 545
No of Connections Tested: 545

No of Inspected Floor-Frames: **56**
%W1 : 50.0 %
Damage Score :**1.09**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
4	NS	5	32	14	1	5	0	5	0	9	4	0	0
9	NS	5	32	14	2	1	0	2	0	5	2	0	0
B	EW	5	32	14	0	3	0	1	0	6	2	0	0
G	EW	5	32	14	2	0	0	1	0	5	1	0	0

Survey Form : old
Survey Date : 8/22/94

Building ID: **NYA550**

Pre Nridge Status : OC
Status as of 8/22/94 OC
Inspection/Testing: C
Repair/Retrofit: NS

Geographic Zone: SO

Northridge Tag : U

Non-MRF Structural Damage?

Non-Structural Damage?
Life Safety related:

Other:

Design Code :
Year Designed : 1985
Year Built : 1985

MRF Stories Above Ground: 6
MRF Stories Below Ground: 0

Ground Floor Area [sf]: 53,400
Upper Floor Area [sf]: 21,000

Plan Irregularities?
Y reentrant corner

Vertical Irregularities?
Y mass & geom irreg at floor 4 setback.

Column Fy [ksi]: 36
Girder Fy [ksi]: 36
Floor Construction Type: MCL
Web Connection Type: B
Flange Weld Process: U

Number of Frames in Each Direction:
N-S 5 NE-SW
E-W 5 NW-SE
Notes: At floors 5-7(rf), 2 NS, 2 EW.

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 90
No of Connections Inspected: 31
No of Connections Tested: 31

No of Inspected Floor-Frames: **15**
%W1 : 100.0 %
Damage Score :**.13**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
2C	EW	3	32	2	0	0	0	0	0	1	0	0	0
2K	EW	3	32	1	0	0	0	0	0	0	0	0	0
5C	EW	3	32	2	0	0	0	0	0	0	0	0	0
5K	EW	3	32	1		0		0		0	0	0	0
7	EW	3	32	2	0	0	0	0	0	1	0	0	0
B	NS	3	32	2	0	0	0	0	0	1	0	0	0
J	NS	3	32	1	0	0	0	0	0	0	0	0	0
O	NS	3	32	2	0	0	0	0	0	0	0	0	0
R	NS	3	32	2	0	0	0	0	0	1	0	0	0

Survey Form : old

Survey Date : 8/28/94

Building ID: **NYA577**

Pre Nridge Status : OC

Status as of 8/28/94 OC

Inspection/Testing: C

Repair/Retrofit: NS

Geographic Zone: WLA

Northridge Tag : U

Non-MRF Structural Damage?

Non-Structural Damage?
Life Safety related:

Other:

Design Code :

Year Designed : 1980

Year Built : 1981

MRF Stories Above Ground: 14

MRF Stories Below Ground: 0

Ground Floor Area [sf]: 32,000

Upper Floor Area [sf]: 17,700

Plan Irregularities?
N

Vertical Irregularities?
Y mass & geom irreg at floor 2 & 3 low roof setbacks.

Column Fy [ksi]: 50

Girder Fy [ksi]: 36

Floor Construction Type: MCL

Web Connection Type: B

Flange Weld Process: U

Number of Frames in Each Direction:

N-S 6 NE-SW

E-W 2 NW-SE

Notes: At ground, including small frames under low roofs: 8 NS, 4 EW, 2 NWSE.

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 94

No of Connections Inspected: 29

No of Connections Tested: 29

No of Inspected Floor-Frames: **20**

%W1 : 100.0 %

Damage Score :**.53**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
A	EW	4	30	5	0	0	0	0	0	5	0	0	0
B	EW	4	30	4	0	0	0	0	1	4	0	0	0
C	NS	1	31	4	0	0	0	0	1	4	0	0	0
D	NS	1	31	5	0	0	0	0	0	5	0	0	0
E	NS	1	27	1	0	0	0	0	0	0	0	0	0
H	NS	1	27	1	0	0	0	0	0	1	0	0	0

Survey Form : new

Survey Date : 9/20/94

Building ID: **NYA591**

Pre Nridge Status : OC

Status as of 9/20/94 OC

Inspection/Testing: C

Repair/Retrofit: NS

Geographic Zone: WLA

Northridge Tag : U

Non-MRF Structural Damage?
NO "N"

Non-Structural Damage?
Life Safety related: U

Other: U

Design Code : LABC

Year Designed : 1970

Year Built : 1970

MRF Stories Above Ground: 28

MRF Stories Below Ground: 4

Ground Floor Area [sf]: 24,000

Upper Floor Area [sf]: 24,000

Plan Irregularities?
N

Vertical Irregularities?
N

Column Fy [ksi]: 36

Girder Fy [ksi]: 36

Floor Construction Type: MCL

Web Connection Type: W

Flange Weld Process: U

Number of Frames in Each Direction:

N-S 0 NE-SW

E-W 2 NW-SE

Notes: NS direction is Braced Frame Dual System

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 208

No of Connections Inspected: 18

No of Connections Tested: 18

No of Inspected Floor-Frames: **16**

%W1 : 100.0 %

Damage Score :**.09**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
3	EW	11	20	5	0	0	0	0	1	2	0	0	0
9	EW	11	20	2	0	0	0	0	0	0	0	0	0
F	NS	3	40	4	0	0	0	0	0	0	0	0	0
G	NS	3	40	2	0	0	0	0	0	0	0	0	0
R	NS	3	40	3	0	0	0	0	0	0	0	0	0

Survey Form : new
Survey Date : 9/19/94
Building ID: **NYA592**
Pre Nridge Status : OC
Status as of 9/19/94 OC
Inspection/Testing: C
Repair/Retrofit: NS
Geographic Zone: WLA

Northridge Tag : U
Non-MRF Structural Damage?
NO "N"

Non-Structural Damage?
Life Safety related: U

Other: U

Design Code : LABC
Year Designed : 1969
Year Built : 1969
MRF Stories Above Ground: 20
MRF Stories Below Ground: 1
Ground Floor Area [sf]: 24,300
Upper Floor Area [sf]: 24,300

Plan Irregularities?
N

Vertical Irregularities?
N

Column Fy [ksi]: 36
Girder Fy [ksi]: 36
Floor Construction Type: LC
Web Connection Type: W
Flange Weld Process: U

Number of Frames in Each Direction:
N-S 2 NE-SW
E-W 2 NW-SE
Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 124
No of Connections Inspected: 10
No of Connections Tested: 10
No of Inspected Floor-Frames: **10**
%W1 :
Damage Score :**0.00**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
1	EW	5	22	5	0	0	0	0	0	0	0	0	0
10	EW	5	22	1	0	0	0	0	0	0	0	0	0
F	NS	9	25	4	0	0	0	0	0	0	0	0	0

Survey Form : old

Survey Date : 8/17/94

Building ID: **SOA**

Pre Nridge Status : OC

Status as of 8/12/94 OC

Inspection/Testing: C

Repair/Retrofit: C

Geographic Zone: SO

Northridge Tag : Y

Non-MRF Structural Damage?
YES "Base plate anchors broke free from base plates. Large areas of spalled concrete around many column bases. One base shifted 3/4" north, another 3/8"."

Non-Structural Damage?
Life Safety related: YES Facade of Brick veneer cracked & broke away from anchorage,...falling hazard....

Other: YES Lots of broken glazing panels, cracked facade, stucco cracks @ elev core, racked doors, ...ceiling panels...interior walls...settlement of exterior slabs and walkways.

Design Code : LABC 1980

Year Designed : 1984

Year Built : 1985

MRF Stories Above Ground: 4

MRF Stories Below Ground: 0

Ground Floor Area [sf]: 29,800

Upper Floor Area [sf]: 25,015

Plan Irregularities?
Y reent corners

Vertical Irregularities?
N

Column Fy [ksi]: 36

Girder Fy [ksi]: 36

Floor Construction Type: MC

Web Connection Type: B

Flange Weld Process: U

Number of Frames in Each Direction:
N-S 4 NE-SW
E-W 6 NW-SE
Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 184

No of Connections Inspected: 160

No of Connections Tested: 160

No of Inspected Floor-Frames: **22**

%W1 : 0.0 %

Damage Score :**1.95**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
A	NS	5	13	4	0	0	0	2	0	3	1	0	0
B	NS	5	13	4	0	1	0	2	0	2	1	0	0
C	NS	5	13	4	0	1	0	2	0	2	2	0	0
D	NS	5	13	4	0	1	0	2	1	2	2	0	0
E	EW	5	13	1	0	0	0	0	0	0	0	0	0
F	EW	2	13	1		0	0	0	0	0	0	0	0
G	EW	4	13	1		0	0	0	0	0	0	0	0
H	EW	2	13	1		0	0	0	0	0	0	0	0
I	EW	4	13	1		0	0	0	0	0	0	0	0
J	EW	5	13	1		0	0	0	0	0	0	0	0

Survey Form : old
Survey Date : 8/25/94
Building ID: **SOM1**

Pre Nridge Status : OC
Status as of 5/27/94 OC
Inspection/Testing: C
Repair/Retrofit: NS
Geographic Zone: MW

Northridge Tag : N

Non-MRF Structural Damage?
YES "Noticable separation of mid-floor stair landing from adjacent stair drywall."

Non-Structural Damage?
Life Safety related: NO "None"

Other: YES "Some ceiling panels."

Design Code : LABC 1985
MRF Stories Above Ground: 4
Ground Floor Area [sf]: 18,400
Year Designed : 1986
MRF Stories Below Ground: 0
Upper Floor Area [sf]: 18,400
Year Built :

Plan Irregularities?
N

Vertical Irregularities?
N

Column Fy [ksi]: 36
Girder Fy [ksi]: 36
Floor Construction Type: W
Web Connection Type: B
Flange Weld Process: U

Number of Frames in Each Direction:
N-S 3 NE-SW
E-W 3 NW-SE
Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 38
No of Inspected Floor-Frames: 9
No of Connections Inspected: 17
%W1 : 100.0 %
No of Connections Tested: 17
Damage Score :.33

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
A	EW	2	24	2		0		0		2	0	0	0
B	EW	2	17	1		0		0		0	0	0	0
C	EW	2	22	2		0		0		0	0	0	0
D	NS	3	30	2		0		0		2	0	0	0
E	NS	2	30	1		0		0		1	0	0	0
F	NS	2	30	1		0		0		1	0	0	0

Survey Form : new
Survey Date : 9/23/94

Pre Nridge Status : OC
Status as of 9/23/94 OC
Inspection/Testing: C
Repair/Retrofit: NS

Building ID: **WEA**

Geographic Zone: UC

Northridge Tag : N

Non-MRF Structural Damage?
YES "CMU block @ elev shaft cracked & fell; steel bms pulled from wall; wood bms @ stairwell damaged."

Non-Structural Damage?
Life Safety related: YES "Elev unusable; stair well exit inhibited"

Other: YES "isolated ceil'g tiles fell; tall cabinets (file) fell."

Design Code : UBC 1976
Year Designed : 1979
Year Built : 1981

MRF Stories Above Ground: 4
MRF Stories Below Ground: 0

Ground Floor Area [sf]: 7,000
Upper Floor Area [sf]: 18,000

Plan Irregularities?
N

Vertical Irregularities?
Y mass irreg

Column Fy [ksi]: 36
Girder Fy [ksi]: 36
Floor Construction Type: W
Web Connection Type: B
Flange Weld Process: U

Number of Frames in Each Direction:
N-S 2 NE-SW
E-W 4 NW-SE
Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 48
No of Connections Inspected: 48
No of Connections Tested: 48

No of Inspected Floor-Frames: **24**
%W1 : 0.0 %
Damage Score :**1.54**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
10	EW	1	24	4	0	0	0	1	0	1	0	0	1
2	EW	1	24	4	0	0	0	0	0	0	0	0	0
5	EW	1	24	4	0	0	0	2	0	2	0	0	2
7	EW	1	24	4	0	0	0	1	0	1	0	0	1
B	NS	1	30	4	0	0	0	1	2	2	0	0	1
F	NS	1	30	4	0	0	0	0	0	0	0	0	0

Survey Form : old
Survey Date : 9/6/94
Building ID: **WJE1**

Pre Nridge Status : OC
Status as of 6/1/94 OC
Inspection/Testing: C
Repair/Retrofit: C
Geographic Zone: WH

Northridge Tag : N

Non-MRF Structural Damage?
YES "6 inch permanent lateral displacement in height of 18 story building. Steel stair connections broken. Mechanical room block walls broken at connections to steel floor framing. Marble panel anchorages in lobby damaged."

Non-Structural Damage?
Life Safety related: YES "Elevators not operational. Fire and electrical systems temporarily out."

Other: YES "Ceiling tiles displaced, drywall partitions cracked, overturned shelves, etc."

Design Code : UBC 1985
Year Designed :
Year Built : 1986

MRF Stories Above Ground: 18
MRF Stories Below Ground: 1

Ground Floor Area [sf]: 19,200
Upper Floor Area [sf]: 19,200

Plan Irregularities?
N

Vertical Irregularities?
N

Column Fy [ksi]: 50
Girder Fy [ksi]: 36
Floor Construction Type: MC
Web Connection Type: B
Flange Weld Process: FCAW

Number of Frames in Each Direction:
N-S 2 NE-SW
E-W 2 NW-SE
Notes:

MRF Connection Inspection/Testing Scope and Damage Summary

Total No of Conns in Inspected FF's: 272
No of Connections Inspected: 272
No of Connections Tested: 41

No of Inspected Floor-Frames: **68**
%W1 : 0.0 %
Damage Score :**.46**

Number of Floor-Frames in each Damage Class for each inspected/tested Frame.

Frame	Direction	Bays	Avg Width	Flr-Frms	TG	BG	TC	BC	TW	BW	S	PZ	CW
A	NS	2	28	17	0	0	0	4	0	9	0	0	0
B	NS	2	28	17	0	0	0	2	0	4	0	0	0
C	EW	2	31	17		0		0		0	0	0	0
D	EW	2	31	17		0		0		0	0	0	0

Appendix B: Survey Forms

SURVEY OF STEEL MRF BUILDINGS AFFECTED BY THE JANUARY 1994 NORTHRIDGE EARTHQUAKE

Building Name/ID: ______________

Survey Engr: __________ Firm: ______________

Orig Date: ______________

Revn Date: ______________ Page: __________

INSTRUCTIONS TO SURVEY ENGINEERS

1. Complete survey form for each structurally distinct MRF building.
2. Report all inspected and/or tested conditions, **whether damaged or undamaged.**
3. Do not leave blanks. Use "U", "NA", or dashes "--" where necessary. See abbreviations.
4. **Please give the street address in Section I. If confidential, this information will not be released to database users. If address or building name is to be kept confidential, use an appropriate unique code for "Building Name/ID" at the top of each page.**

ABBREVIATIONS

General

N	No, None	U	Unknown	PD	Principal Direction
NA	Not Applicable	Y	Yes	MRF	Moment-Resisting Frame
O	Other			HAZ	Heat-Affected Zone
				UT	Ultrasonic Testing
				VI	Visual Inspection

Building Use

A	Apartment House	OF	Office
C	Condominiums	P	Parking
D	Data/Computing Center	R	Retail
E	Emergency (fire, ambulance, etc)	S	School
H	Hospital/Clinic	SD	School w/ DSA approval
HO	Hospital w/ OSHPD approval	T	Theatre/Church/Assembly
HL	Hotel/Motel	U	Utility
L	Laboratory/Research	W	Warehouse
M	Manufacturing/Industry		

Floor Construction Types

W	Wood diaphragm w/ wood or metal joists
M	Bare metal deck w/ steel beams or joists
MC	Metal deck w/ normal wt concrete fill
MCL	Metal deck w/ lightweight concrete fill
P	Precast concrete planks w/ topping slab

Lateral Load Resisting Systems

OMRF	Ordinary MRF
SMRF	Special MRF
DMRF	Ductile MRF (pre-1988 UBC)
CBF	Concentrically Braced Frame
EBF	Eccentrically Braced Frame
DSW	Dual System: MRF + shear walls
DCBF	Dual System: MRF + CBF
DEBF	Dual System: MRF + EBF

Weld Processes

FCAW	Flux Cored Arc Weld
SMAW	Shielded Metal Arc Weld
SAW	Submerged Arc Weld
GMAW	Gas Metal Arc Weld

DEFINITIONS

Building	Set of diaphragms laterally supported by the same set of frames or structurally separated from other diaphragms by seismic joints.
MRF	Moment-resisting frame. System of moment-connected beams and columns generally in a single vertical plane. One frame has the same name/designation at each floor.
Connection	Intersection of one frame beam with one frame column, generally comprising a top flange connection, a bottom flange connection, and a web connection. A typical *joint* with a continuous column and beams on both sides constitutes *two* connections.
Floor-Frame	The set of connections in one MRF at one floor level.

SURVEY OF STEEL MRF BUILDINGS AFFECTED BY THE JANUARY 1994 NORTHRIDGE EARTHQUAKE

Building Name/ID: ______________________

Survey Engr: __________ **Firm:** ______________

Orig Date: ______________

Revn Date: ______________ **Page:** __________

SECTION I: PROCEDURAL

Person(s) Completing Survey (Survey Engineer) ______________________

Agency/Firm ______________________________________

Firm Address ______________________________________

Telephone ____________________

Building Location		Confidential? (Y/N)
Street Number	______________________	_____
Street Name	______________________	_____
City	______________________	
Zip Code	______________________	
Cross Street(s)	______________________	
Neighborhood/District	______________________	

Note: for major renovations or additions at the same address, please distinguish original frames from added or strengthened frames and complete the applicable sections of a separate form.

