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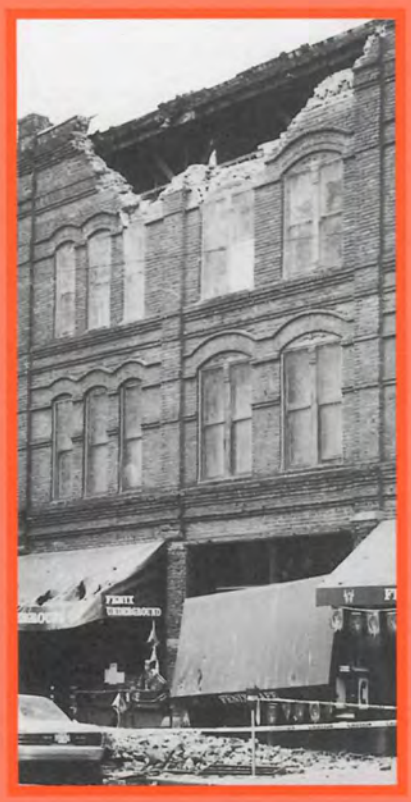

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David W. Look and Dirk H.R. Spennemann

Disaster Preparedness, Planning, and Mitigation

Planning for a disaster is planning for the inevitable; a matter of "when," not "if." As individuals and as a community we accept that disasters will occur, we come to terms with their impacts, and we try to minimize them through planning. It is **the priority** that often will suddenly shift—from last to first. Cultural resources take their greatest losses during or after disasters, when portions and sometimes even entire objects, buildings, structures, and districts are lost. Therefore, disaster preparedness and planning should be inextricable elements of our cultural resource stewardship. The articles in this second issue of *CRM* on disaster management focus on disaster preparedness, planning, and mitigation.[1]

While we can plan for natural disasters based on our shared past experiences, we cannot plan for the ever-escalating loss of life and destruction caused by terrorist attacks. The September 11, 2001, attacks on the World Trade Center and the Pentagon, resulting in a death toll over 5,000 people, were unprecedented in method, magnitude, and impact. While the physical impact was local, the psychological shock waves were reverberating globally. Inadvertently, this special issue of *CRM* is both timely and topical. It had long been edited and was being readied for publication when the events occurred. Indeed, they are still unfolding as this special issue of *CRM* goes to press.

The natural forces that have created and shaped our environment—and produced some of the most scenic and enjoyable places—are still at work. Vicki Sandstead's article makes some very good points: it is only recently that disasters have been considered anything other than acts of God; almost everything is located in one disaster zone or another; disasters will continue to happen; and the National Park Service does not adequately plan for potential disasters.

Disaster preparedness planning is a cycle that includes feedback that is used in revising plans with new data and knowledge learned from the last disaster.

The recent Nisqually Earthquake in Washington State resulted in a significant loss of material history. The role of Historic Seattle, a non-profit community preservation organization, is documented by Heather MacIntosh. She stresses the need for the preservation community to establish a relationship with the larger community before any disaster and how it would have made a difference. But the earthquake affected the resources of a much larger area than Seattle and Olympia. Michael Sullivan's description of the regional assessment survey, documentation, and findings helps us to understand the scope of the damage and to better plan for when we will need to respond rapidly to save what remains after a disaster. The recovery phase will be based on the excellent work done during the response phase. Planning is a loop. The feedback from the response and recovery should be incorporated into the revision of the next disaster preparedness plan.

Planning is the key to reducing vulnerability, loss of life, injuries, and damage. The properties of the National Trust for Historic Preservation are insured by Chubb Insurance, which requires each property to have a disaster preparedness plan. In Charity Roy's article, she takes a business approach to disaster preparedness. By substituting "organization" or "park" for "business" or "company" and "superintendent" for "CEO," her advice is applicable to almost any situation.

The only thing better than learning from one's own mistakes (and successes) is learning from those of others. It is also much less painful. Those who have been through recent disasters (and survived) need to assess what worked and what failed or under-performed.

The National Park Service (NPS) is self-insured. Until very recently, few parks have included cultural resources in their emergency preparedness. The NPS *Management Policies* and the NPS Cultural Resource Challenge now

include cultural resource protection and emergency preparedness.[2]

Parks with frequent disasters, such as Harper's Ferry National Historical Park (NHP), have had to deal with repeated events such as floods. Not surprisingly, these parks are far more advanced in their planning for protecting cultural resources during and after disasters than parks that have very infrequent emergencies. Our irreplaceable resources are especially vulnerable to natural and anthropogenic disaster during treatment when the protection and fate of the resource are in the hands of a contractor. Bruce Noble discusses the benefits of advance planning. Decisions made before the floods helped Harpers Ferry NHP recover quickly from the two 1996 floods. Peter Dessauer and David Wright recount how the precautions taken during construction reduced losses.

People generally think of disasters as events that occur suddenly, causing damage in a matter of seconds, hours, or days. Some disasters, however, occur so slowly that we suddenly realize we are in a disaster that has been underway for some time and may continue for an extended period of time. Dryland salinity falls into this category, as discussed in the article by Dirk Spennemann. The cumulative damage may not be known for years and the public may not be aware or concerned until the damage reaches crisis proportions.

Disaster recovery includes not only the repair of damage but retrofit to reduce future damage from future disasters. Prior to the repair, retrofit, and the restoration of the Basilica of St. Francis of Assisi, Giorgio Croci had to determine the seismic forces for use in the structural analysis and design and to develop innovative solutions. Hopefully, in the future what was learned from this project can be transferred to preventative retrofit of other projects, thus benefiting the planning for and survival of many cultural resources.

We have much to share with and to learn from the rest of the world. Cultural resources in poor countries are vulnerable because of a lack of maintenance, adequate research and documentation of known and unknown resources, and no resources for recovery. Disasters in developing nations are even more tragic where there are usually no equivalents of our Federal Emergency Management Agency (FEMA), state offices of emergency services, and local emergency agencies. June Taboroff's article focuses on the cultural resource assistance by the World Bank and ProVention Consortium after disasters.