Indicate items available to the survey engineer or used as the basis of survey responses:

	Available	Used
Architectural drawings	_____	_____
Structural design drawings	_____	_____
Structural as-built drawings	_____	_____
Original structural calcs	_____	_____
Geotech/soil report	_____	_____
Site specific design spectrum	_____	_____
Steel/Welding specifications	_____	_____
Fabrication/Erection drawings	_____	_____
Post-Northridge visual insp'n data	_____	_____
Post-Northridge testing data	_____	_____
Post-Northridge calcs/analysis results	_____	_____
Photographs of inspected conditions	_____	_____
Weld or steel samples removed	_____	_____
Other ____________________	_____	_____

SURVEY OF STEEL MRF BUILDINGS AFFECTED BY THE JANUARY 1994 NORTHRIDGE EARTHQUAKE

Building Name/ID: ______________________

Survey Engr: __________ Firm: __________

Orig Date: __________

Revn Date: __________ Page: __________

SECTION II: BUILDING HISTORY

Year Designed ________ Year Constructed ________

Building Use (see Abbrev.): Principal ________ Other? ________________

Secondary ________ Other? ________________

Is the building owner a government or non-profit agency? ______

Pre-Northridge building status (Occupied, Under Construction, Vacant, etc.) ______________

Post-Northridge Team

Visual Insp Engr/Firm ________________________________

Testing Lab ________________________________

Repair/Retrofit Engr ________________________________

Current building status (Occupied, Under Construction, Vacant, etc.) ______________

Visual inspection Complete, In Progress, or Not Started (C, IP, NS) ______

Testing Complete, In Progress, or Not Started ______

Repair/Rehabilitation Design Complete, In Progress, or Not Started ______

Repair/Rehab Construction Complete, In Progress, or Not Started ______

Additional description of current building status ________________________

____

Date of above status information ____________

SURVEY OF STEEL MRF BUILDINGS AFFECTED BY THE JANUARY 1994 NORTHRIDGE EARTHQUAKE

Building Name/ID: ____________________

Survey Engr: __________ Firm: ____________

Orig Date: ____________

Revn Date: ____________ Page: ________

SECTION III: NORTHRIDGE EARTHQUAKE PERFORMANCE

Was the building tagged after Northridge (Unknown, None, Red, Yellow, Green)? ________

If building was retagged or had its tag status changed in any way, please explain:

____

____

Describe structural damage other than in MRF connections (consider permanent lateral set, if any):

____

____

____

____

Describe non-structural damage (consider especially falling hazards and loss of egress):

____

____

____

____

Describe the impact of damage on users (e.g., known injuries? voluntary evacuation? business downtime?): ____

____

____

____

Classify the distribution of structural damage (including MRF connection damage) as None, Isolated, or Widespread: ________

Classify the impact of structural damage (including MRF connection damage) on the building's overall life safety as None, Minimal, or Substantial: ________

Classify potential required repairs of all damage as None, Cosmetic (non-structural only), Moderate (repairable without substantial demolition), or Heavy: ________

SURVEY OF STEEL MRF BUILDINGS AFFECTED BY THE JANUARY 1994 NORTHRIDGE EARTHQUAKE

Building Name/ID: ______________________

Survey Engr: __________ Firm: ______________

Orig Date: ____________

Revn Date: ____________ Page: ________

SECTION IV: BUILDING DESCRIPTION

Total # of stories above ground: _____ # of steel MRF stories above ground: _____

Total # of stories below ground: _____ # of steel MRF stories below ground: _____

Maximum roof height above ground: _____

Approximate footprint area: __________ Approximate typical floor area: __________

Typical floor construction (see Abbreviations): ________

Describe the lateral load-resisting system in each Principal Direction (see Abbreviations):
Note: If building's frames are in two directions only, ignore PD3 and PD4.

	PD1	PD2	PD3	PD4
Compass Direction	______	______	______	______
Lateral System	______	______	______	______

Which (if any) vertical irregularities per 1991 UBC Table 23-M appear to be present in the building?

____

Which (if any) plan irregularities per 1991 UBC Table 23-N appear to be present in the building?

____

Design Code & year ________

Typical column F_y (ksi) ________ Typical girder F_y (ksi) ________

Typical girders expected to act composite with deck? ______

Typical girder web connections welded only (W), bolted only (B), or welded & bolted (WB)? ______

Girder flange weld process (see Abbreviations): _______ Field or Shop? ______

Describe each MRF in Section V table. Add sheets as necessary. Only inspected or tested conditions need be reported, but descriptions of member sizes, number of bays, etc. in uninspected frames are also appreciated.

SURVEY OF STEEL MRF BUILDINGS AFFECTED BY THE JANUARY 1994 NORTHRIDGE EARTHQUAKE

Building Name/ID: ____________________

Survey Engr: __________ Firm: __________

Orig Date: __________

Revn Date: __________ Page: __________

SECTION V: DAMAGE DESCRIPTION

1. Respond to the questions on this and the next page.
2. Assign a name to each MRF. A given frame should have the same name at each floor.
3. Complete one copy of the table below for each inspected MRF, **whether damaged or not.**
4. Show the MRF locations and names on a plan sketch in Section VII below.

Note: Generally, each line of each Section V table will describe one inspected floor-frame. However, one line can be used for several identical floors. Frames with more than seven non-identical inspected floor levels will require more than one page. As an alternate to completing the tables, provide Section VIII frame elevations for each frame, showing member sizes, extent of inspection/testing, and damage type according to the reference schedule of damage types below.

Describe the type and extent of typical visual inspection and typical testing (y/n/u):

Visual Inspection:		Testing:	
fireproofing removed from beam	____	ultrasonic	____
fireproofing removed from col flange	____	magnetic particle	____
fireproofing removed from panel zone	____	dye penetrant	____
steel cleaned	____	weld sample taken	____
backup bars removed for weld VI/UT	____	bm/col sample taken	____
slab removed for top flange access	____	plumbness survey	____

window wall removed for far side access at perimeter frames ____

	inspected?	tested?
beam top flange	____	____
beam bottom flange	____	____
column flange	____	____
full width of beam/column flange	____	____
shear connection inspected	____	
panel zone inspected	____	

Basis for selecting locations to VI/UT (e.g. cost, access, analysis, random): ____________________

Describe inspection or testing criteria/procedures (e.g. AWS D1.1): ____________________

____

____

Describe any constraints on typical VI/testing (e.g. at top flanges and perimeter frames):

____

____

SURVEY OF STEEL MRF BUILDINGS AFFECTED BY THE JANUARY 1994 NORTHRIDGE EARTHQUAKE

Building Name/ID: ____________________

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SECTION V continued

Describe any observed evidence of poor workmanship (e.g. use of end dams, small cope holes):

____

____

____

Describe any observed deviations from approved drawings or specifications. __________

____

____

____

Is there reason to think that poor workmanship or deviations contributed to damage? Explain:

____

____

____

Of all the weld damage indicated in the floor-frame tables below, estimate the percentage that is UT-detected incipient root cracks only (type W1) or minor discontinuities that may have existed pre-earthquake: __________

If Column Web damage (class CW) is indicated for any of the floor-frames in the tables below, describe more completely the nature and location of such damage (or illustrate in Section VI below):

____

____

____

SURVEY OF
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Building Name/ID: ____________________

Survey Engr: __________ **Firm:** __________

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SECTION V continued Describe each inspected floor-frame. See Section V instructions above.

FRAME ______ **FLOORS** ______ through ______ **Principal Direction:** ______

Floor	# of bays	typ bay width(s)	typ column section	typ girder section	# of conns total	# of conns insp'd	# of conns tested	damage types observed (Circle all that apply. Upper row for top flange damage, lower row for bottom flange damage.)
								G CF W S PZ CW NONE G CF W PZ CW NONE
								G CF W S PZ CW NONE G CF W PZ CW NONE
								G CF W S PZ CW NONE G CF W PZ CW NONE
								G CF W S PZ CW NONE G CF W PZ CW NONE
								G CF W S PZ CW NONE G CF W PZ CW NONE
								G CF W S PZ CW NONE G CF W PZ CW NONE
								G CF W S PZ CW NONE G CF W PZ CW NONE

Damage types (see reference schedule and details):

G	Girder Damage	S	Shear Connection Damage
CF	Column Flange Damage	PZ	Panel Zone Damage
W	Flange Weld Damage	CW	Column web Damage

SURVEY OF STEEL MRF BUILDINGS AFFECTED BY THE JANUARY 1994 NORTHRIDGE EARTHQUAKE

Building Name/ID: ____________

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SECTION V continued

REFERENCE SCHEDULE OF DAMAGE TYPES (See Reference Details below for pictorial description.)

G GIRDER DAMAGE
- G1 buckled flange
- G2 yielded flange
- G3 flange tearout near weld
- G4 flange crack outside HAZ

CF COLUMN FLANGE DAMAGE
- C1 incipient flange crack (detected by UT)
- C2 complete flange tearout or divot
- C3 full or partial cross-flange crack in HAZ
- C4 full or partial cross-flange crack outside HAZ
- C5 lamellar flange tearing

W FLANGE WELD DAMAGE
- W1 incipient crack, especially at weld root (detected by UT)
- W2 crack through weld metal, full or partial width of flange
- W3 fracture at girder interface
- W4 fracture at column interface

S SHEAR CONNECTION DAMAGE
- S1 column to web or column to shear tab weld crack
- S2 web to shear tab supplemental weld crack
- S3 web or shear tab crack, especially through bolt holes
- S4 web or shear tab deformation, especially at holes
- S5 loose, damaged, or missing bolts; faying surfaces out of contact

PZ PANEL ZONE DAMAGE
- P1 fracture, buckle, or yield of continuity plate
- P2 crack in continuity plate welds
- P3 buckle, yield, or ductile deformation of doubler plate or column web
- P4 crack in doubler plate welds

CW COLUMN WEB DAMAGE
- P5 partial depth crack in column web or doubler plate (extension of C3 or C4)
- P6 full or near full depth crack in column web or doubler plate

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Building Name/ID: ____________________

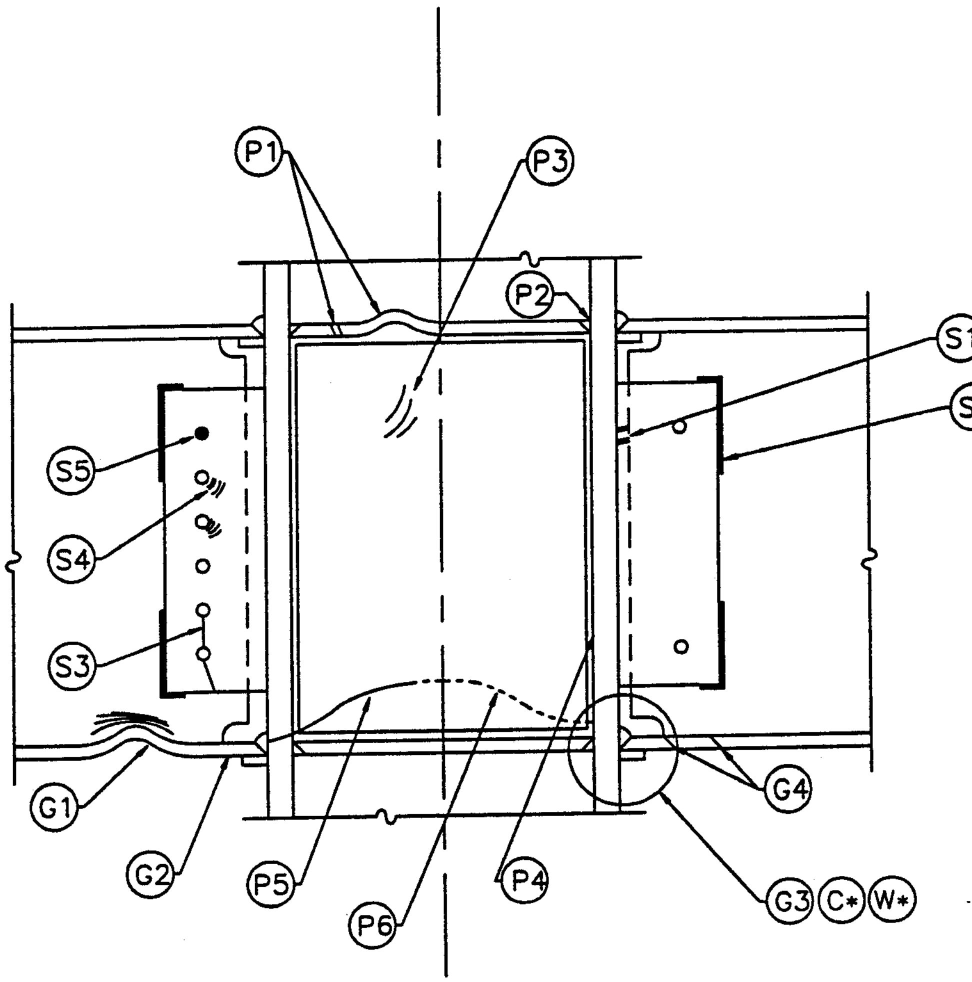
Survey Engr: __________ Firm: ____________

Orig Date: ______________

Revn Date: ______________ Page: __________

SECTION V continued

REFERENCE DETAIL (See Reference Schedule above for damage type descriptions.)

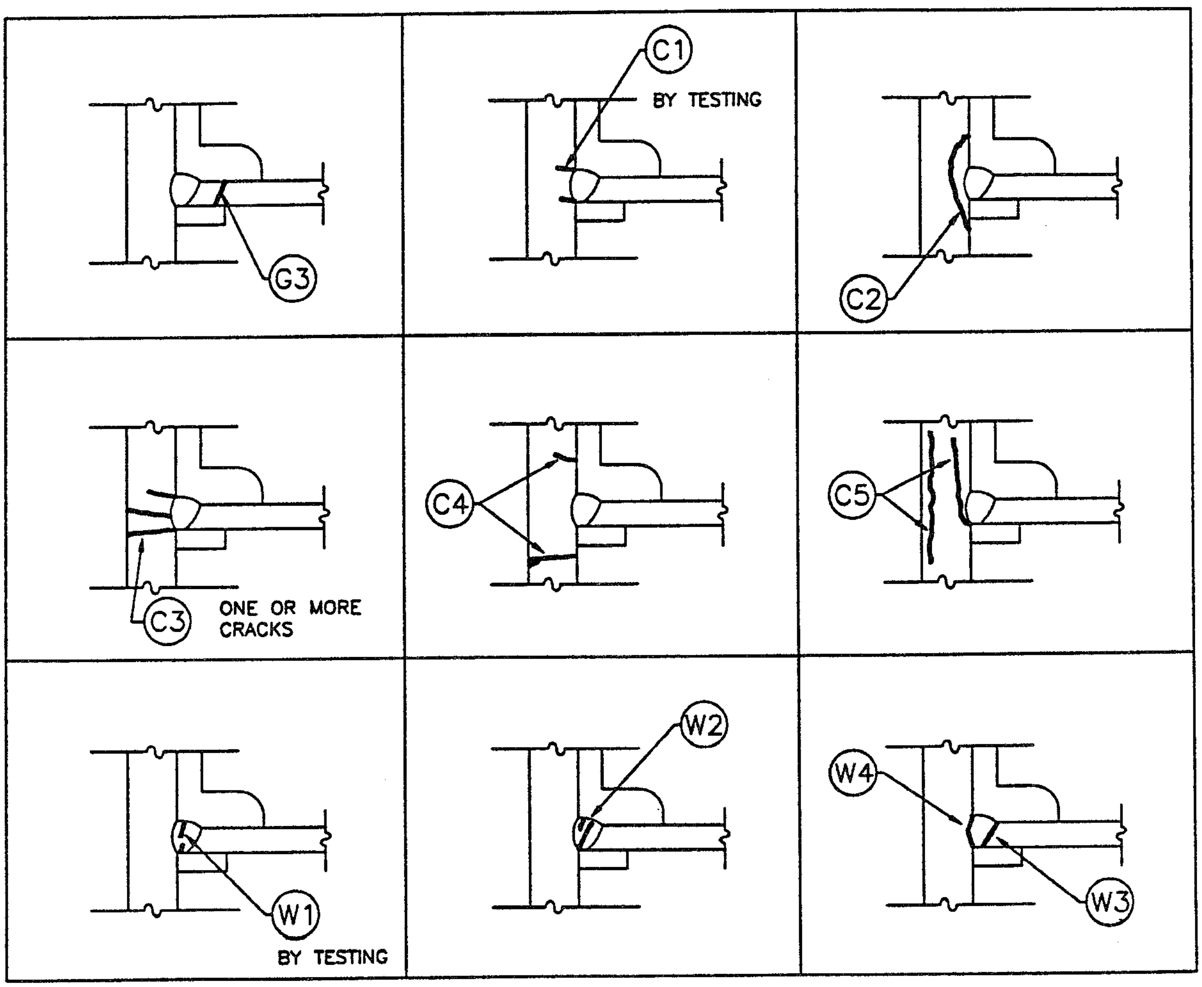


REFERENCE DETAIL: MRF JOINT DAMAGE TYPES

NOTE: SEE REFERENCE SCHEDULE FOR DESCRIPTION

SECTION V continued

REFERENCE DETAIL (See Reference Schedule above for damage type descriptions.)



REFERENCE DETAIL: MRF DAMAGE TYPES

NOTE: SEE REFERENCE SCHEDULE FOR DESCRIPTION

SURVEY OF
STEEL MRF BUILDINGS
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Building Name/ID: ______

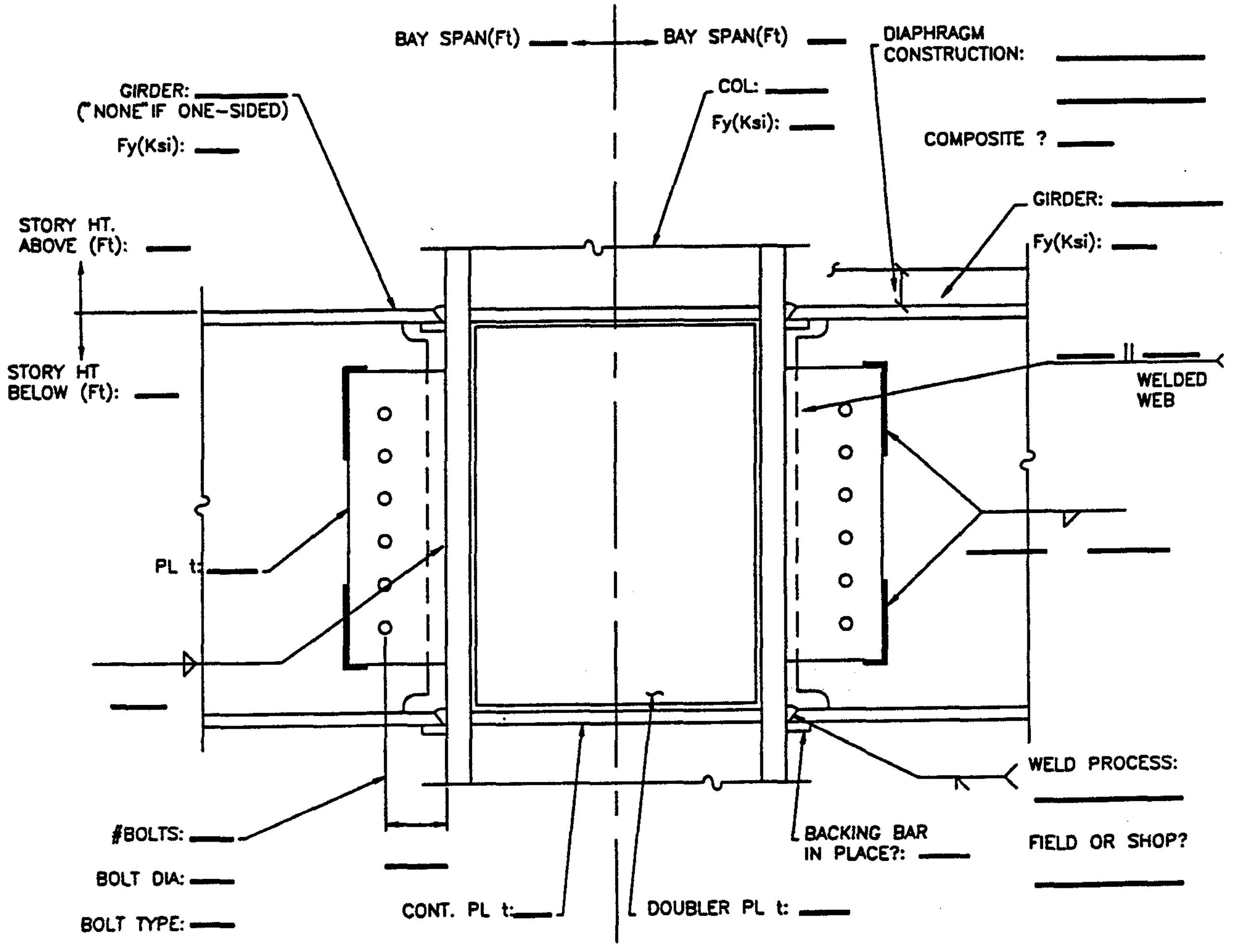
Survey Engr: ______ Firm: ______

Orig Date: ______

Revn Date: ______ Page: ______

SECTION VI: SPECIFIC DAMAGE DETAILS

Instructions to Survey Engineer: Complete details shown for one or two specific conditions per building. Show damage and identify by type according to Reference Schedule above.



JOINT DAMAGE TEMPLATE DETAIL – STRONG AXIS COL. ELEV.

NOTES:
1. U.N.O., AS-BUILT DIMENSIONS AND SIZES SHOWN ON ONE SIDE TOP OR BOTTOM ARE TYP. , TO BOTH SIDES, TOP AND BOTTOM.
2. SEE PLAN DETAILS FOR ADDITIONAL INFORMATION.
3. REFER TO DAMAGE TYPE DETAIL/SCHEDULE FOR EXPLANATION OF DAMAGE FLAGS.

DATE VISUALLY INSPECTED: ______ DATE TESTED: ______

FLOOR: ______ FRAME DESIGNATION (PER SEPARATE PLAN SKETCH) : ______

JOINT LOCATION IN FRAME (DESCRIBE OR REFER TO SEPARATE ELEVATION) : ______

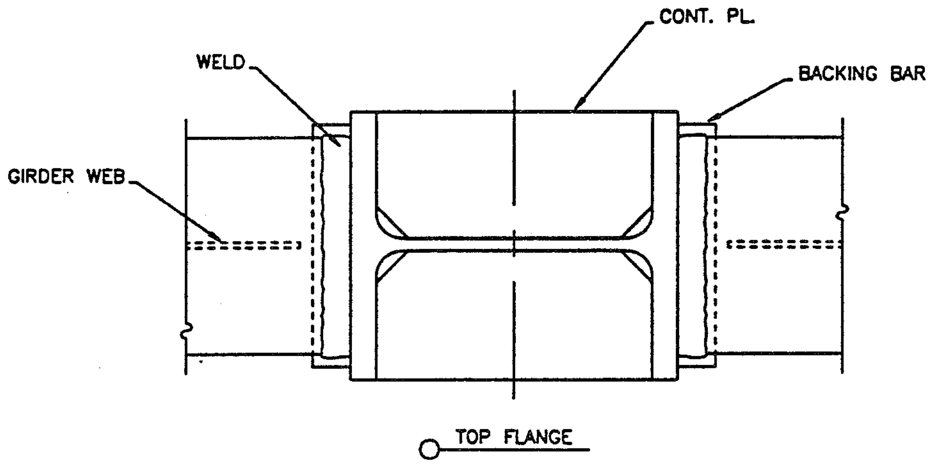
AT THIS FLOOR AND FRAME, DAMAGE SHOWN IS ______ TYPICAL, ______ WORST CASE

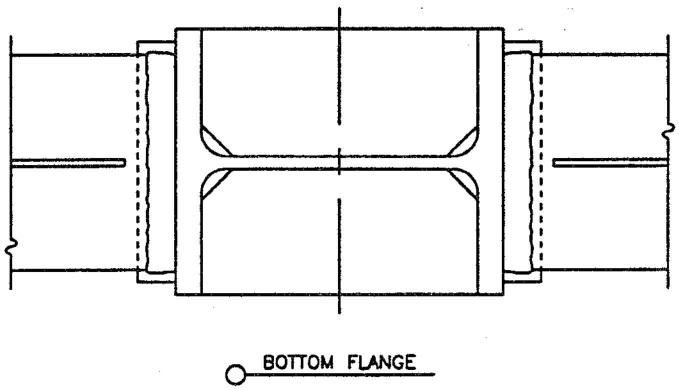
MOST SIMILAR JOINTS ON THIS FLOOR HAD ______ NO DAMAGE, ______ LESS DAMAGE, ______ SIMILAR DAMAGE

SURVEY OF STEEL MRF BUILDINGS AFFECTED BY THE JANUARY 1994 NORTHRIDGE EARTHQUAKE	
	Building Name/ID: ____
	Survey Engr: ____ Firm: ____
	Orig Date: ____
	Revn Date: ____ Page: ____

SECTION VI: SPECIFIC DAMAGE DETAILS

Instructions to Survey Engineer: Complete details shown for one or two specific conditions per building. Show damage and identify by type according to Reference Schedule above.





JOINT DAMAGE TEMPLATE DETAIL – STRONG AXIS PLAN

NOTES:

1. SEE COLUMN ELEVATION FOR MEMBER SIZES, DIMENSIONS, AND ADDITIONAL INFORMATION.
2. REFER TO DAMAGE TYPE DETAIL/SCHEDULE FOR EXPLANATION OF DAMAGE FLAGS.

FLOOR: ____ FRAME DESIGNATION (PER SEPARATE PLAN SKETCH) : ____

SURVEY OF
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AFFECTED BY THE JANUARY 1994
NORTHRIDGE EARTHQUAKE

Building Name/ID: ____________________

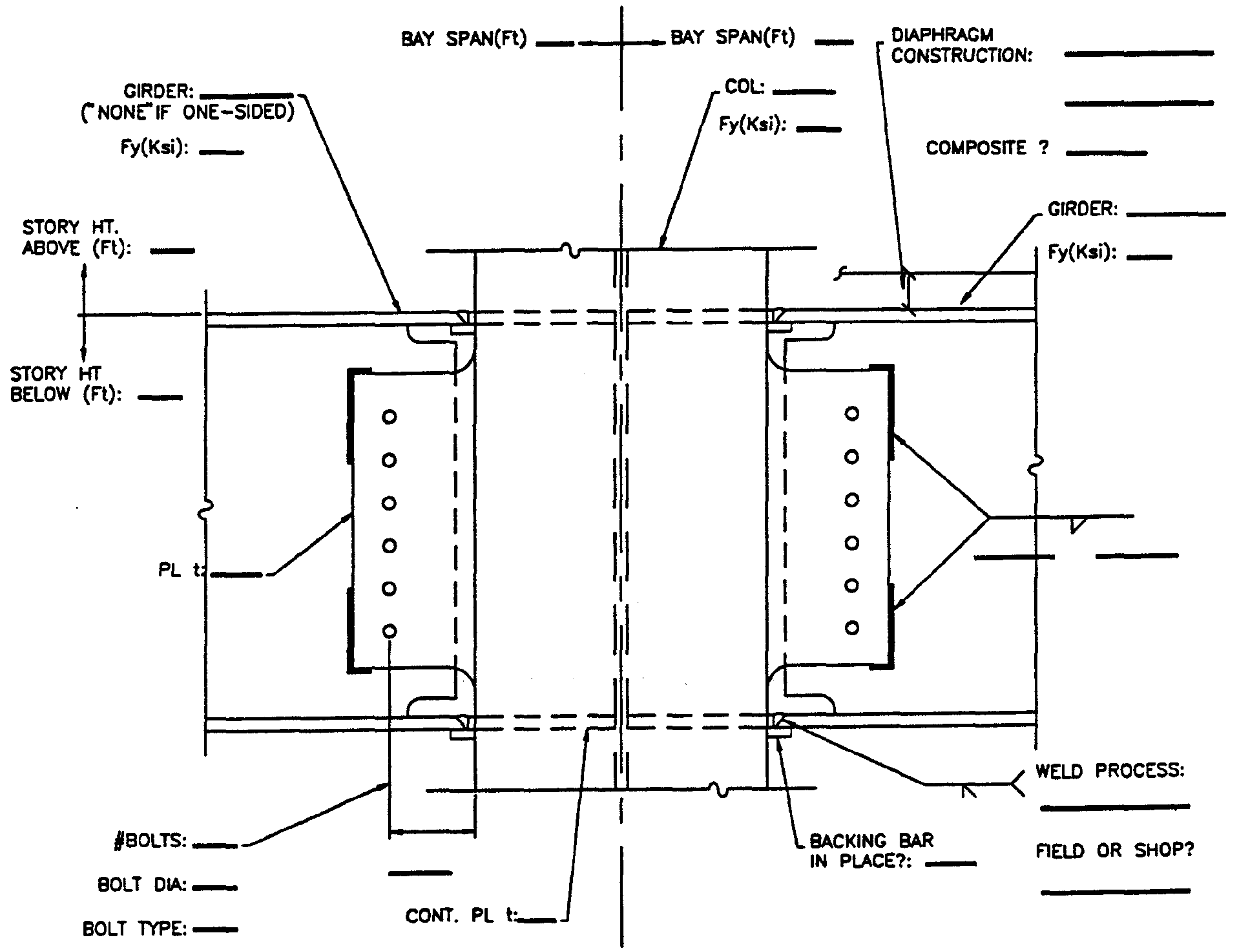
Survey Engr: __________ Firm: ____________

Orig Date: ____________

Revn Date: ____________ Page: __________

SECTION VI: SPECIFIC DAMAGE DETAILS

Instructions to Survey Engineer: Complete details shown for one or two specific conditions per building. Show damage and identify by type according to Reference Schedule above.



JOINT DAMAGE TEMPLATE DETAIL – WEAK AXIS COL. ELEV.

NOTES:
1. U.N.O., AS-BUILT DIMENSIONS AND SIZES SHOWN ON ONE SIDE TOP OR BOTTOM ARE TYP., TO BOTH SIDES, TOP AND BOTTOM.
2. SEE PLAN DETAIL FOR ADDITIONAL INFORMATION.
3. REFER TO DAMAGE TYPE DETAIL/SCHEDULE FOR EXPLANATION OF DAMAGE FLAGS.

DATE VISUALLY INSPECTED: __________ DATE TESTED: __________

FLOOR: __________ FRAME DESIGNATION (PER SEPARATE PLAN SKETCH) : ____________________

JOINT LOCATION IN FRAME (DESCRIBE OR REFER TO SEPARATE ELEVATION) : ____________________

AT THIS FLOOR AND FRAME, DAMAGE SHOWN IS ______ TYPICAL, ______ WORST CASE

MOST SIMILAR JOINTS ON THIS FLOOR HAD ______ NO DAMAGE, ______ LESS DAMAGE, ______ SIMILAR DAMAGE

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Building Name/ID: ____________________

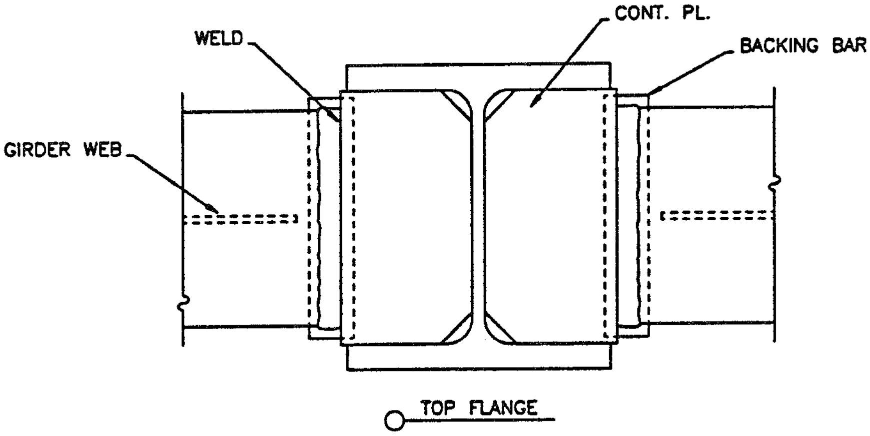
Survey Engr: __________ Firm: ____________

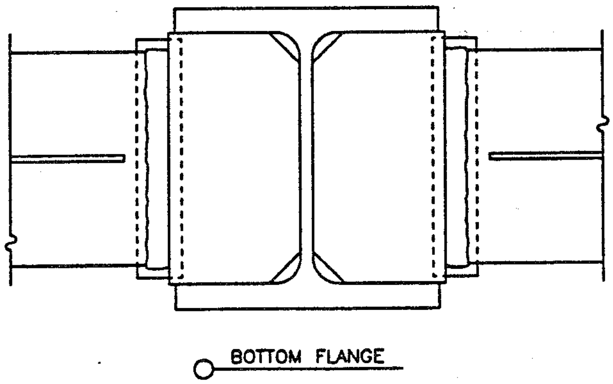
Orig Date: ____________

Revn Date: ____________ Page: ________

SECTION VI: SPECIFIC DAMAGE DETAILS

Instructions to Survey Engineer: Complete details shown for **one or two specific conditions** per building. Show damage and identify by type according to Reference Schedule above.





JOINT DAMAGE TEMPLATE DETAIL – WEAK AXIS PLAN

NOTES:

1. SEE COLUMN ELEVATION FOR MEMBER SIZES, DIMENSIONS, AND ADDITIONAL INFORMATION.
2. REFER TO DAMAGE TYPE DETAIL/SCHEDULE FOR EXPLANATION OF DAMAGE FLAGS.