Randolph Langenbach reports the almost total devastation he observed in India; however, even in the ruble he found indications that "a significant amount of seismic mitigation can be achieved from small differences in construction methods."

Disasters can damage and destroy cultural heritage places, but they also initiate a strong emotional response in the community immediately affected by the events. Some of this response is geared toward memorials and some toward the management of property in a damaged state. If we wish to retain rem(a)inders of these events, do we need to restore them or memorialize them? The paper by Rosemary Hollow and Dirk Spennemann on the management of atrocity sites raises some of these issues.

The attacks on the World Trade Center and the Pentagon once more bring into focus human capacity to commit atrocities and humanity's capacity to deal with the aftermath.

Notes

1 See *CRM* 23:6, 2000.

2 National Park Service Management Policies 2001, "5.3 Stewardship," page 52. Cultural Resource Challenge, U.S. National Park Service, December 2000, pages 15-16.

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David Look and Dirk Spennemann are co-guest editors of this issue of *CRM*.

Vicki Jo Sandstead

History's Big Lessons

Twenty years ago, in his popular series *Cosmos,* Carl Sagan mused that it is only in the last 400 years that we have come to understand the forces of and our place in the universe. We are even newer to understanding our planet and the energy that shapes it. We do know that violent catastrophic activities have sculpted Earth, changing its history and that of civilization since the beginning of time. This article will explore geological events—those associated with Earth's crust that may have influenced the course of civilization.

To picture Earth's crust, imagine the seams of a baseball. A dominant seam circles the Pacific Ocean and is the source of American and Japanese tectonic plate collisions that cause earthquakes. This "Ring of Fire" also contains three-quarters of the Earth's volcanoes. Every year, the energy released by Earth's crust in earthquakes and volcanoes is equal to 100,000 nuclear bombs.

Another seam, very similar to California's San Andreas Fault, extends from eastern Turkey to Greece and is known as the Anatolian Fault. Like its American counterpart, it is a network of smaller fault segments that divide two tectonic plates—Eurasia and Anatolia. Nearby, the Arabian plate, moving north slightly faster than its neighbor the African plate, has crafted the Caucasus Mountains. The African plate has been shrinking the Mediterranean basin at the heart of what we call the cradle of Western civilization. Remnants of ancient sea floors remain; however, most rock was pressed down toward Earth's mantle, melting and producing magma that resurfaces through cracks forming volcanoes like Mount Ararat in Turkey. Also in Turkey, the earliest known artistic depiction of a volcano, dating about 6200 BC, is found in the stone-age site Catal Huyuk.

According to Columbia University geophysicists Bill Ryan and Walter Pitman,[1] the Anatolian fault may have triggered the first catastrophic event for which written records survive—an enormous flood that turned a freshwater lake into the Black Sea about 7,600 years ago. Riverbanks and freshwater sources have always attracted farmers and settlements to them. The lake was much lower and smaller at the end of the Ice Age. As glaciers melted, rising seas carved today's Bosporus from the Sea of Marmara into the Black Sea basin. Calculations indicate that the level of the lake would have risen half a foot per day. Villages would have disappeared under water in a couple of weeks. Escaping would have required inhabitants to travel between a half and one mile per day. A beach has been discovered below 550 feet of water near the Black Sea's south shore. Was this the sequence of events in the Old Testament narrative of Noah? I suspect that early agrarian culture was no less devastated than the Midwestern U.S.A. farmer was in the "great flood of 1993."

History has many lessons for today. On August 17, 1999,[2] a vast section of the Golcuk, Turkey, waterfront sank 50 feet into the sea. The lower floors of two seven-story buildings plunged into the gulf of Marmara, killing 50 men gambling in a ground-floor cafe. Official earthquake deaths were over 17,000. Some 85,000 buildings were destroyed and 40,000 families left homeless. In the past 2,000 years, almost 600 earthquakes have been documented. There have been 40 earthquakes of 7+ magnitude since the first century AD. There have been 13 major earthquakes

Midwest flooded farm, 1993. Photo courtesy FEMA.

in Turkey since 1939. Two of these, which destroyed much of Istanbul in 1509 and again in 1766, are part of a 250-year rupture cycle—the math on that adds up to the next one occurring around 2016.

Concurrent with Turkey's coasts dropping into the sea, the land in Greece is rising. Along the Gulf of Corinth one can see quarried rocks that were originally laid underwater to build a harbor around 500 BC. However, modern day Athenians were surprised when on September 7, 1999, there was a 5.9 magnitude earthquake that lasted a mere 15 seconds, killing 143 people and leaving more than 50,000 homeless.

The earliest advanced civilization of Europe, the Bronze Age Minoans were farmers and seafaring merchants who traded in the Mediterranean. They flourished and declined in the space of a few hundred years. Their sophistication included architecture with light and airshafts and bathrooms with water supply. Around 1500 BC, a great earthquake destroyed the center of their agricultural economy on Crete. After they rebuilt, another major quake occurred. Knossos survived in the 14th and 13th centuries under Mycenaean domination. When a major earthquake in 1250 BC demolished the city of Mycenaea, they rebuilt; but 50 years later another earthquake leveled the area. By the 12th century BC, both cultures were wiped out and history entered the Greek Dark Age.

A recent U.S. Geological Survey (USGS) study says the odds are 7 in 10 that an earthquake of at least 6.7 magnitude will strike the San Francisco area before 2030. In 1989, the Loma Prieta epicenter, 60 miles south of San Francisco, resulted in 68 deaths and seven billion dollars in property damage. The largest quake to hit the continental U.S. since 1906, Loma Prieta was the first before a prime-time TV audience watching the third game of the World Series between the Oakland Athletics and the San Francisco Giants. Geologic technology that measures movement and assesses faults indicates the Loma Prieta earthquake did little to relieve seismic pressure building since 1906.