FLOOR: ________ FRAME DESIGNATION (PER SEPARATE PLAN SKETCH) : ____________________

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Building Name/ID: ______________________

Survey Engr: __________ Firm: ______________

Orig Date: ____________

Revn Date: ____________ Page: __________

SECTION VII: PLAN SKETCH

Instructions to Survey Engineer: Provide a plan sketch of the building showing compass direction, Principal Directions, basic floor plate dimensions, relative locations of frames, and frame names/designations as tabulated above in Section V.

SURVEY OF
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Building Name/ID: ____________________

Survey Engr: __________ Firm: __________

Orig Date: __________

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SECTION VIII: FRAME ELEVATIONS (Optional)

Instructions to Survey Engineer: Provide frame elevations showing frame name/designation, Principal Direction, basic bay and story dimensions, and indications of inspected and damaged connections.

SURVEY OF STEEL MRF BUILDINGS DAMAGED BY THE NORTHRIDGE EARTHQUAKE, JANUARY, 1994

Building: ____________________

Engineer: ____________________

Firm: ____________________

Date: __________ Page: __________

Building ID #: [| | |] 001 (for internal use only)

GLOSSARY OF TERMS

Building Use

A	-	Apartment House
C	-	Condominiums
E	-	Emergency (police, fire ambulance, etc.)
H	-	Hospital/Clinic
HO	-	Hospital w/OSHPD compliance
HL	-	Hotel
M	-	Manufacturing/Industry
OF	-	Office
P	-	Parking
R	-	Retail
S	-	School
SD	-	School w/DSA compliance
T	-	Theater/Church/Public Assembly
U	-	Utility
W	-	Warehouse
O	-	Other

Plan Shapes

R	-	Rectangular Shaped
S	-	Square Shaped
L	-	L-Shaped
U	-	U-or W-Shaped
D	-	Doughnut (center courtyard)
O	-	Other

Lateral Load Resisting Systems

EBF	-	Eccentrically Braced Frame
CBF	-	Concentrically Braced Frame
SMRF	-	Special MRF
OMRF	-	Ordinary MRF
DSW	-	Dual System SMRF with shear walls
DEBF	-	Dual System SMRF with EBF
DCBF	-	Dual System SMRF with CBF

Column Fixity

P	-	Pinned base
F	-	Fixed base or continuous into stiff wall element
C	-	Continuous into basement frame columns

Foundation Types

SF	-	Individual spread footings
CF	-	Continuous or combined footings
M	-	Mat
P	-	Piles or caissons with individual pile caps
PC	-	Piles or caissons with combined or continuous pile cap

Floor Construction Types

W	-	Wood diaphragm with wood or metal floor joists
M	-	Bare metal deck with steel beams or floor joists
MC	-	Metal deck with normal weight concrete fill
MCL	-	Metal deck with lightweight concrete fill
P	-	Precast concrete planks with topping slab
Other	-	Describe

Weld Process Used

FCAW	-	Flux-Cored Arc Weld
SMAW	-	Shielded Metal-Arc Weld
SAW	-	Submerged-Arc Weld
GMAW	-	Gas metal-Arc Weld
O	-	Other

SURVEY OF STEEL MRF BUILDINGS DAMAGED BY THE NORTHRIDGE EARTHQUAKE, JANUARY, 1994

Building: ______________________

Engineer: ______________________

Firm: ______________________

Date: __________ Page: __________

Building ID #: [| | |] 001 (for internal use only)

INSTRUCTIONS:

1) Complete entire survey form for original building.
2) For major renovations or additions, complete the applicable portions of a separate survey form.
3) Please respond to all items. Where necessary, use "U" (for unknown) or dashes "---" to show that information is not available. Do not leave blanks without explanation.
4) Where not specified, the following abbreviated responses may be used: Y = yes, N = no, U = Unknown, or N/A = not applicable.

SECTION I: Procedural

1) Date of original survey: [|] / [|] / [|] 101
2) Date of this revision to survey: [|] / [|] / [|] 102
3) Person Completing Survey [ ] 103
4) Agency/Firm [ ] 104
5) Phone Number [| |] - [| |] - [| | |] 105

6) Building Location
   Number [ ] 106
   Street [ ] 107
   City [ ] 108
   Zip Code [ ] 109
   Cross Street [ ] 110
   Vicinity/Neighborhood [ ] 111

7) Is this survey for the original building (O), for a pre-Northridge renovation (R), or an addition (A)? Enter O, R, or A. [ ] 112
   (Note: For each major renovation/addition, complete the applicable portions of a separate survey form)

8) Basis of survey responses (enter Y, N or N/A to each):
   Structural Drawings [ ] 113
   Fabrication/Erection Drawings [ ] 114
   Firsthand post-Northrige visual inspection [ ] 115
   Post-Northridge visual inspection report by other engineer [ ] 116
   Post-Northridge test report [ ] 117

SURVEY OF STEEL MRF BUILDINGS DAMAGED BY THE NORTHRIDGE EARTHQUAKE, JANUARY, 1994

Building: ____________________

Engineer: ____________________

Firm: ____________________

Date: __________ Page: __________

Building ID #: [| | |] 001 (for internal use only)

ECTION II: Building History

1) Year Designed: [| | |] 201 2) Year Constructed: [| | |] 202

3) Years of Major Renovations/Additions: [| | |] 203a [| | |] 203b [| | |] 203c
(Note: For each major renovation/addition, complete the applicable portions of a separate survey form)

4) Building Use: (Enter the appropriate choice for each from the glossary of terms, building use section)

Principal Use	[|]	204	If other, please describe ____________
Secondary Use	[|]	205	If other, please describe ____________
Tertiary Use	[|]	206	If other, please describe ____________

5) Is this primarily a government building? (Enter Y or N) [ ] 207

6) Pre-Northridge Team:

Engineer of Record:		208
Architect:		209
Source of Steel (i.e. US, Japan, etc.)		
Steel Fabricator:		210
Steel Erector:		211
Permit Granting Authority:		212

7) Post-Northridge Team:

Inspecting Engineer:		213
Inspection/Testing Lab:		214
Repair/Retrofit Engineer:		215
Repair/Retrofit General Contractor:		216
Permit Granting Authority:		217

8) Building status before Northridge earthquake: [|] 218
OC = occupied, LM = limited occupancy, V = vacated, UC = under construction, O = other ____________

9) Current Building Status:

Enter OC for occupied, LM for limited occupancy, or V for vacated:		219
Is an investigation or testing in progress (IP), completed (C), or not yet started (NS)?		220
Is the repair or rehabilitation design in progress (IP), completed (C), or not yet started (NS)?		221
Is the repair or rehabilitation construction in progress (IP), completed (C), or not yet started (NS)?		222

Additional description of building status: ________________________________ 223

____

____

____

0) Date of above status report: [|] / [|] / [|] 224

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SURVEY OF STEEL MRF BUILDINGS DAMAGED BY THE NORTHRIDGE EARTHQUAKE, JANUARY, 1994

Building: ____________________

Engineer: ____________________

Firm: ____________________

Date: __________ Page: __________

Building ID #: [| | |] *001* (for internal use only)

SECTION III: Earthquake Performance

1) Did the building sustain *non-structural* damage in previous earthquakes? (Y or N)
   - 1971 San Fernando Earthquake [ ] *301*
   - 1987 Whittier Narrows Earthquake [ ] *302*
   - 1992 Big Bear Earthquake [ ] *303*

2) Did the building sustain structural damage in previous earthquakes? (Y or N)
   - 1971 San Fernando Earthquake [ ] *304*
   - 1987 Whittier Narrows Earthquake [ ] *305*
   - 1992 Big Bear Earthquake [ ] *306*

3) Was any previous damage repaired prior to the Northrigde Earthquake? (Y, N, or N/A) [ ] *307*

4) Was the building tagged after the Northridge Earthquake? (R=red, Y=yellow, G=green, N=none) [ ] *308*

5) Was the building voluntarily evacuated? (Y or N) [ ] *309*

6) Describe any Northridge structural damage observed (other than steel MRF joints discussed below). Consider base plates, anchor bolts, diagonal braces, non-MRF members, shear walls, disphragms, etc. ____________________ *310*

7) Classify structural damage (including MRF joints) in terms of its distribution as None (N), Isolated (I) or Widespread (W). [ ] *311*

8) Classify structural damage (including MRF joints) in terms of its impact on the building's overall life-safety as None (N), Minimal (M), or Substantial (S). [ ] *312*

9) Classify overall damage (including MRF joints) in terms of repairability as None (N), Cosmetic (non-structural only) (C), Moderate (repairable without substantial demolition) (M), or Heavy (H). [ ] *313*

10) Was ther permanent lateral deflection? (Y or N) [ ] *314*
    If Yes, please describe: ____________________

11) Was there apparent pounding? (Y or N) [ ] *315*

12) Was there apparent foundation failure? (Y or N) [ ] *316*
    Was there apparent liquefaction? (Y or N) [ ] *317*
    Was there apparent differential ground movement? (Y or N) [ ] *318*
    Was there apparent settlement? (Y or N) [ ] *319*

13) List/describe any Northridge life-safety related *non-structural* damage. Consider blocked exits (including stairs and elevators), falling hazards over exits and sidewalks, hazardous material spils, loss of fire protection systems, etc.: ____________________ *320*

14) List/describe any other Northridge non-structural damage. Consider exterior cladding, parapets, glazing, partitions, ceilings, lights, equipment failures (including HVAC/Electrical/Plumbing), overturned shelving, etc.: ____________________ *321*

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SURVEY OF STEEL MRF BUILDINGS DAMAGED BY THE NORTHRIDGE EARTHQUAKE, JANUARY, 1994

Building: ______________________

Engineer: ______________________

Firm: ______________________

Date: __________ Page: __________

Building ID #: [| | |] 001 (for internal use only)

ECTION IV: Building Description and Design

1) Total # of stories above ground: [|] 4101
   Total # of stories below ground: [|] 4102

2) # of Steel MRF stories above ground: [|] 4103
   # of Steel MRF stories below ground: [|] 4104

3) Maximum roof height above ground: [| | |] feet 4105

Approximate Ground Floor Dimensions:

4) Total Length: [| | |] feet 4106
5) Total Width: [| | |] feet 4107
6) Total ground floor enclosed area: [| | | | |] sq. ft. 4108
7) Total building floor area (not including roof area): [| | | | |] sq. ft. 4109
8) Plan shape of building at ground floor: (See glossary of terms, for choices) [ ] 4110 If other, describe: __________
9) Plan shape of building at typical MRF floor: (See glossary of terms, for choices) [ ] 4111 If other, describe: __________

0) Design Code Used: (U = UBC, T = Title 24, O = Other ______________________) [ ] 4201

1) Year of Design Code: [| | |] 4203

2) UBC Construction Type (I, II, III, IV, or V): [|] 4204

3) ASD or LRFD for steel MRF? [| | |] 4205

4) Was a dynamic analysis used for the design of the building? (Y or N) [ ] 4206

5) Describe additional design criteria (MPE, drift limits, etc.), if any. ______________________ 4301

____

____

____

____

____

6) Code Static Design
   Importance Factor, I, used: [| |] 4302
   Soil Factor, S, used: [| |] 4303

7) Principal Direction 1 (PD1):
   Compass direction for Principal Direction 1 (N-S, NE-SW, etc.): [| | | |] 4304
   Steel Lateral Load Resisting System (See glossary of terms for choices): [| |] 4305
   Coefficient K (pre-1988): [| |] 4305
   Coefficient Rw: [| |] 4307
   Fundamental Period T used for design, in seconds: [| |] 4308
   Base Shear Coefficient V/W (if available): [| |] 4309

8) Principal Direction 2 (PD2):
   Compass direction for Principal Direction 2 (N-S, NE-SW, etc.): [| | | |] 4310
   Steel Lateral Load Resisting System (See glossary of terms for choices): [| |] 4311
   Coefficient K (pre-1988): [| |] 4312
   Coefficient Rw: [| |] 4313
   Fundamental Period T used for design, in seconds: [| |] 4314
   Base Shear Coefficient V/W (if available): [| |] 4315

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SURVEY OF STEEL MRF BUILDINGS DAMAGED BY THE NORTHRIDGE EARTHQUAKE, JANUARY, 1994

Building: ______________________

Engineer: ______________________

Firm: ______________________

Date: __________ Page: __________

Building ID #: [| | |] 001 (for internal use only)

(Section IV Continued)

19) Potential Structural Irregularities (indicate Y, N, or N/A):

	PD1		PD2	
Discontinuous Columns/Weak Story		4401		4407
Soft Story		4402		4408
Plan setbacks/out-of-plane offsets		4403		4409
Diaphragm Discontinuity		4404		4410
Torsional Irregularity		4405		4411
Reentrant Corners		4406		4412

20) Grade of Steel Specified: (36, 50, or sim)

Frame Columns		4501
Frame Girders		4502
Diagonal Braces		4503

21) Ground level column fixity, P, F or C (See glossary of terms for description): [ ] 4504

22) Foundation Types (See glossary of terms for choices): [ ] 4505

Describe the following non-structural components.
Consider materials, vertical support, lateral support, ability to accommodate interstory drifts, etc.

23) Exterior Cladding/Glazing/Curtain Walls/Parapets: ______________________ 4506

____

____

24) Interior Partitions, including stair and shaft enclosures: ______________________ 4507

____

____

25) Ceilings: ______________________ 4508

____

____

SURVEY OF STEEL MRF BUILDINGS DAMAGED BY THE NORTHRIDGE EARTHQUAKE, JANUARY, 1994

Building: ______________________

Engineer: ______________________

Firm: ______________________

Date: __________ Page: __________

Building ID #: | | | | | 001 (for internal use only)

ECTION V: Detailed MRF Data

;omplete 1 set of Section V data for each floor with inspected connections, i.e. provide sets 1, 2, 3, etc., where the floor number becomes the last digit of the database entry number below)

~~Floor Number, X (i.e. 1, 2, 3, etc.) =~~ | |

1) Floor Number: | | | 5101X

2) Story height above: | | | feet 5102X

3) Story height below: | | | feet 5103X

4) Floor Area: | | | | | | sq. feet 5104X

5) Approximate Floor Dimensions: Length | | | | feet 5105X
Width | | | | feet 5106X

6) Does floor have discontinuities or reentrant corners as noted above? (Y or N) | | | 5107X

7) Floor Construction (See glossary of terms for choices): | | | 5108X If other, describe: ______________________

8) Total number of MRF's intersecting this floor in Principal Direction 1: | | | 5109X

9) Total number of MRF's intersecting this floor in Principal Direction 2: | | | 5110X

SURVEY OF STEEL MRF BUILDINGS DAMAGED BY THE NORTHRIDGE EARTHQUAKE, JANUARY, 1994

Building: ______

Engineer: ______

Firm: ______

Date: ______ Page: ______

Building ID #: ☐☐☐☐ 001 (for internal use only)

SECTION V: Continued

Complete the following information for each inspected frame at this floor, i.e. provide data sets a, b, etc. for floors 1, 2, etc.

Floor Number, X (i.e. 1, 2, 3, etc.) = ☐ Frame Number, x (i.e. A, B, C, etc.) = ☐

10) Principal Direction: ☐☐ 5201Xx
11) Total Frame Length ☐☐☐☐ feet 5202Xx
12) Length of diaphragm openings adjacent to frame: ☐☐☐☐ feet 5203Xx
13) Column Strong or Weak Axis (S or W): ☐ 5204Xx
14) Box Columns (Y or N): ☐ 5205Xx
15) Number of Bays: ☐☐ 5206Xx
16) Total number of beam-column connections: ☐☐ 5207Xx
17) Total number of connections visually inspected: ☐☐ 5301Xx
18) Total number of connections tested: ☐☐ 5302Xx
19) Minimum bay width: ☐☐☐ feet 5303Xx
20) Typical bay width: ☐☐☐ feet 5304Xx
21) Maximum bay width: ☐☐☐ feet 5305Xx
22) Typical end column section: ☐☐☐☐☐☐☐ 5306Xx
23) Typical interior column section: ☐☐☐☐☐☐☐ 5307Xx
24) Typical girder section: ☐☐☐☐☐☐☐ 5308Xx
25) Is the girder expected to act composite with the deck? (Y or N) ☐ 5309Xx

Complete the following for a typical inspected connection at this frame and floor:

26) Top flange Complete (C) or Partial (P) penetration weld? ☐ 5401Xx
27) Was the top flange backing bar left in place? (Y or N) ☐ 5402Xx
28) Bottom flange Complete (C) or Partial (P) penetration weld? ☐ 5403Xx
29) Was the bottom flange backing bar left in place? (Y or N) ☐ 5404Xx
30) Were run-off dams used? (Y or N) ☐ 5405Xx
31) What weld process was used? (See glossary of terms for choices) ☐ 5406Xx If other, describe: ______
32) Was the connection of the girder web to the shear tab welded only (W), bolted only (B), or welded & bolted (WB)? ☐☐ 5407Xx

~~33) What type of damage do the MRF connections at one or both end columns have?~~ ☐☐ ~~5501XX~~
~~See attached sheet and enter Type 1, 2, etc. or enter GW if girder web was welded directly to the column.~~

SURVEY OF STEEL MRF BUILDINGS DAMAGED BY THE NORTHRIDGE EARTHQUAKE, JANUARY, 1994

Building: ______________________

Engineer: ______________________

Firm: ______________________

Date: __________ Page: ______

FLOOR ______ FRAME ______

TOTAL # of CONNECTIONS ______

Building ID #: [| | |] 001 (for internal use only)

SECTION V: Continued

# of CONNECTIONS INSPECTED ______

Damage Description: For this floor and frame, indicate the total # of connections showing each damage type. Indicate ll for conditions not inspected. Indicate NA where appropriate.