The research of volcanologist Haraldur Sigurdsson[3] penetrates the effects of geophysical events on ancient cultures and provides us new understanding. Working with archeologists, Professor Sigurdsson has reshaped our views of the effects of disasters on ancient civilization by calibrating melted glass, carbonized vegetables, cooked people, blown-down walls, and dislodged and collapsed roofs. For the same Minoan culture that suffered earthquakes, a gigantic eruption of the volcano Santorini on Thera, 70 miles away, brought culture nearly to an end around 1650 BC. The amount of magma from this explosion is estimated at 84 million tons. One of the largest eruptions in the last 10,000 years, three times as much ash spewed out as previously believed, enough to cover the state of Ohio under a layer more than 10 feet deep. This magnitude of ash would destroy crops and the grasses that fed livestock and totally wipe out any agrarian economy. Some scholars propose this is the biblical plague of Exodus when "there was a thick darkness in all the land of Egypt for three days."[4]

In Europe, Naples is the center of the most active geologic zone. An earthquake in February of AD 62 was centered near Pompeii, a city of 20,000. Buildings collapsed in nearby Naples. Historians believed for a long time that in AD 79 falling ash from a volcanic eruption of Vesuvius buried Pompeii, and that the more prosperous Herculaneum, home to 4,500 people, was inundated in slower massive mudflows that allowed residents to escape.

Professor Sigurdsson scrutinizes 2,000-year-old archeological evidence from this prime real estate to provide a different chilling story. The terminal velocity of falling fist-sized rocks was 112 miles per hour. The rate of raining rocks was 84 per minute per square yard. The density of dead in a beachfront shelter was three per square meter. Vesuvius' output at the eruption's height was 165,000 tons of debris per second. Sigurdsson also uses the eruption's most insightful witness, the 17-year-old Pliny the Younger, whose letters are the oldest surviving historical observation of volcanic eruption. His uncle, Pliny the Elder, commander of the Roman Fleet at Misenum and the most important reporter of Roman science from that era, died at Stabiae during this eruption of Vesuvius.

In the last 10,000 years, the Naples area has experienced 100 explosive events. Around 570 BC, the Roman poet Virgil describes Etna in his poem the Aeneid, which certainly influenced the later writing of Dante and Saint Augustine about the underworld. In *Metamorphoses,* Ovid compares the volcano Etna to a living beast that breathes out flames and describes how the beast's orifices change as he moves. Vesuvius has erupted over 50 times since AD 79.[5] In 1631, mud and

lava flows killed 3,500 people. Its most recent eruption was in 1944. Today, Vesuvius' prime slopes are again crowded with nearly a million people living in the evacuation zone. Modern man may no longer attribute catastrophes to hell, beasts, or angry gods, but he persists in building in harm's way!

While much of recorded eyewitness history in other parts of the world describes disasters, in the Americas geological records are relied upon. One of our most popular national parks, Crater Lake, is now a dead volcano, but the area around it is active, smoking and fuming and under watch. When Mt. St. Helens exploded in 1980, a layer of ash blanketed Spokane, 250 miles away. This is estimated at only 1/40 the ash produced by Santorini in 1650 BC. The eruption that created Crater Lake in 4600 BC was more comparable to Santorini than to Mt. St. Helens! A similar event is within the realm of possibility today.

Many of our spectacular national parks were born of catastrophic disasters.[6] In Alaska, the 1912 eruption in Katmai National Park[7] formed the Valley of Ten Thousand Smokes.[8] More than seven cubic miles of ash covered 46,000 square miles in 60 hours. Robert Griggs wrote about it in *National Geographic* in 1917.

> The magnitude of the eruption can perhaps be best realized if one could imagine a similar outburst centered in New York City. All of Greater New York would be buried under from 10 to 15 feet of ash; Philadelphia would be covered by a foot of gray ash and would be in total darkness for 60 hours; Washington and Buffalo would receive a quarter of an inch of ash, with a shorter period of darkness. The sound of the explosion would be heard in Atlanta and St. Louis, and the fumes noticed as far away as Denver, San Antonio, and Jamaica.

Formed about 2,300 years ago, New Mexico's Capulin Volcano is one of the youngest features in the Raton-Clayton volcanic field. Hawaii Volcanoes[9] National Park has very active volcanoes. Hawaiian culture has many fascinating nature-myths that reflect their constant exposure to volcanoes. Mount Kilauea has been continuously erupting since 1983.[10] In 1996, the volcano destroyed 181 homes and a National Park Service visitor center. Yellowstone National Park, a "hot spot" like Hawaii, has had three very large eruptions in the last two million years.

It is remarkable that many national parks illustrate the effects of violent events, yet we do not believe in the inevitability of geophysical occurrences enough to mandate thorough catastrophic disaster planning and preparation! Planning and preparation are essential, predicated on the knowledge that disasters do happen, that they will happen. To listen and not heed, to read and not respond is foolhardy. Planning and preparedness are essential for life and property. They are also proper stewardship for the natural and historic resources under our protection.

Notes

1. William Ryan and Walter Pitman, *Noah's Flood*, Simon & Schuster, New York, New York, 1998.
2. This was one of the five deadliest earthquakes of the 20th century. In 1976, the 7.8 magnitude Tangshan earthquake in China killed around 240,000 people. The September 1923 earthquake in Japan claimed 140,000 lives. The deadliest recorded occurred in 1556 in China, and took the lives of nearly one million people.
3. Haraldur Sigurdsson, *Melting the Earth*, Oxford University Press, New York, New York, 1999; *Encyclopedia of Volcanoes*, Academic Press, San Diego, CA, 1999.
4. J.G. Bennett, "Geophysics and Human History: New Light on Plato's Atlantis and the Exodus," *Systematics* 1:127-56.
5. Robert Decker and Barbara Decker, *Volcanoes*, 3rd edition.
6. A few others are:
   Arizona—Sunset Crater Volcano National Monument and Chiricahua National Monument
   California—Devils Postpile National Monument, Lava Beds National Monument, Pinnacles National Monument, Lassen Peak National Park last erupted from 1914 to 1917
   Idaho—Craters of the Moon National Monument and Washington-Mount Rainier National Park
7. Although most volcanoes in the Valley of Smokes are now dead, Mount Trident, a new vent on the west flank of Katmai, became active in 1949, and has exploded several times, most recently in 1974.
8. As the Pacific plate moves over the top of this hot spot over tens of millions of years, each volcanic island was created as hot plumes of magma rose from within the earth's mantle and broke through the earth's crust.
9. Probably the most studied volcano in the world, it has written records dating back to 1823, which make it an ideal test site for a new system to predict eruptions using a network of receivers hooked into the satellite GPS.

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Heather MacIntosh

Responding to Nisqually

Historic Seattle's Role After the Earthquake

On February 28, 2001, a 6.8 magnitude earthquake hit western Washington. Months later, the preservation community is still feeling the impact.

Although most of the city's older buildings fared remarkably well, especially those with seismic retrofits, a number of unreinforced masonry buildings in south downtown suffered significant damage. Concentrations of brick buildings in historic Pioneer Square, the Chinatown-International District, and a warehouse district known locally as SODO were hardest hit due to their location on a liquifaction zone.

Half a year later (September 2001), damage estimates are still somewhat speculative and, in many cases, more damage has come to light than initially reported. Mayor Paul Schell's request to the President for a $57 million recovery grant was only partially answered with relief for transportation improvements, but none for damaged historic buildings. Some property owners are still waiting for checks from the Small Business Administration (SBA). The city's Office of Housing has developed a program, with funding from Fannie Mae, that will facilitate the rehabilitation of historic residential hotels in Chinatown. The South Downtown Foundation, in conjunction with Community Capital Development, a nonprofit community and economic development organization, has developed a program to aid businesses and housing projects with significant earthquake losses. In Seattle, those with an interest in historic buildings, including business and property owners, preservationists, and city officials are hoping to see more aid come as the rising need becomes clearer.

Cadillac Hotel, Seattle, Washington, March 1, 2001. The Cadillac Hotel is the most controversial building damaged in the Nisqually earthquake. Photo by the author.

Historic Seattle's Response

The wide range of preservation needs rising from the earthquake could not be met by one agency alone. As Seattle's only nonprofit organization dedicated to the preservation of the city's architectural heritage, Historic Seattle played a key role in the city's earthquake response as a preservation advocate and press contact, information and contractor resource, and eventually a funding source for quake-damaged historic properties. For weeks after the disaster, City of Seattle and King County preservation office staff worked long hours to aid individual landmark property owners in understanding the barrage of reports, damage tags, and potential assistance packages.

Most initial media attention focused on severely damaged buildings and public safety concerns rather than retrofit successes or preservation issues. Many preservation proponents feared the premature demolition of weakened historic buildings. Historic Seattle promoted two primary points during the first month after the quake when public interest was still high—"don't rush to tear down damaged historic buildings" and "older buildings are safe." With few excep-

tions, property owners of historic buildings have not prematurely taken down unstable buildings or parapets. The mild hysteria surrounding falling bricks in the affected historic districts abated soon after the quake.

Funding for Damaged Historic Buildings

Coordination was important for both immediate and long-term earthquake response for a number of reasons, including fundraising around the disaster. Of all the issues raised by the quake, funding for historic preservation has emerged as one of the most important. Many property owners and potential funders believed the Federal Emergency Management Agency (FEMA) and the SBA would provide low interest loans that would cover damage, but these programs do not fund what are considered "cosmetic fixes" like rebuilding historic cornices or repairing decorative terracotta tiles. The programs were sold to the public as primary funding solutions, but their usefulness to historic building owners suffering a variety of damages was mixed. Funding gaps were common.

Financing architectural and engineering plans, retrofits, and repairs was a primary concern, and will continue to be for months to come. Within the first 10 days of the quake, Historic Seattle committed $250,000 from its Save the Buildings Fund toward earthquake response, with the hope of stimulating preservation action and leveraging more funding from local foundations and public agencies. To date, Historic Seattle's pledge has been the largest local commitment.

Working with the City of Seattle's Office of Economic Development, the city's Department of Neighborhoods that houses the City of Seattle's preservation office, and a nonprofit capitol development agency, Historic Seattle helped craft a public funding program for property owners of historic buildings. Conceived as a financial and technical assistance team, the fund has been used primarily to pay for loan officers who have helped property owners understand and package various loan programs, and as a pool for reimbursing owners for architectural and engineering services up to $10,000 for each project.

Historic Seattle reserved a pool of $145,000 from its initial pledge for actual repair work and "special cases." Historic religious buildings, like the Seattle Hebrew Academy, with needs that exceed the loan caps allowable by the SBA, have had trouble meeting their rehabilitation budgets and will require grants from private benefactors. For special case buildings such as these, Historic Seattle hopes to leverage funding with seed money for repairs and retrofits.

The immediate problem of funding quake repairs will hopefully lead to more public discussion of funding for historic preservation through greater use of existing incentives, more low interest loan programs, and private funding for preservation activities stimulated by community outreach after the quake. Historic Seattle is now planning an economic analysis of historic preservation's impact on business in downtown Seattle that should facilitate even greater understanding of the relationship between funding nuts-and-bolts preservation and maintaining a critical element of economic development.

Community Outreach

While Historic Seattle's pledge of $250,000 received more press attention, the organization's role as a community resource and advocate arguably had much greater immediate impact. For the majority of property owners affected by the quake, a list of reputable contractors with experience repairing historic buildings was invaluable. Currently, there is no preservation specialists directory, but due to demand following the quake, Historic Seattle posted contractor information on our web site which will serve as the first entries of a contractor database.

During the first few weeks after the quake, contact with preservation organizations in California and the western office of the National Trust also provided well-needed moral support. These organizations provided models for editorials, ideal earthquake response checklists, and model unreinforced masonry building ordinances designed to counteract potential ordinance revisions that would negatively affect historic brick buildings. This invaluable organizational support underscored the need for proactive communication between preservation organizations, especially those on the West Coast who are perpetually "between earthquakes."

Developing a mutually-beneficial relationship with the local press was another outgrowth of the earthquake we hope to nurture in the future. Initially, Historic Seattle contracted with a local public relations firm to make press contact, but soon members of the press were calling our organization directly with questions about non-earthquake related topics. Providing compelling historical, technical, and theoretical quotes for

earthquake articles encouraged trust between Historic Seattle and local reporters covering building and development news.