34)

Damage Type (see detail)		Description	# of Inspected Top Connections Damaged	# of Inspected Bottom Connections Damaged
Girder Damage	G1	Buckled flange	5502Xx	5503Xx
	G2	Yielded flange	5504Xx	5505Xx
	G3	Flange tear-out	5506Xx	5507Xx
	G4	Flange crack outside heat-affected zone (HAZ)	5508Xx	5509Xx
Column Flange Damage	C1	Incipient flange crack	5510Xx	5511Xx
	C2	Flange tear-out	5512Xx	5513Xx
	C3	Full or partial cross-flange crack in HAZ	5514Xx	5515Xx
	C4	Full or partial cross flange crack outside HAZ	5516Xx	5517Xx
	C5	Lamellar flange crack	5518Xx	5519Xx
Flange Weld Damage	W1	Incipient weld crack	5520Xx	5521Xx
	W2	Full or partial crack through weld metal	5522Xx	5523Xx
	W3	Fracture at girder interface	5524Xx	5525Xx
	W4	Fracture at column interface	5526Xx	5527Xx
Shear Connection Damage	S1	Weld crack at column (welded web only)	5528Xx	5529Xx
	S2	Weld crack at shear tab	5530Xx	5531Xx
	S3	Crack in girder web or shear plate through bolt holes	5532Xx	
	S4	Plastic deformation of web or plate at bolt holes	5533Xx	
	S5	Loose, damaged, or missing bolts	5534Xx	
Panel Zone Damage	P1	Damage to continuity plate	5535Xx	5536Xx
	P2	Crack in continuity plate weld	5537Xx	5538Xx
	P3	Damage to doubler plate	5539Xx	
	P4	Crack in doubler plate weld	5540Xx	
	P5	Partial depth crack in column web (extension of C3)	5541Xx	5542Xx
	P6	Full (or near full) depth crack in column web	5543Xx	5544Xx

ovide additional descriptions of MRF joint damage as appropriate: ______________________ 5545Xx

____

____

____

Building: ______________________

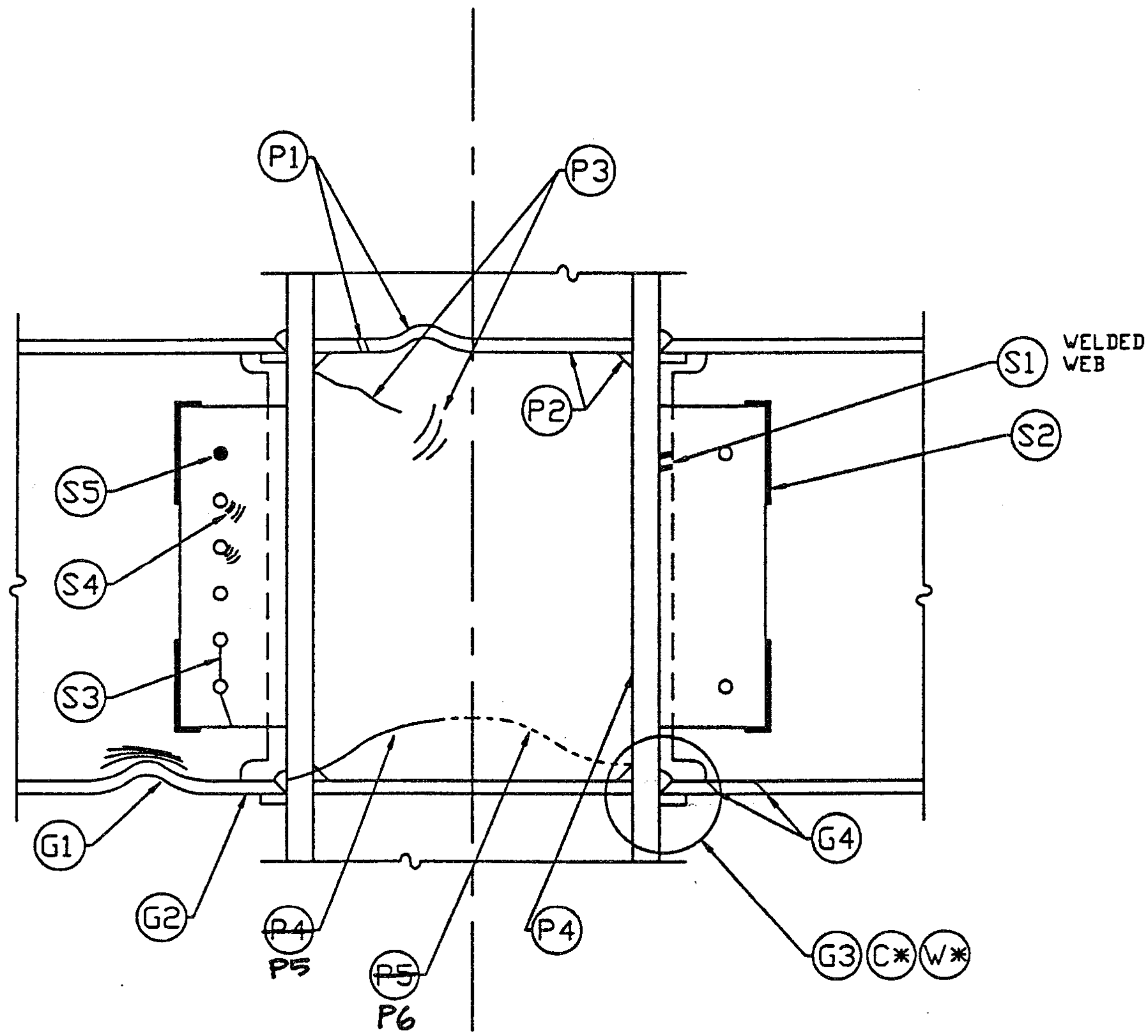
Engineer: ______________________

Firm: ______________________

Date: __________ Page: __________

Building ID #: [| | |] 001 (for internal use only)

SECTION V: Continued



REFERENCE DETAIL: MRF JOINT DAMAGE TYPES

NOTE: SEE SURVEY FORM SECTION V FOR DESCRIPTION

Building: ______

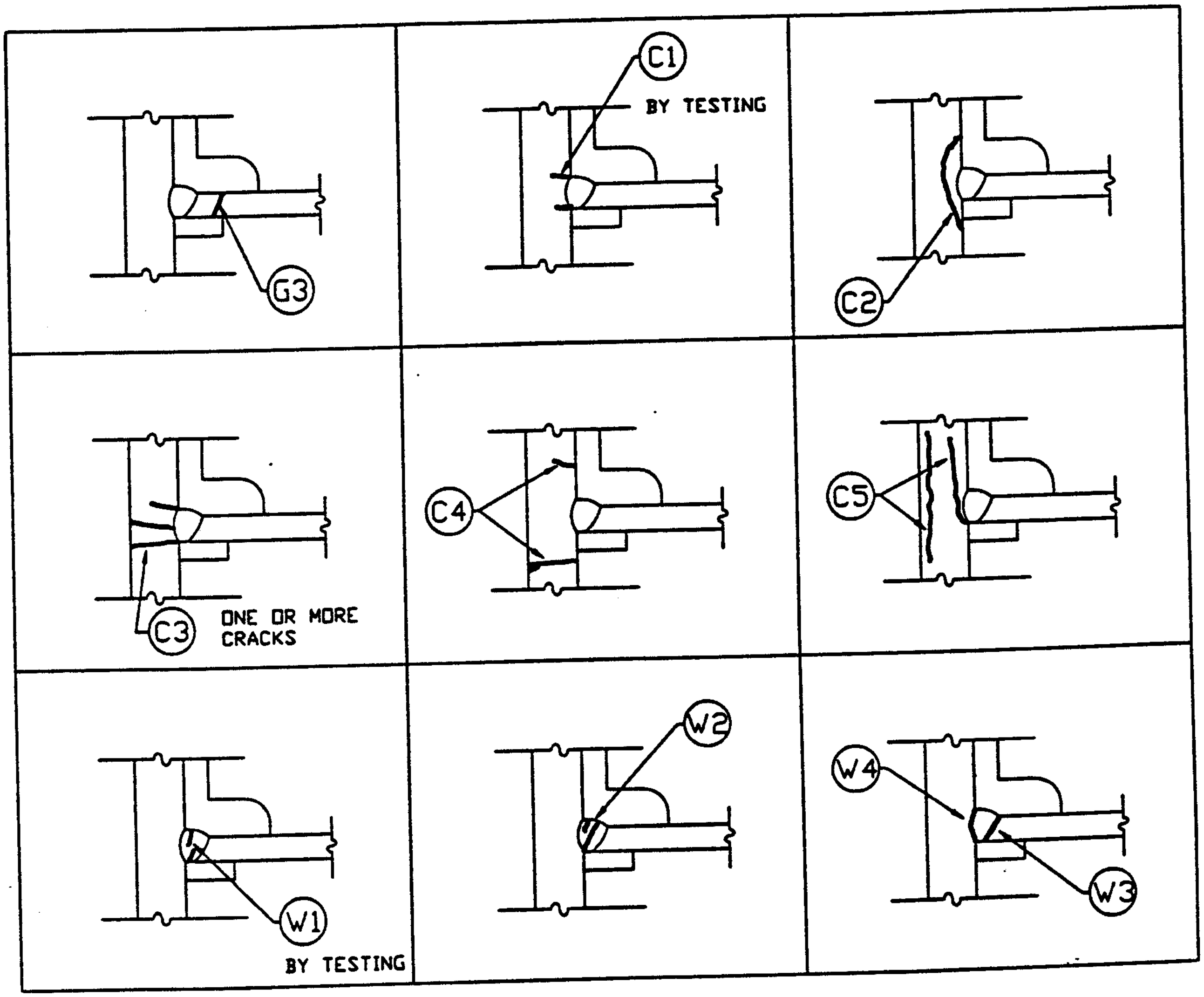
Engineer: ______

Firm: ______

Date: ______ Page: ______

Building ID #: [ ][ ][ ][ ] 001 (for internal use only)

ECTION V: Continued



REFERENCE DETAIL: MRF DAMAGE TYPES

SURVEY OF STEEL MRF BUILDINGS DAMAGED BY THE NORTHRIDGE EARTHQUAKE, JANUARY, 1994

Building: ______

Engineer: ______

Firm: ______

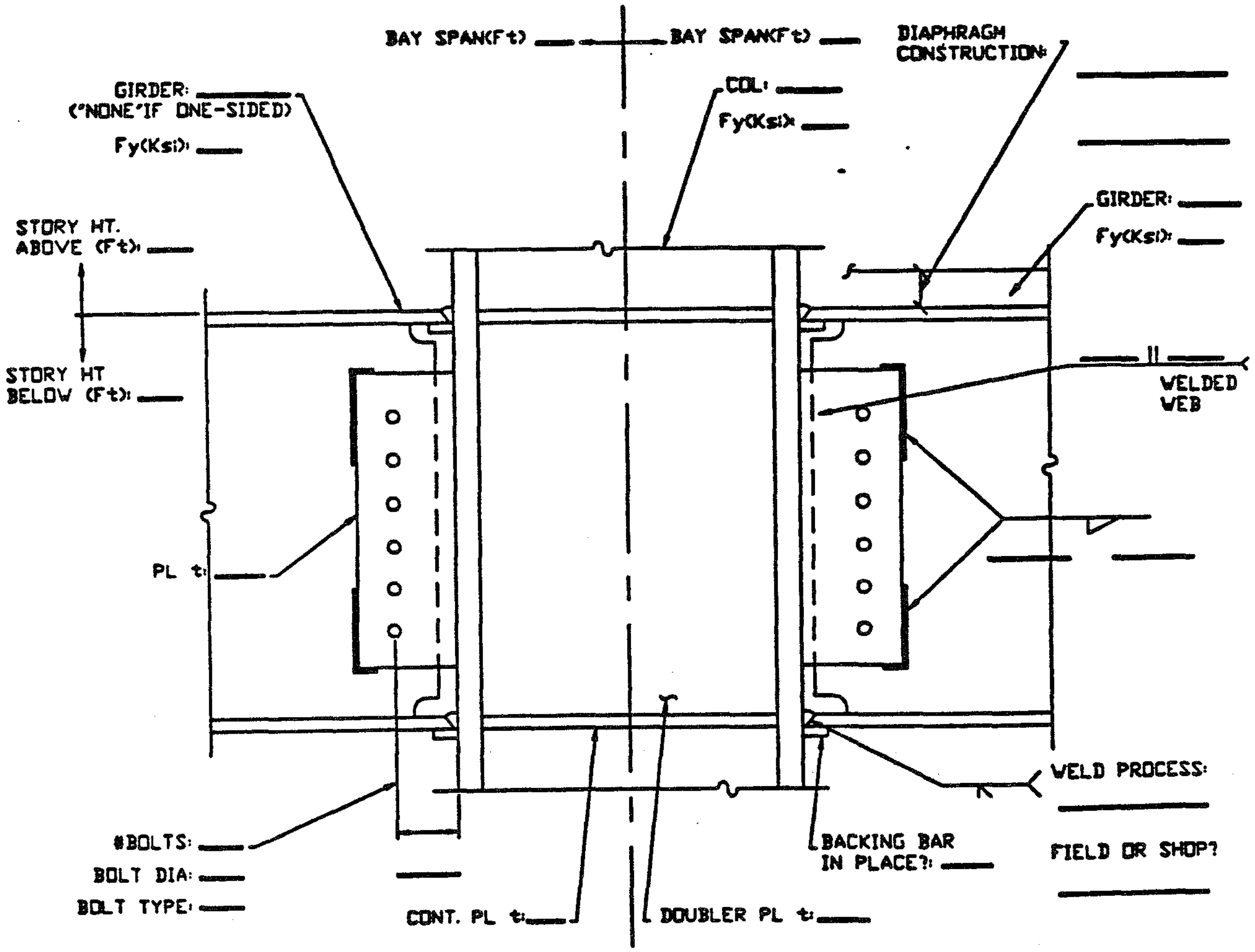
Date: ______ Page: ______

Building ID #: [ ][ ][ ][ ][ ] 001 (for internal use only)

SECTION VI: Details of Specific Damaged Joints (ONE OR TWO DETAILS PER BUILDING ONLY.)

INSTRUCTIONS TO REPORTING ENGINEER :

1. COMPLETE DETAIL FOR SPECIFIC (NOT GENERIC) JOINT BY FILLING IN ALL BLANKS.
2. SKETCH DAMAGE OBSERVED AT SPECIFIC (NOT GENERIC) JOINT ON DETAIL, AND ADD FLAGS. E.G. C1 TO INDICATE DAMAGE TYPE C1, TO REFERENCE SEPARATE DAMAGE TYPE SCHEDULE.
3. COMPLETE INFORMATION BELOW.



JOINT DAMAGE TEMPLATE DETAIL - STRONG AXIS COL. ELEV.

NOTES:

1. U.N.O., AS-BUILT DIMENSIONS AND SIZES SHOWN ON ONE SIDE TOP OR BOTTOM ARE TYP. TO BOTH SIDES, TOP AND BOTTOM.
2. SEE PLAN DETAILS FOR ADDITIONAL INFORMATION.
3. REFER TO DAMAGE TYPE DETAIL/SCHEDULE FOR EXPLANATION OF DAMAGE FLAGS.