A Report Card for Seattle

Because the impact of the earthquake was relatively minor, that is, resulting in no fatalities and, as of today, no loss of significant historic buildings, the natural disaster may have aided preservation in Seattle. The quake provided an opportunity for preservation to be of immediate interest to the general public. It tested the effectiveness of the local preservation community, and showed us where we need improvement. The lessons will undoubtedly be many, but it will probably take years to understand how much we learned from the experience.

Historic Seattle has continued to follow the long-term impact of the quake and is stepping up its advocacy efforts. This year, Historic Seattle hired a preservation advocate to monitor development activity, facilitate grass roots activism, create an online advocacy newsletter, and exchange ideas and information with local government. Nisqually confirmed Historic Seattle's decision to fund advocacy efforts as an integral but discrete function of this organization.

Today, only one lesson seems clear. The local preservation community can only be effective if it establishes an ongoing, generally positive, and mutually-beneficial relationship with the community at large, including policy makers, any city agency governing buildings and land use, grass roots organizations, the press, allied organizations and other preservationists. Had a strong network predated the quake, it would have been much easier to share information, quickly understand the scope of the impact, and conceive effective response strategies. This network would significantly aid mitigation for future preservation disasters, be they natural or man made.

Heather MacIntosh, MA, MarH, HPC, has been Historic Seattle's Preservation Advocate since February 2001. Since 1993, she has participated in preservation projects on the East and West Coast. Since moving to Seattle in 1998, she has served as deputy director of HistoryLink, an online encyclopedia of Seattle and King County history, conducted a historical inventory of Newcastle, Washington, and other preservation projects in King and Pierce Counties.

Michael Sean Sullivan

The Nisqually Earthquake

At 10:54 a.m. on February 28, 2001, there was a shift in the Juan de Fuca Plate 10 miles northeast of the state capital of Olympia and 40 miles beneath southern Puget Sound. During the next 45 seconds a powerful seismic event of magnitude 6.8 carried most of the population of Washington State through the remarkable experience of a major earthquake.

Once the shock of the earthquake subsided, most people who experienced it believed they had been a part of history in the making. Initially, however, while there was obvious damage to a number of significant properties, it was generally believed that because of the depth of the quake, most damage, even to historic properties, was relatively isolated. Now that many months have passed, it has become clear with regard to historic and cultural resources that there has been a significant loss of material history as a result of the Nisqually earthquake. In more than any other terms, the cost of the disaster must be measured in damage to the region's physical heritage, its historic buildings and sites, and the fabric of its oldest downtowns and neighborhoods.

Within a few days of the earthquake, the Washington State Office of Archaeology and Historic Preservation, working with the Federal Emergency Management Agency (FEMA), assembled preservationists and architects to plan a comprehensive assessment of damage to historic buildings and sites in the shake area. Eight counties, including a major portion of the population and building stock in the state, were declared a disaster zone by FEMA. Already, serious damage to historic buildings in Seattle's Pioneer Square Historic District was heading news stories about the aftermath of the earthquake. Significant damage to the massive domed State Capitol (Legislative) Building in Olympia provided

Vertical crack in façade pilaster on the Aberdeen Post Office building. Artifacts field photo.

graphic images of the event's magnitude. It also led to an extended closure of the building interrupting a session of the State Legislature. Early FEMA response was already recording a pattern of serious damage to older brick and masonry buildings throughout the region, particularly those that had not undergone seismic upgrades. In the 60 days that followed, damage to more than 350 historic buildings and sites were documented in a massive rapid response effort.

Planning the Assessment Survey

The logistical planning for the damage assessment fieldwork was developed using a variety of disparate kinds of information. Teams of experienced preservationists, historians, and architects were brought together by Artifacts Inc, an architectural conservation consulting firm based in Tacoma. Basic survey routes and destinations were developed to visit all the registered national, state, and local sites in the disaster counties. Because the field teams also intended to document damage to potential historic properties as well as some older ineligible buildings in historic downtowns and districts, map overlays were developed. The "probability" overlays were created from early railroad and inter-urban route maps, pre-World War II road maps, and particularly the Works Progress Administration (WPA) State Guidebook (1940) that provided uncluttered maps and narratives of the region's early development and visitor attractions. The pre-war road maps and tours in the WPA guide helped to design efficient travel paths for the field teams and routed them through areas of early settlement and construction without having to wind through suburbs and post-war urban areas.

The field teams worked in assigned counties for up to 10 hours a day. They carried cell phones so newly reported damage could be conveyed directly to the field and assessments could be made immediately. At the base office, support people continued to call ahead to county emergency service contacts, museums, historical societies, libraries and organizations connected with a loose network of people who cared about local landmarks and were likely to be aware of any damaged historic property.

Type of Documentation

The assessment survey relied on three types of field documentation: written assessment form data, Global Positioning Systems (GPS) readings for location and future mapping, and extensive digital photography. The assessment forms provided a means of recording standardized information about each property, including name, location, construction type, date of construction, ownership, landmark status, GPS reading, and narratives of the damage. The GPS coordinates

Building Priority

Public

courthouses, town halls, government assembly, schools (grade, middle, high), colleges and universities, libraries, post offices, fire and police stations, railroad depots, park buildings

Private

assembly, theaters, meeting rooms, fraternal halls, hospitals, medical, churches, institutional, commercial, retail, apartments, multi-housing residences

Vulnerability by Construction Type

(In descending order)

Brick-veneer, unreinforced

upper walls, parapets, corners, around window openings

Stone Masonry

upper bearing walls, foundations, veneer sections

Plaster/Stucco

inverted horizontal areas, around openings, walls and cornices

Concrete

unreinforced areas, column capitals and bases, foundations, lower walls

Wood frame/Timber

timber and truss joints, upper walls, window and door openings

were taken by handheld device and recorded on the forms. Digital format cameras recorded images onto 3-1/2 inch disks.

The Findings

Every earthquake leaves a signature. In the case of the Nisqually quake, it was the damage done by the movement of the event that began as a watery, liquid feeling underfoot followed by a sharp drop and then a long slow sloshing that seemed to move north and south for about 30 seconds. Immediately after the quake, it was clear that the severity of the quake was not determined by the proximity to the epicenter. Ground and soil type ordained the intensity of movement and attendant damage with alluvial valleys, river deltas, and poorly compacted man-made fills suffering the most. Unfortunately, these are the areas in the southern Puget Sound region where people settled, railroads were routed, and towns were built.

Another factor that contributed to historic structure damage was construction type. Unreinforced brick buildings (c.1875-1900) fared the worst, with stone masonry (c.1875-1920) and concrete (c. 1905-1950) following. Wood frame and timber buildings typically were not seriously damaged even in the areas of most severe shaking. The most troubling pattern of destruction was between dissimilar building materials on composite structures. Many commercial buildings with wood or timber framing and brick veneer lost entire exterior walls and parapets as the sharp jolt early in the quake sheared the attachments between materials and the following rolling motion tipped the outer wall away. Similar damage occurred on bridges where steel and concrete connect, on reinforced concrete frame buildings with stone or brick cladding, and on hundreds of wood frame houses where brick chimneys fell away.

In all, more than 364 historic properties in Washington State suffered more than $52 million in damage. Several National Register sites were either destroyed or are presently slated for demolition because of earthquake damage. In the old logging port of Aberdeen, many of the last remnants of its pioneering downtown are irreparable and destined to be lost. In the railroad town of Auburn, at the foot of Stampede Pass, several three-story brick buildings that make up the core of its glory days are doomed. The brave Wilkeson Arch has fallen. It stood at the entrance to the quarry town that cut the stone for the state capitol on a back road to Mount Rainier. Even in

Upper façade and parapet damage to Cadillac Hotel building, Pioneer Square Historic District, Seattle. Artifacts field photo.

Seattle's vital Pioneer Square Historic District, where the greatest dollar value damage was experienced, but the best assistance programs are available, several buildings are in jeopardy as a result of opportunistic interests looking for a higher use, among them the venerable Cadillac Hotel.

The earthquake damage assessment project has quickly become a strategic tool in Washington State's efforts to assist directly with repairs to damaged historic properties. The documentation will also help the State Historic Preservation Office conduct prompt Section 106 reviews of federal disaster assistance efforts. And finally, from the standpoint of a historical document, the written accounts and thousands of images in the report make up a startlingly graphic and poignant record of history being both made and lost. *

Note

* The complete report can be found on the Washington State Office of Archaeology and Historic Preservation's web site at <www.oahp.wa.gov>. In addition, a more definitive report on the earthquake is available from the Earthquake Engineering Research Institute (EERI) <www.eeri.org>. Among others, the EERI report was sponsored by the University of Washington and the National Science Foundation Pacific Earthquake Research Center (PEER).

Michael Sean Sullivan is Principal, Artifacts Consulting, Inc., Tacoma, Washington.

Photos courtesy Artifacts Consulting, Inc.

Acknowledgment

This article was edited by Stephen A. Mathison, historical architect, Washington State Office of Archaeology and Historic Preservation.

Charity Roy

Disaster Recovery

Developing a Plan

Disasters affect people and their businesses throughout the world everyday. Nearly 50% of all businesses that suffer major losses never fully recover, and often they do not re-open. Within the United States, a business catches fire every five minutes, with 40% of these businesses never re-opening. However, businesses that plan for disasters by developing a Disaster Recovery Plan can dramatically increase their chances of recovery.

A Disaster Recovery Plan (DRP) provides the guidelines necessary to ensure the recovery of all vital functions of a business in the event of a disaster. It establishes proactive procedures in preparation for a disaster, evacuation and safety procedures during a disaster, and recovery procedures following a disaster. It also identifies recovery priorities that may get blurred during the havoc of a catastrophe.

The following steps can be used to assist a company in developing a DRP. These steps will vary depending on the specific operation, its location, and its needs. However, they can be used as a core to design a working DRP.

Establish a Planning Team

Developing a DRP is a time-consuming and costly project that involves input from the entire company and outside advisors, such as fire and police departments. A planning coordinator should be chosen to organize a planning committee and to ensure the plan is developed and updated. The planning committee should consist of key personnel from each department that is critical to the operations and the safety of the company. This will ensure that all responsibilities within the plan are met. A schedule and budget should also be established to identify the time, effort, and finances needed to see the project to completion. It is very important that management demonstrates its commitment to the project by initiating a mission statement that outlines the company's objectives for the plan.

Perform a Risk Assessment

The next step is to identify the types of perils that can occur, as well as their probability and the vulnerability of the specific operation. Look at each potential disaster and discuss the affects that the disaster will have within the facility and within the community. There are many types of disasters, so it is important to consider the "worst case scenario," concentrating on the disasters most likely to occur in your specific area.

Once the potential perils have been identified, it is important to review the controls that are in place to prevent a loss. Some of these loss control techniques would include:

- Smoke detectors or a sprinkler system monitored by a central station would reduce or prevent damage caused by a fire.
- Room cut-offs could be used to prevent or slow the migration of a fire.
- Security staff or burglary detection could prevent theft of property.
- Back-up information would allow the quick restoration of important files following a loss of computer equipment.
- Buildings could be retrofitted to increase the strength of the structure in earthquake-prone areas.
- Gable end roof bracing could reduce the damage caused from tornado and hurricane high winds.
- Shrubs, brush, woodpiles, and combustible debris removal could decrease the risk of damage during wildfires and forest fires.

Identify Critical Assets

During the beginning stages of DRP development, it is necessary to identify the assets or critical parts of the business that are highly susceptible to loss. This step should include:

- determining the proper value of the building
- assessing current conditions of property and collection using current values
- documenting sources of income and extra expenses, such as admissions and sales, grants, gift shop revenue, and inventory
- identifying critical machinery or equipment
- identifying critical areas of the building with concentrations of high value items

Catalogues and other collection records should be stored off site. This will assist with the identification of property following a disaster. In addition, it is important to store vital records, back-up files, and insurance documents at a secure location off-site.