DATE VISUALLY INSPECTED: ______ DATE TESTED: ______

FLOOR: ______ FRAME DESIGNATION (PER SEPARATE PLAN SKETCH) : ______

JOINT LOCATION IN FRAME (DESCRIBE OR REFER TO SEPERATE ELEVATION) : ______

AT THIS FLOOR AND FRAME, DAMAGE SHOWN IS ______ TYPICAL, ______ WORST CASE

MOST SIMILAR JOINTS ON THIS FLOOR HAD ______ NO DAMAGE, ______ LESS DAMAGE, ______ SIMILAR DAMAGE

SURVEY OF STEEL MRF BUILDINGS DAMAGED BY THE NORTHRIDGE EARTHQUAKE, JANUARY, 1994

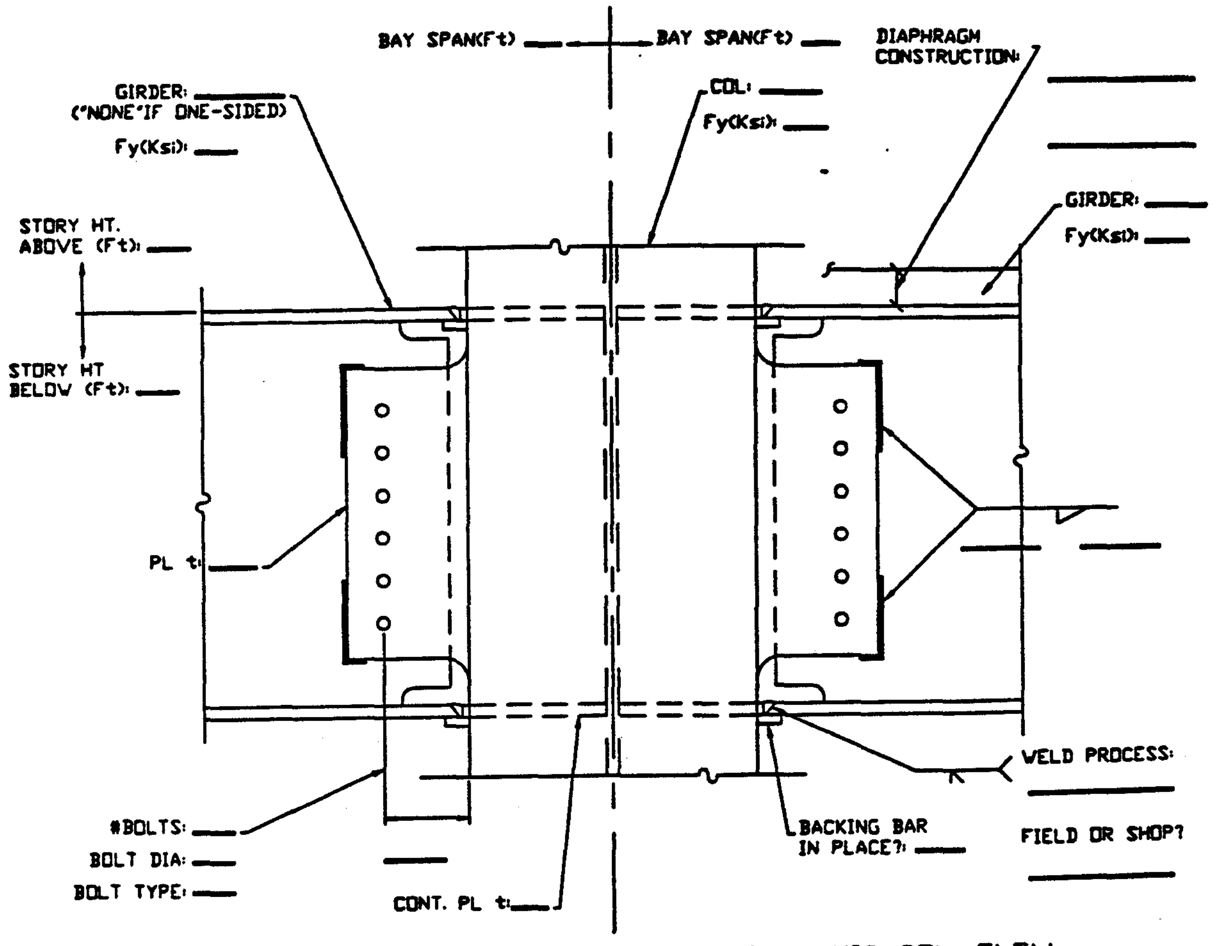
Building: ______
Engineer: ______
Firm: ______
Date: ______ Page: ______

Building ID #: [| | |] 001 (for internal use only)

SECTION VI: Details of Specific Damaged Joints

INSTRUCTIONS TO REPORTING ENGINEER :

1. COMPLETE DETAIL FOR SPECIFIC (NOT GENERIC) JOINT BY FILLING IN ALL BLANKS.
2. SKETCH DAMAGE OBSERVED AT SPECIFIC (NOT GENERIC) JOINT ON DETAIL, AND ADD FLAGS, E.G. C1 TO INDICATE DAMAGE TYPE C1, TO REFERENCE SEPARATE DAMAGE TYPE SCHEDULE.
3. COMPLETE INFORMATION BELOW.



JOINT DAMAGE TEMPLATE DETAIL - WEAK AXIS COL. ELEV.

NOTES:

1. U.N.O., AS-BUILT DIMENSIONS AND SIZES SHOWN ON ONE SIDE TOP OR BOTTOM ARE TYP. TO BOTH SIDES, TOP AND BOTTOM.
2. SEE PLAN DETAIL FOR ADDITIONAL INFORMATION.
3. REFER TO DAMAGE TYPE DETAIL/SCHEDULE FOR EXPLANATION OF DAMAGE FLAGS.

DATE VISUALLY INSPECTED: ______ DATE TESTED: ______

FLOOR: ______ FRAME DESIGNATION (PER SEPARATE PLAN SKETCH) : ______

JOINT LOCATION IN FRAME (DESCRIBE OR REFER TO SEPERATE ELEVATION) : ______

AT THIS FLOOR AND FRAME, DAMAGE SHOWN IS ______ TYPICAL, ______ WORST CASE

MOST SIMILAR JOINTS ON THIS FLOOR HAD ______ NO DAMAGE, ______ LESS DAMAGE, ______ SIMILAR DAMAGE

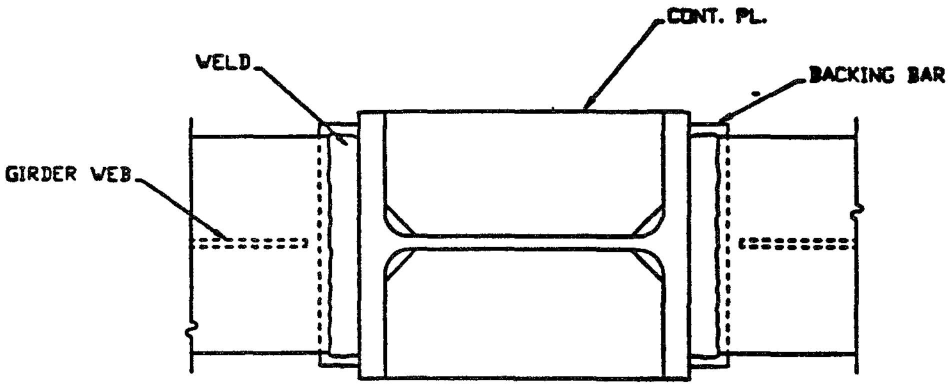
Building: ______________
Engineer: ______________
Firm: ______________
Date: ________ Page: ________

Building ID #: ☐☐☐☐ 001 (for internal use only)

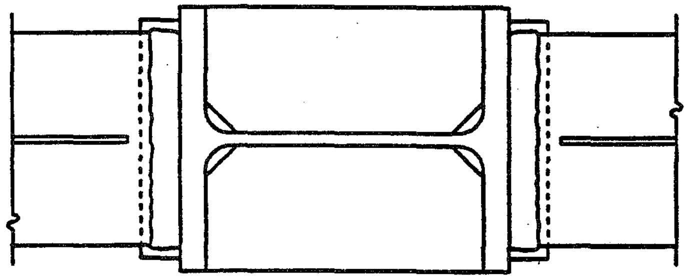
SECTION VI: Details of Specific Damaged Joints

INSTRUCTIONS TO REPORTING ENGINEER :

1. COMPLETE DETAIL FOR SPECIFIC (NOT GENERIC) JOINT BY FILLING IN ALL BLANKS.
2. SKETCH DAMAGE OBSERVED AT SPECIFIC (NOT GENERIC) JOINT ON DETAIL, AND ADD FLAGS, E.G. C1 TO INDICATE DAMAGE TYPE C1, TO REFERENCE SEPARATE DAMAGE TYPE SCHEDULE.
3. COMPLETE INFORMATION BELOW.



TOP FLANGE



BOTTOM FLANGE

JOINT DAMAGE TEMPLATE DETAIL - STRONG AXIS PLAN

NOTES:

1. SEE COLUMN ELEVATION FOR MEMBER SIZES, DIMENSIONS, AND ADDITIONAL INFORMATION.
2. REFER TO DAMAGE TYPE DETAIL/SCHEDULE FOR EXPLANATION OF DAMAGE FLAGS.

FLOOR: ______ FRAME DESIGNATION (PER SEPARATE PLAN SKETCH) : ______________

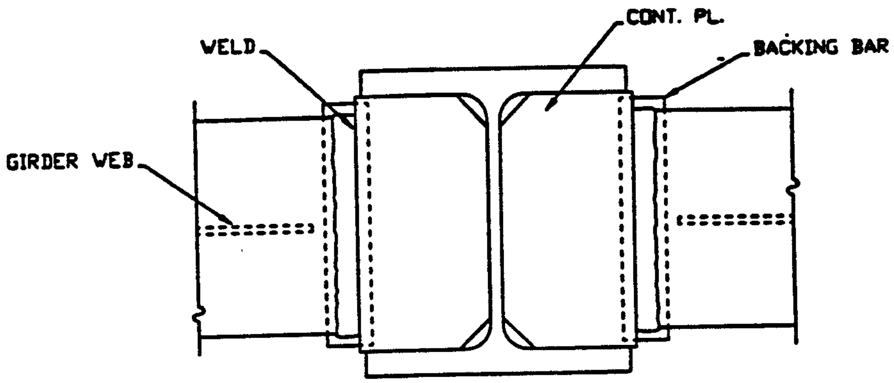
Building: ____________________
Engineer: ____________________
Firm: ____________________
Date: __________ Page: __________

Building ID #: [| | |] 001 (for internal use only)

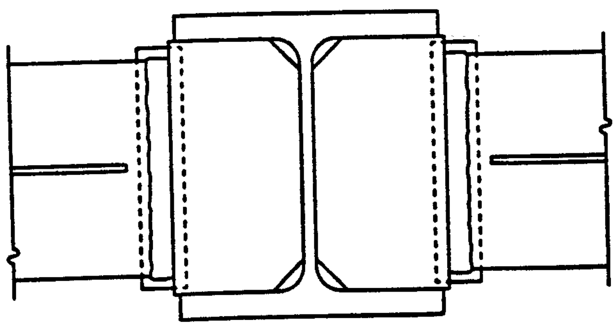
SECTION VI: Details of Specific Damaged Joints

INSTRUCTIONS TO REPORTING ENGINEER :

1. COMPLETE DETAIL FOR SPECIFIC (NOT GENERIC) JOINT BY FILLING IN ALL BLANKS.
2. SKETCH DAMAGE OBSERVED AT SPECIFIC (NOT GENERIC) JOINT ON DETAIL, AND ADD FLAGS, E.G. C1 TO INDICATE DAMAGE TYPE C1, TO REFERENCE SEPARATE DAMAGE TYPE SCHEDULE.
3. COMPLETE INFORMATION BELOW.



TOP FLANGE



BOTTOM FLANGE

JOINT DAMAGE TEMPLATE DETAIL - WEAK AXIS PLAN

NOTES:

1. SEE COLUMN ELEVATION FOR MEMBER SIZES, DIMENSIONS, AND ADDITIONAL INFORMATION.
2. REFER TO DAMAGE TYPE DETAIL/SCHEDULE FOR EXPLANATION OF DAMAGE FLAGS.

FLOOR: ______ FRAME DESIGNATION (PER SEPARATE PLAN SKETCH) : ____________________

SURVEY OF STEEL MRF BUILDINGS DAMAGED BY THE NORTHRIDGE EARTHQUAKE, JANUARY, 1994

Building: ______________________

Engineer: ______________________

Firm: ______________________

Date: __________ Page: __________

Building ID #: [| | |] 001 (for internal use only)

SECTION VII: Plan Sketch of Building

Provide a sketch of the building plan showing the compass orientation, street orientation, overall building dimensions, frame locations and spacings, and frame designations.

SURVEY OF STEEL MRF BUILDINGS DAMAGED BY THE NORTHRIDGE EARTHQUAKE, JANUARY, 1994

Building: ______________________

Engineer: ______________________

Firm: ______________________

Date: __________ Page: __________

Building ID #: [| | |] 001 (for internal use only)

ECTION VIII: Frame Elevations of Building

rovide one sketch per frame of the frame elevation showing the frame designation, floor numbering, approximate story height and bay width dimensions, and damage locations with *reference* to damage type listed on the attached sheet.

Appendix C: Inspection & Testing Criteria and Report Formats

SMITH-EMERY COMPANY
The Full Service Independent Testing Laboratory, Established 1904
781 East Washington Blvd.
Los Angeles, California 90021
(213) 749-3411
Fax (213) 746-7228

Date of Issue: July 11, 19

ULTRASONIC TEST PROCEDURE FOR SEISMIC EVALUATION

1. SCOPE

   A. THIS PROCEDURE COVERS THE METHODS AND ACCEPTANCE AND REJECTION CRITERIA FOR PULSE-REFLECTION ULTRASONIC EXAMINATION OF POSSIBLE CRACKS IN COLUMN FLANGES. WELD METAL OR BASE METAL OF WIDE FLANGE BEAM MOMENT CONNECTIONS.

   B. THIS PROCEDURE COVERS SHEAR WAVE (ANGLE BEAM) TESTING METHODS AND LONGITUDINAL (STRAIGHT-BEAM) TESTING METHODS USING CONTACT TECHNIQUES WITH HAND OPERATED PROBES.

   C. PROCEDURE REQUIREMENTS TO THIS EXAMINATION SHALL CONFORM TO THE FOLLOWING SPECIFICATIONS.

      C.1 ASTM E-114-90 PRACTICE FOR ULTRASONIC PULSE-ECHO STRAIGHT-BEAM TESTING BY THE CONTACT METHOD.

      C.2 ASTM E-164-88 STANDARD PRACTICE FOR ULTRASONIC CONTACT EXAMINATION OF WELDMENTS.

      C.3 AWS D1.1-94 STRUCTURAL WELDING CODE SECTION #6 AND #8.

      C.4 ASNT RECOMMENDED PRACTICE SNT-TC-1A.

2. EQUIPMENT

   A. INSTRUMENTS

      A.1 KRAUTKRAMER ULTRASONIC DETECTOR (TYPE USK-6 AND USK-7)

   B. TRANSDUCERS

      B.1 TRANSDUCERS FOR STRAIGHT BEAM EXAMINATION SHALL HAVE AN ACTIVE AREA OF NOT LESS THAN 1/2 INCH NOR MORE THAN 1 INCH. TRANSDUCERS SHALL BE CAPABLE OF RESOLVING THE THREE REFLECTIONS AS DESCRIBED IN AWS D1.1 SECTION #6 PAR: 6.21.1 WITH NOMINAL FREQUENCIES OF 2.25 MHZ.

         B.1.A IN ADDITION A TWIN CRYSTAL 5 MHZ WITH AN OVERALL DIAMETER OF 1/2 INCH (10mm - 12mm) MAY BE UTILIZED AS AN AID FOR DISCONTINUITY SIZING AND RECOGNITION.

      B.2 TRANSDUCER CRYSTALS FOR ANGLE BEAM EXAMINATION SHALL BE SQUARE OR RECTANGULAR IN SHAPE AND MAY VARY FROM 5/8 INCH TO 13/16 INCH IN HEIGHT AND 5/8 INCH TO 1 INCH IN WIDTH. THE MAXIMUM RATIO OF WIDTH TO HEIGHT SHALL BE 1.2 TO 1.0 AND THE MINIMUM 1.0 TO 1.0 WITH NOMINAL FREQUENCIES OF 2.25 MHZ. A 45°, 60° AND 70° WEDGE SHALL BE USED FOR ALL WELD EXAMINATION.

         B.2.A WHERE ACCESSIBILITY IS LIMITED A 1/2" DIAMETER, 2.25 MHZ TRANSDUCERS MAY BE EMPLOYED UTILIZING ANGLES OF 45° 60° AND 70°.

Anaheim
5427 East La Palma Ave.
Anaheim, California 92807
(714) 693-1026
Fax (714) 693-1034

San Francisco
Hunters Point Shipyard, Bldg. 114
P.O. Box 880550
San Francisco, California 94188
(415) 822-8880
Fax (415) 822-5864

B.3 BOTH TYPES OF TRANSDUCERS SHALL MEET THE MINIMUM REQUIREMENTS AS SPECIFIED IN AWS D1.1.

C. BASIC CALIBRATION REFLECTORS (BLOCK).

C.1 IIW-BLOCK

C.2 BASIC CALIBRATION BLOCKS AS SPECIFIED IN AWS D1.1

D. COUPLANT

D.1 COUPLANTS USED TO ASSURE TRANSMISSION OF SIGNAL BETWEEN TRANSDUCERS AND THE TEST SURFACE WILL BE CELLULOSE GUM, GLYCERINE OR OTHER APPROVED MATERIALS.

3. PERSONNEL

A. SHALL BE THOSE QUALIFIED TO THE REQUIREMENTS OF ASNT SNT-TC-1A, AS REQUIRED BY THE QUALITY CONTROL SECTION OF THE SMITH-EMERY COMPANY QUALITY ASSURANCE PROGRAM AND THE REFERENCING SECTION OF THE AWS CODE. PERSONNEL WHO CONFORM ARE PERMITTED TO PERFORM THIS EXAMINATION AND INTERPRET THE RESULTS.