Develop the Plan

Once a team has been established and a complete risk assessment has been performed, it is time to develop the plan. The basic steps of the plan will vary from business to business. The following are the basic sections traditionally needed in a plan and an outline of the sections and points that should be discussed.

Executive Summary. The executive summary should state the purpose and main objectives of the plan. Key personnel should be identified, along with their authority and responsibility. A general discussion of the types of disasters that could occur would also be included in this section of the plan.

Assignment of Responsibility. This section states who is in charge during and after a disaster. A line of authority and responsibility should be established to ensure leadership under any possible staffing scenarios. People who normally make decisions in the organization may not be available in a disaster situation. It is therefore important to train more than one individual on emergency response procedures.

Through the use of a phone list or phone tree, management can communicate with their staff to provide direction and instructions to manage the recovery procedures. The phone list should be updated periodically and provided to the members of the planning committee and the management of the company. At least one individual, usually the planning coordinator, should be given the authority to activate the phone tree and indicate the next steps to take following a disaster. There should also be strict instructions as to who will communicate with authority, employees, and media.

In the event of a disaster, there may be individuals looking to pilfer property, increasing losses and damage on-site. Employees should be provided with staff identification badges that will not only restrict access to the site but will continue to improve communication with authority, as well.

Emergency Response Procedures. This section of the DRP identifies the immediate responses following a disaster. It will give employees the tools they need to escape from or react to a disaster. All employees should be aware of the answers to these two questions whenever there is a threat: What do I do? Where do I go? There should be a subsection for every possible disaster that was identified by the planning committee during the risk assessment. Itemized recovery steps should be conducted for each disaster, with a priority on human safety and welfare. These steps should also identify the susceptibility of the assets, collection, or equipment to damage.

Once employees have been safeguarded it is important to stabilize the building and its contents. This includes weatherization and security. It may be necessary to hire a security company to watch over the building to prevent looting. Setting up a prior contract or identifying a company within the report would assist with recovery. It may also be necessary to relocate staff, equipment, and assets to a back-up, or alternate, location. Setting up shared agreements with competitors or identifying the capacities of your company's other locations may provide emergency storage and allow operations to continue.

Recovering and Renewing Operations. Once the employees and visitors are safe and the building is stabilized, the damage needs to be assessed. There may be structural, smoke, or water damage. Contractors who are qualified to repair, rehabilitate, or replace the building and its contents should be secured and listed within the plan. The list of equipment and assets that was previously developed, prioritized, and kept off-site will be needed at this time to identify items lost in the disaster. Prioritizing this list will also ensure that efforts are geared toward the items most susceptible to damage or those with the highest value. It is important to make sure archival materials are not discarded. This can be achieved by assigning employees who are familiar with the operations and the value of items to participate in the clean up of the building. Restoration companies can also assist with the restoration of documents and collections. The contractors, engineers, architects, and restoration companies should all be identified within the plan and prepared to respond following a disaster. The cost associated with recovering and renewing operations should be identified and discussed within the plan.

On-Premises Functions and Supplies. The building manager should expect to provide personnel resources for an extended period of time during a disaster, including an evacuation team, a fire brigade, and first aid trained employees. It is important to establish in-house disaster supplies and kits based on the local and regional disasters identified in the Risk Assessment process. Verifying and checking the supplies periodically

to make sure the first aid kit will stand up in the event of a disaster are also necessary. If the building is located within an area susceptible to sudden catastrophes such as earthquakes and tornadoes, there should be enough supplies to sustain employees for a few days. The supplies should be stored in a secure location. If the disaster supply room is locked the key should be easily accessible in the event of a disaster. A budget should also be established to purchase and replenish supplies as needed.

If there are sensitive collections, emergency object handling should be clearly outlined. Copies of floor plans identifying high priority collections should be provided to the emergency evacuation team and the emergency rescue team to assist with recovery operations. Conservators should also be obtained to outline emergency conservatory procedures.

Off-Premises Functions and Supplies. Setting up off-premise supplies and buildings will enable you to recover your operations faster and easier. An alternate disaster-operating center, such as a trailer or motor home, should be prearranged. A location to move the collection and other sensitive items should be identified. Arrangements can also be made with local cold storage warehouses or grocery stores to use freezer space for the storage of wet books, periodicals, and documents.

Coordinate with Outside Organizations

The internal development of the plan is complete, but sharing it with outside emergency responders will improve the effectiveness of emergency evacuation and response and will help reduce loss. To do this, determine the following protocol with an outside agency response:

- Which entrance will responders use? Can emergency personnel reach the building in the event of a fire?
- Where and to whom do the emergency responders report?
- How will personnel communicate with outside responders?

Test the Plan

Once the plan has been written and reviewed it is important to test the plan to ensure it functions as smoothly as written. This is the time when all the kinks are worked out, so expect some areas of the plan to fail. But this is also the time to make any necessary adjustments, so that when the plan is needed it will work. Invite outside agencies and organizations that are part of your plan, including the fire department, to participate in the test.

Implement and Distribute

The last step is to implement and distribute the plan. It should be given to the company's CEO, senior managers, key members of the emergency response team, and the community response agencies. The operations of the facility are constantly changing; therefore, it is important to conduct periodic reviews of the plan and to update it at least on an annual basis.

There is a wealth of knowledge on the Internet to assist with the development of a Disaster Recovery Plan. One of my favorite web sites is <www.fema.gov>.

Charity Roy, ASP, is the Chubb Loss Control Representative, Chubb Insurance <croy@chubb.com>.

September 11, 2001

Not all history is good and beautiful, but all historic sites provide an opportunity to learn and reflect on what it means to be an American. None of us will ever forget where we were or how we felt when we first learned of the terrorist attacks on the World Trade Center (WTC) in New York City and the Pentagon in Arlington, Virginia. The Pentagon Office Building Complex was designated in 1989 as a National Historic Landmark (NHL) by the Secretary of the Interior. As a prominent part of the New York City skyline, the World Trade Center was a landmark in the generic sense. Now it is the historic site of the worst terrorist attack in the history of the world.