4. JOINT CONFIGURATION

A. THE WELD JOINT ASSEMBLAGE WILL CONFORM TO SKETCH NO. 1.

5. SURFACE

A. ALL SURFACES MUST BE THOROUGHLY CLEANED OF FIREPROOFING, RUST, HEAVY MILL SCALE AND OTHER FOREIGN MATTER THAT WOULD PREVENT POSITIVE COUPLING OF THE TRANSDUCER TO THE SCANNING SURFACE. SEE EXHIBIT #4

6. PRETEST VISUAL INSPECTION

A. A DETAILED INSPECTION SHALL BE MADE PRIOR TO ANY COUPLING MEDIUM BEING APPLIED. OBSERVATIONS WHICH MAY BE INDICATIVE AS INTERNAL FAILURE SUCH AS BACKING DISTORTION, CRACKED TACK WELDS, BACKING BAR SEPARATION, OR MILL SCALE DETACHMENT AND COLUMN BLISTERING WILL BE NOTED ON THE REPORT.

7. CALIBRATION

A. CALIBRATION

A.1 CALIBRATION FOR SHEAR WAVE (TRANSVERSE) SHALL BE DONE IN ACCORDANCE WITH AWS D1.1 SECTION NO. 6 PAR: 6.21.2.

B. STRAIGHT BEAM

B.1 CALIBRATION FOR LONGITUDINAL MODE SHALL BE DONE IN ACCORDANCE WITH AWS D1.1 SECTION NO 6 PAR: 6.21.1.

8. RE-CALIBRATION

A. THE PROPER FUNCTIONING OF THE EXAMINATION EQUIPMENT SHALL BE CHECKED AND THE EQUIPMENT CALIBRATED TO THE REFERENCE BLOCKS AS FOLLOWS:

A.1 WHEN THERE IS A CHANGE OF OPERATORS.

A.2 AT 30 MINUTE MAXIMUM TIME INTERVAL.

A.3 AT ANY TIME THE OPERATOR THINKS THERE MAY BE A MALFUNCTION.

A.4 WHEN THE ELECTRICAL CIRCUITY IS DISTURBED IN ANYWAY, CHANGE OF TRANSDUCER, BATTERIES, COAXIAL CABLES ETC.

A.5 IF DURING A CHECK IT IS DETERMINED THAT THE EQUIPMENT IS NOT FUNCTIONING PROPERLY, ALL WELDS TESTED SINCE THE LAST VALID CALIBRATION CHECKS SHALL BE RE-EXAMINED.

9. EXAMINATION COVERAGE

A. ALL WELDS AND BASE MATERIALS ASSOCIATED WITH THE MOMENT FRAME ASSEMBLAGE AS SHOWN IN SKETCH #1 SHALL HAVE 100% COVERAGE.

10. SCANNING

A. STRAIGHT BEAM

A.1 SCANNING SHALL BE CONDUCTED SO AS TO REVEAL ALL LAMELLAR DEFECTS CONTAINED IN ALL BASE MATERIALS AND ALL INDICATIONS INCLUDED IN THE WELD METAL.

A.2 COLUMN FLANGES WILL BE SCANNED 8 INCHES BELOW TOP BEAM FLANGE AND 8 INCHES ABOVE AND BELOW BOTTOM BEAM FLANGE. COLUMN FLANGES WILL BE SCANNED FROM BOTH SIDES OF COLUMN IF POSSIBLE AS SHOWN IN SKETCH #1 SCAN "D".

A.3 SCANNING db LEVELS SHALL BE AS FOLLOWS:

a. CONDUCT THE EXAMINATION WITH A TEST FREQUENCY AND INSTRUMENT ADJUSTMENT THAT WILL PRODUCE A MINIMUM 50 TO A MAXIMUM 75% OF FULL SCALE REFERENCE BACK REFLECTION FROM THE OPPOSITE SIDE OF A SOUND AREA OF THE COLUMN FLANGE. AN ADDITIONAL 15 dbs WILL BE ADDED TO THIS REFERENCE LEVEL FOR SCANNING PURPOSES. INDICATIONS DETECTED AT THE BEAM FLANGE WELD TO COLUMN FLANGE INTERFACE AND PROPAGATING INTO COLUMN FLANGE WILL BE FURTHER EVALUATED UTILIZING 70°, 45° OR 60° ANGLE BEAM TRANSDUCERS AS SHOWN IN SKETCH #1 SCAN "C".

B. SHEAR WAVE

B.1 THE SCANNING PROCEDURE FOR ANGLE BEAM TESTING OF THE TOP AND BOTTOM BEAM FLANGE WELDS SHALL BE AS FOLLOWS:

a. TOP BEAM FLANGE WELD WILL BE SCANNED FROM FACE "B" AND BOTTOM BEAM FLANGES WILL BE SCANNED FROM BOTH FACE "A" AND "B" UTILIZING A 45°, 70° OR 60° TRANSDUCER DEPENDING ON MATERIAL THICKNESS. SEE SKETCH #1 SCAN "A" AND "B".

b. SCANNING LEVELS FOR SHEAR WAVE WILL BE IN ACCORDANCE WITH AWS SECTION 6 AND 8 EXCEPT AN ADDITIONAL 6 dbs WILL BE ADDED FOR SCANNING PURPOSES. THE INTENT IS TO BE SURE THE DETECTION OF THE BACKSIDE OF THE COLUMN WHILE WATCHING FOR ANY CRACK LIKE SIGNALS IN EITHER THE WELDMENT OR PARENT MATERIAL.

11. ACCEPTANCE AND REJECTION CRITERIA

A. LONGITUDINAL WAVE SCAN

A.1 ANY INDICATIONS DETECTED WITH THE STRAIGHT BEAM PROBE IN THE VICINITY OF BEAM FLANGE WELD COLUMN INTERFACE AND PROPAGATING INTO COLUMN BASE MATERIAL SHOULD BE FURTHER EVALUATED WITH 70°, 45° OR 60° ANGLE BEAM TRANSDUCERS.

B. SHEAR WAVE

B.1 45°, 70° OR 60° ANGLE BEAM TRANSDUCERS WILL BE EMPLOYED TO EVALUATE INDICATIONS AT BEAM FLANGE WELD COLUMN INTERFACE AND INTO COLUMN FLANGE BASE MATERIAL. SEE SKETCH #1 SCAN "A" AND "B". DISCONTINUITIES DETECTED WILL BE CLASSIFIED IN ACCORDANCE WITH ACCEPTANCE/REJECTION CRITERIA. SEE ATTACHED EXHIBIT MARKED 2.

12. REPORTING

A. ALL WELDS SHALL BE REPORTED ON SMITH EMERY COMPANY INSPECTION REPORT FOR SEISMIC EVALUATION AND AS MODIFIED. SEE ATTACHMENT EXHIBIT #3. COPIES ARE TO BE DISTRIBUTED TO THE STRUCTURAL ENGINEER AND OWNER ONLY. NO REPORTS WILL BE DISTRIBUTED TO OTHER INDIVIDUALS OR AGENCIES WITHOUT THE EXPRESSED APPROVAL OF THE OWNER OR HIS AGENT.

13. REPAIR OF WELDS

A. ALL WELDS WILL BE REPAIRED IN ACCORDANCE WITH THE STRUCTURAL ENGINEERS APPROVAL AND AWS D1.1-94.

14. REINSPECTION

A. ANY REINSPECTION OF REPAIRS TO WELDS SHALL BE SUBJECT TO THE SAME REQUIREMENTS OF THIS ULTRASONIC PROCEDURE UNLESS SPECIFICALLY STIPULATED BY THE STRUCTURAL ENGINEER.

15. PREPARED BY:

A. NIGEL FALLS-HAND — SMITH-EMERY COMPANY - ASNT LEVEL II

B. STEVE GROVE - SMITH-EMERY COMPANY - ASNT LEVEL II

16. REVIEWED BY: SMITH-EMERY COMPANY
ROBERT A. [illegible] ASNT LEVEL III/KM-1230

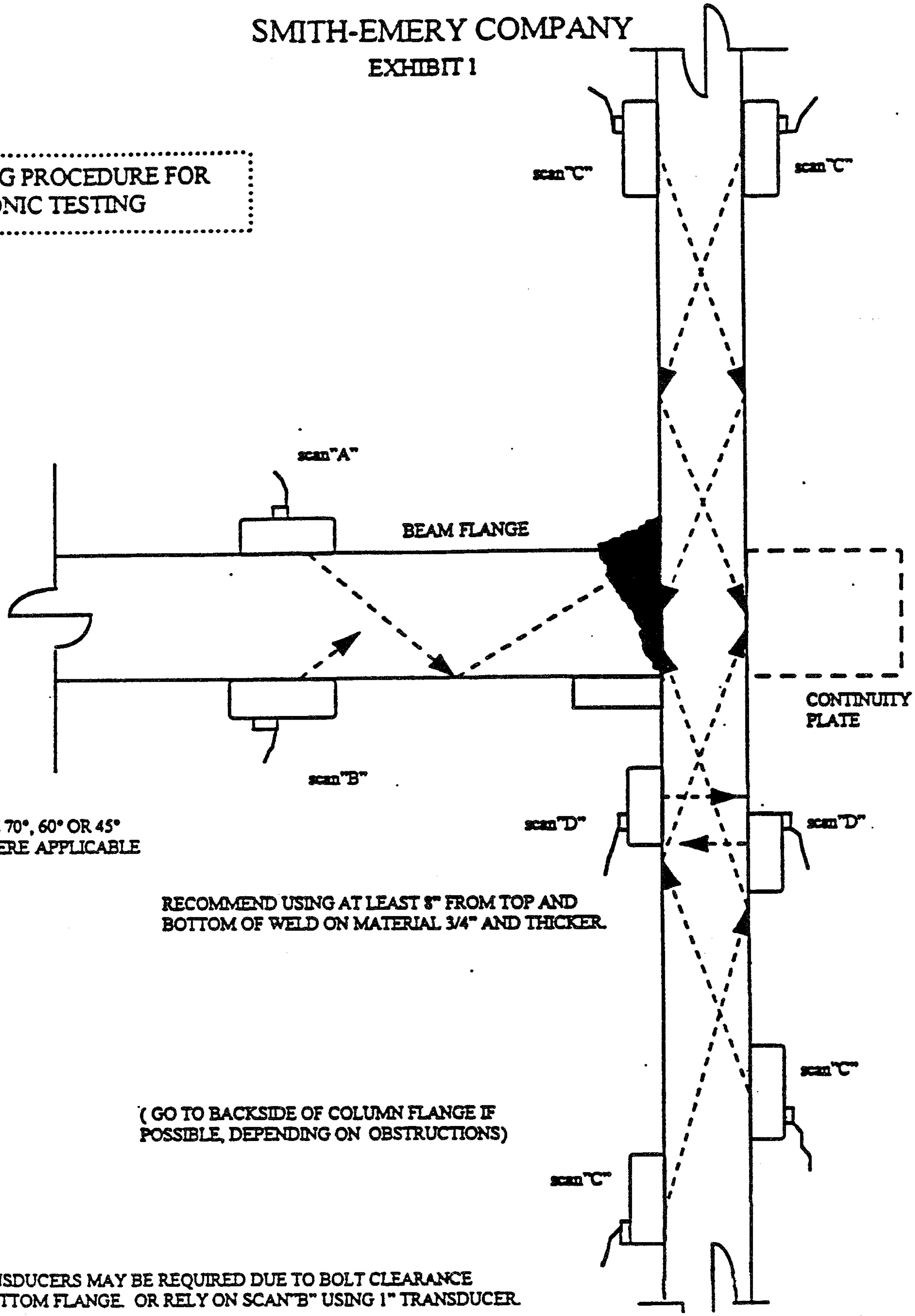
17. APPROVED BY: SMITH-EMERY COMPANY
EDWARD C. TRASORAS
REG. CIVIL ENGINEER #[illegible]

REGISTERED PROFESSIONAL ENGINEER
EDWARD C. TRASORAS
No. 44233
Exp. 6-30-97
CIVIL
STATE OF CALIFORNIA

SMITH-EMERY COMPANY

EXHIBIT 1

SCANNING PROCEDURE FOR ULTRASONIC TESTING



USE 70°, 60° OR 45° WHERE APPLICABLE

RECOMMEND USING AT LEAST 8" FROM TOP AND BOTTOM OF WELD ON MATERIAL 3/4" AND THICKER.

(GO TO BACKSIDE OF COLUMN FLANGE IF POSSIBLE, DEPENDING ON OBSTRUCTIONS)

1/2" TRANSDUCERS MAY BE REQUIRED DUE TO BOLT CLEARANCE FROM BOTTOM FLANGE. OR RELY ON SCAN"B" USING 1" TRANSDUCER.

EXHIBIT 2

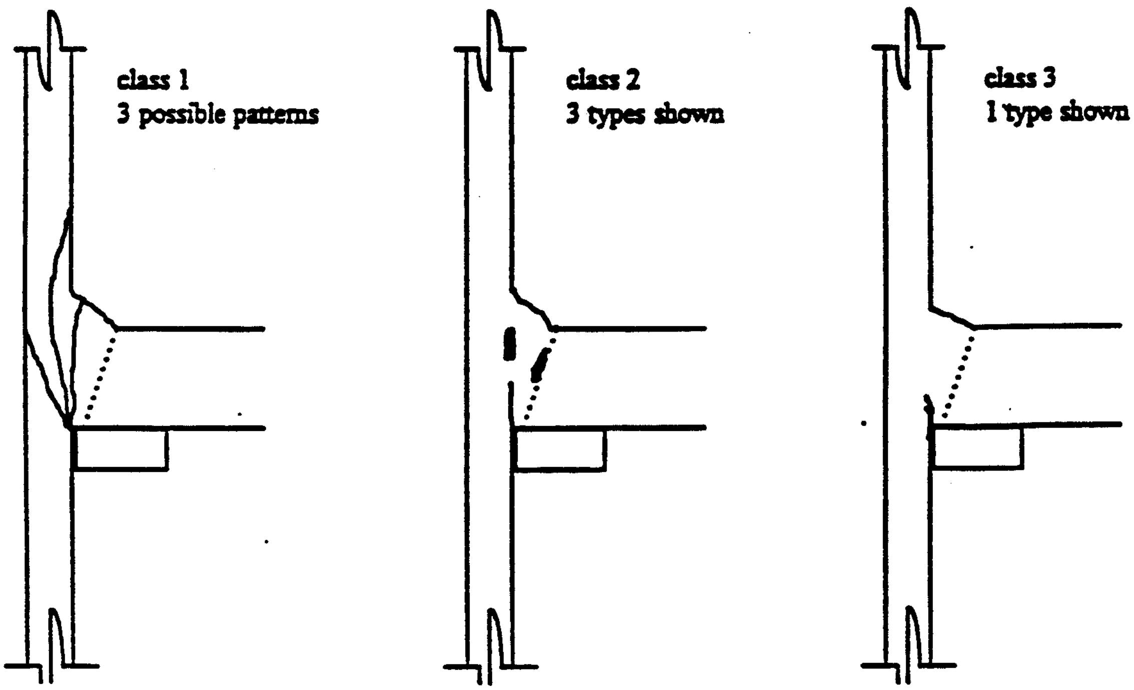
ULTRASONIC CLASSIFICATION
Acceptance-Rejection Criteria

CLASS 1 Severe crack in flange or crack propagating into the column. Exhibiting Planar Flaw Characteristics* or reject levels associated with defects believed to be stress induced.

CLASS 2 Reject level indications possibly from the original construction. May be a prior "Acceptable Level" discontinuity which has been developed by stress. Location is a good indicator, ie. bevel or mid-weld discontinuity is probably original. Root or cap area discontinuities may be opened up to a reject level by building motion.

CLASS 3 Welds containing discontinuity signals at an acceptable level. Normally disregarded. But due to signal type pattern may be small root tears which would be beneficial to investigate and remove.

*CAUTION: FLAW CHARACTERISTICS ARE SUCH THAT AN AWS TABLE 8.3 REJECT CLASSIFICATIONS AMPLITUDE MAY NOT BE ACHIEVED. EVALUATION OF SIGNAL TYPE IS OF UTMOST IMPORTANCE. See Notes 5 on Table 8.2.



Revised 7-19-94

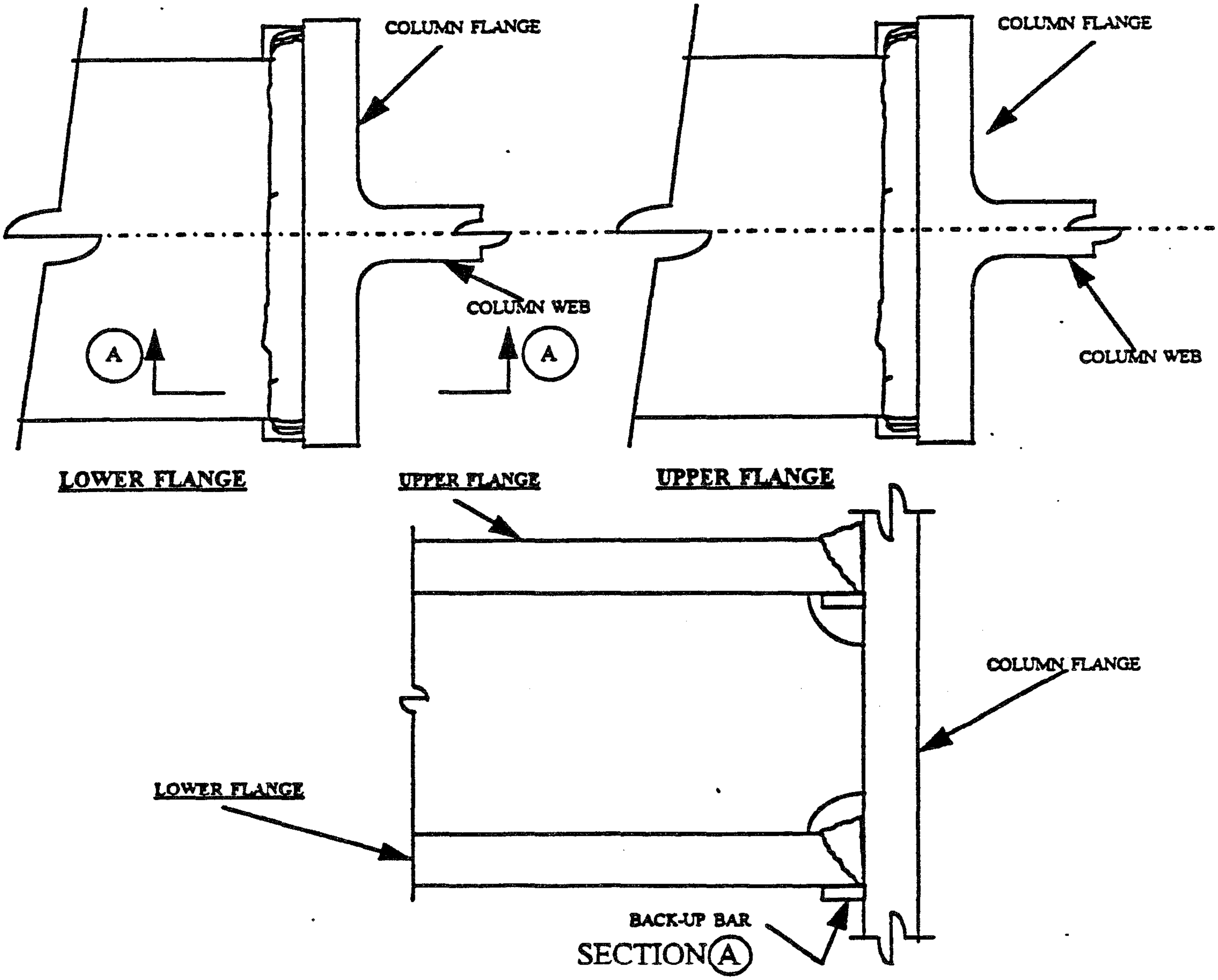
SMITH-EMERY COMPANY

SEISMIC EVALUATION RECORD

EXHIBIT 3

PROJECT NAME________________________
PROJECT ADDRESS________________________
CITY ________________
JOB NUMBER________________
WO NUMBER________________
DATE________________

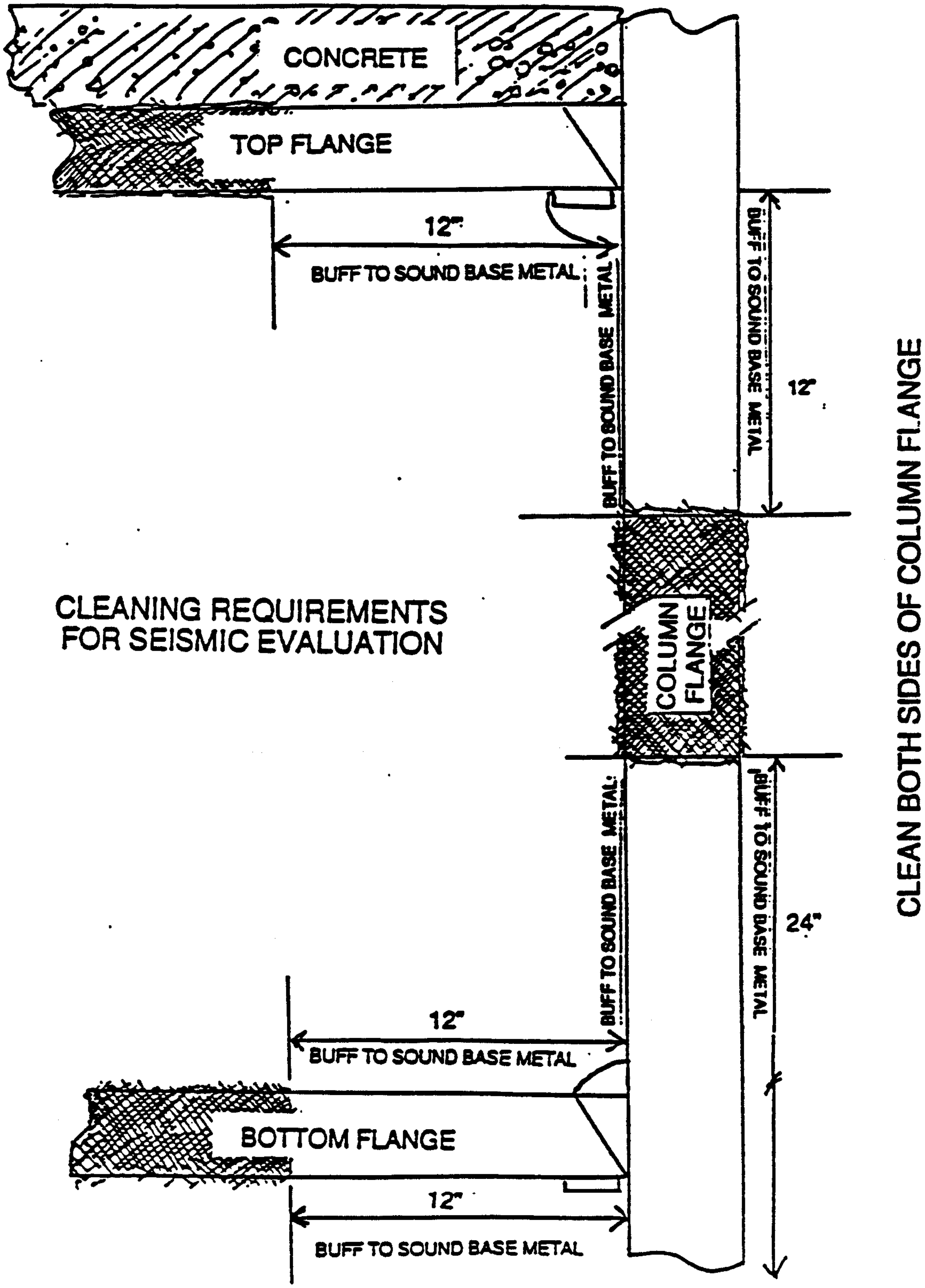
FLOOR LEVEL________________
GRID LOCATION________________
BEAM LOCATION________________
UPPER FLANGE__
LOWER FLANGE__



COMMENTS:____
____
____
____
____
____
____

INSPECTOR________________________ SIGNATURE________________________
COGNIZANT ENGINEER________________________ SIGNATURE________________________

EXHIBIT 4


CONCRETE
TOP FLANGE
12"
BUFF TO SOUND BASE METAL
BUFF TO SOUND BASE METAL
BUFF TO SOUND BASE METAL
12"
CLEANING REQUIREMENTS
FOR SEISMIC EVALUATION
COLUMN FLANGE
BUFF TO SOUND BASE METAL
BUFF TO SOUND BASE METAL
24"
12"
BUFF TO SOUND BASE METAL
BOTTOM FLANGE
12"
BUFF TO SOUND BASE METAL
CLEAN BOTH SIDES OF COLUMN FLANGE

ENGINEERING INSPECTION TESTING

3310 Airport Way
Long Beach, CA 90806
Mail: P.O. Box 47, 90801

(310) 426-3355
(714) 828-6432
FAX (310) 426-6424

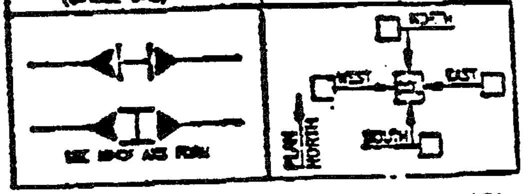
POST-EARTHQUAKE INSPECTION REPORT
STEEL FRAME MOMENT CONNECTIONS

NOTES:
F: FULL LENGTH
NC: NOT CLEAN
NA: NO ACCESS
NM: NON MOMENT

PROJECT ADDRESS: ______
INSPECTION DATE: ______
INSPECTOR: ______
FLOOR FRAMING LEVEL: ______
GRID LOCATION: ______

PROVIDE VISUAL INSPECTION OF ALL JOINT WELDS AND BOLTS, AND U.T. INSPECTION OF ALL C.P. WELDS

COLUMN ORIENTATION (CIRCLE ONE) | VIEWING DIRECTION (CHECK BOX)



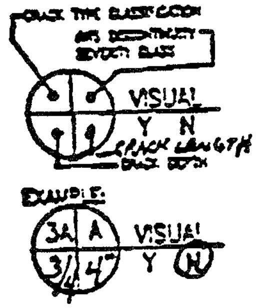
CRACK TYPE CLASSIFICATION

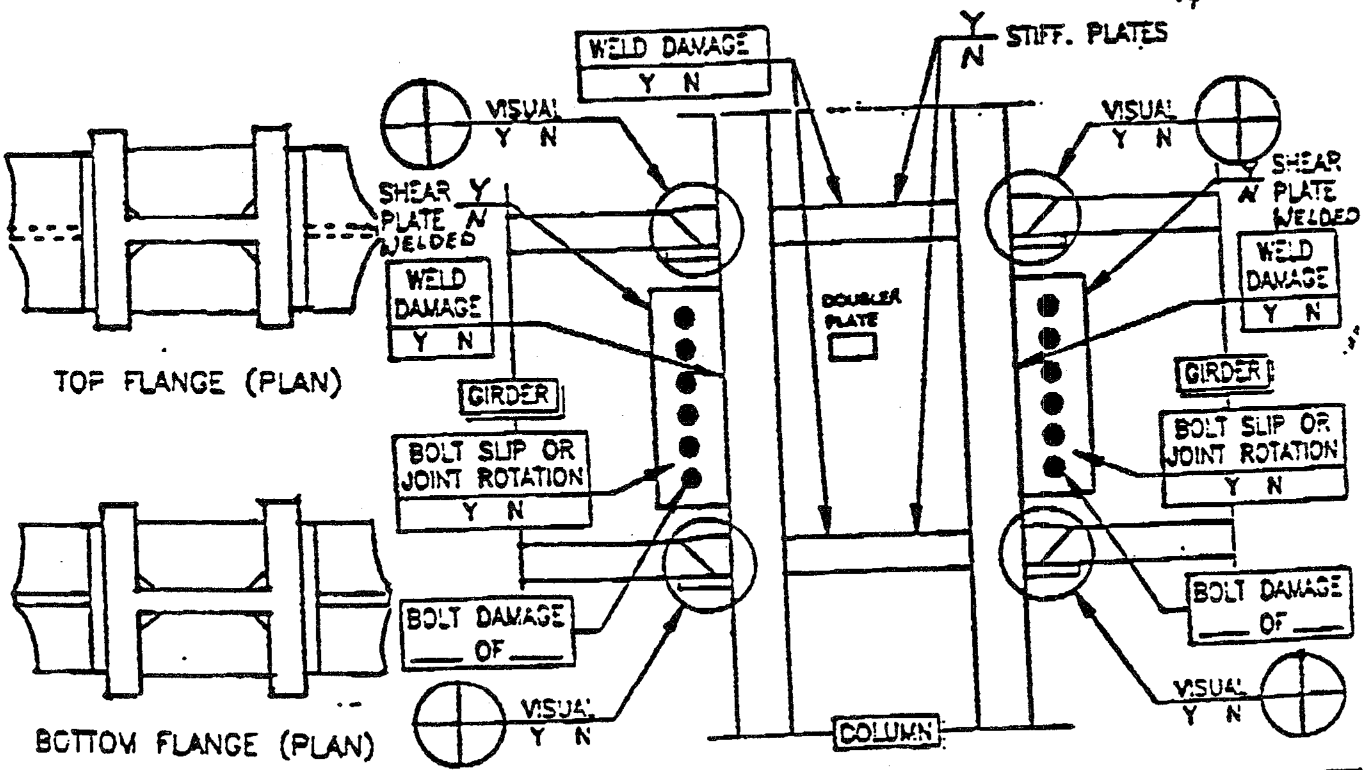
0 – NO DAMAGE FOUND
1 – WITHIN WELD MATERIAL
2 – ALONG HEAT AFFECTED ZONE
3 – EXTENDS INTO COLUMN
 3A – REMAINS IN COLUMN FLANGE
 3B – EXTENDS INTO COLUMN WEB
4 – OTHER: ______

NOTE: FOR CRACK TYPE 3A, 3B, AND 4 SEE PLAN SKETCH

A.W.S. DISCONTINUITY SEVERITY CLASS

A – LARGE DISCONTINUITIES
B – MEDIUM DISCONTINUITIES
C – SMALL DISCONTINUITIES
D – MINOR DISCONTINUITIES
PER AWS ULTRASONIC ACCEPTANCE-REJECTION CRITERIA TABLE 8.2 – AWS D1.1-94





COMMENTS: ______

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STEEL FRAME MOMENT CONNECTIONS

NOTES:
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NC: NOT CLEAN
NA: NO ACCESS
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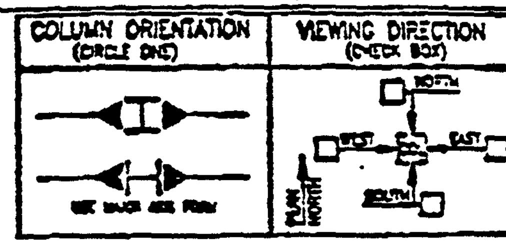
PROJECT ADDRESS: ____________
INSPECTION DATE: ____________
INSPECTOR: ____________
FLOOR FRAMING LEVEL: ____________
GRID LOCATION: ____________

PROVIDE VISUAL INSPECTION OF ALL JOINT WELDS AND BOLTS, AND U.T. INSPECTION OF ALL C.P. WELDS



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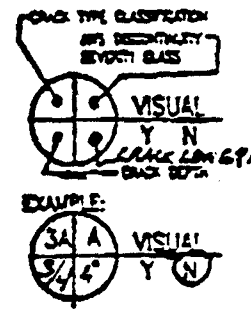
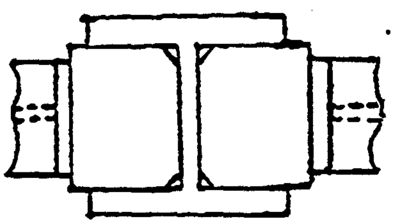
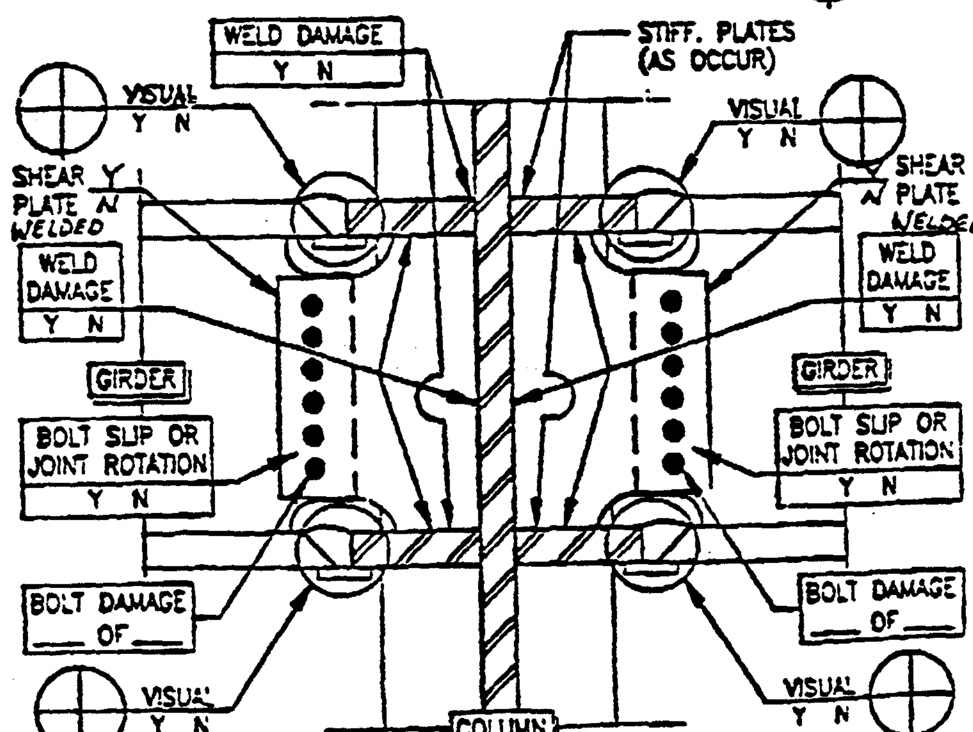
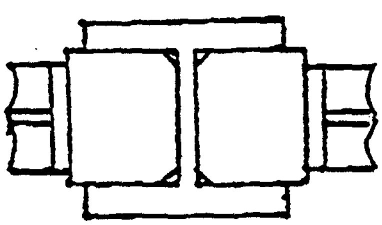



TOP FLANGE (PLAN)




BOTTOM FLANGE (PLAN)

COMMENTS: ____________