On October 5th at the Association for Preservation Technology International Conference at the Asilimar NHL on the Monterey Peninsula, Karin Reed, Eric Hammarberg, and Derek Trelstad gave a chilling presentation on the team's rapid assessment of 51 buildings in the WTC area. The 1830s St. Nicholas Church was totally destroyed. Numerous other buildings had structural damage. As recovery operations in the WTC area continue, historic preservationists face the task of assessing and ultimately repairing damage to cultural properties—mindful that such actions so soon after the event may appear to the uninitiated as callous. But if heritage is to survive, we need to act now.

David W. Look

Bruce J. Noble, Jr.

"Lord Willing n' the Creek Don't Rise"

Flood Sustainability at Harpers Ferry National Historical Park

Located at the confluence of the Potomac and Shenandoah Rivers, Harpers Ferry, West Virginia, has a long history of flood activity. Since Anglo-European settlers first arrived in the area over 250 years ago, Harpers Ferry has averaged approximately one significant flood event per decade. Particularly noteworthy was 1996, because two of the six largest floods ever recorded in Harpers Ferry occurred within eight months. This article will provide an overview of some of the efforts undertaken by Harpers Ferry National Historical Park to enhance resource sustainability in the aftermath of the 1996 floods.

No effort to minimize flood damage will succeed without planning that takes place long before the water begins to rise. In the case of Harpers Ferry NHP, the park has produced a plan that documents the order in which park buildings will be impacted by rising water. This enables the park staff to prioritize efforts to evacuate buildings when flood warnings are posted. Furthermore, it is also essential to have disaster plans that include detailed building evacuation procedures in the event of an emergency. Such plans will highlight valuable artifacts that should be evacuated first, while also indicating artifacts whose material composition will allow them to remain in place during a flood. In emergency situations, knowing when to leave something behind can be almost as important as knowing when to move a priceless object. Finally, the procedures outlined in the plan should periodically be reinforced through practice sessions involving all the park staff.

Museum exhibit case ready to be wheeled from building after removal of decorative base plate. Photo by the author.

Planning decisions made in advance helped Harpers Ferry NHP to recover quickly from the two 1996 floods. For example, park superintendent Don Campbell had designated all basements in the flood zone as "no storage" areas. This message was reinforced with a warning stenciled on basement floors in florescent orange paint. Strict enforcement of this rule enabled evacuation efforts to immediately focus on imperiled artifacts, rather than having to empty basements littered with an accumulation of items waiting to be surplused.

Prior planning also led to the decision to incorporate ground-level hatches into the floors of many buildings in the flood plain. After flood waters subsided, the hatches were opened and the lingering "flood mud" was swept into the basements. This accelerated the recovery by allowing the water and mud to be quickly pumped out of basements during the clean-up process.

After the 1996 floods, the wooden doors in the park's historic buildings absorbed so much water that they became swollen and difficult to close, especially during humid weather. In the course of the flood recovery process, many of these doors were replaced with new ones made of water-resistant woods like western red cedar, white pine, and mahogany. Although these mate-

Left, Virginius Island water intake arch in jeopardy of collapse after losing its structural load, photo courtesy NPS. Right, same arch following stabilization work completed during 1996 flood recovery program, photo by the author.

rials can be costly, they will save money in the long term by standing up to total water immersion without losing their shape.

The park's Virginius Island section presented some unique challenges following the 1996 floods. In the mid-19th century, Virginius Island had been the site of a small water-powered industrial community. During the past century and a half, the manufacturing concerns had gradually declined due to the transition to steam power, the devastation wrought by the Civil War, and the ravages of repeated flood episodes. Even before the 1996 floods, the built environment on Virginius Island had been reduced to a ruinous condition. The historic character of the island was in jeopardy of being completely lost as the area gradually returned to a "natural" state. The September 1996 flood was especially hard on the island and made it clear that intervention was required if the park hoped to continue interpreting this area's industrial heritage to the visiting public.

During the 19th century, a series of water intake channels was instrumental in directing water from the Shenandoah River into tunnels leading to the small factories on Virginius Island. Prior to the 1996 floods, the water intake arches were close to collapsing, the tunnels had been completely filled with silt and other flood debris, and the foundations of historic mill buildings had deteriorated to the point where their total loss had become a realistic possibility. The funding provided by Congress following the 1996 floods made it possible to reopen the tunnels and stabilize the arches and foundations. These steps have ensured that the water distribution system will be visible to the public and incorporated into the park's interpretive programs for decades to come.

Some of the most innovative advances in flood sustainability at Harpers Ferry NHP have been in the area of museum exhibit design. The exhibit titled *Harpers Ferry: A Place in Time* provides the best examples of these innovations. Developed through contracts managed by Harpers Ferry Center and the park, the building housing the exhibit was known to be in the flood plain from the very start of the planning process. When the initial installation of this exhibit was interrupted by the January 1996 flood, the urgency of flood sustainability became even more apparent.

Several steps were taken to protect this exhibit from future flooding. A simple, but important decision involved placing an emergency tool kit in a locked closet in the exhibit. Many specialized tools are needed to disassemble and evacuate a museum exhibit. When a disaster strikes, there is no time to spend searching for particular tools. The tool kit is conveniently located in the exhibit space to ensure that precious minutes are not wasted at the start of the evacuation process.

Like many modern exhibits, *Harpers Ferry: A Place in Time,* makes extensive use of computer technologies. There are several components of the exhibit that rely on interactive touchscreen displays. While the screens themselves must be located in the exhibit space, cabling was run through conduits to computers strategically located safely above historic high water levels on the upper floors of the building. The screens themselves are attached to lightweight stands that can easily be evacuated from the exhibit and moved to higher ground. Such safeguards will minimize damage to expensive computer hardware and expedite the reopening of the exhibit after flooding occurs.

Another innovation in this exhibit involves the design of exhibit cases. Several of the cases sit on wheels that remain hidden behind decorative panels seen by the visiting public. In the event of a flood, these panels can be unlocked and removed, thereby allowing the cases to be wheeled to a truck and transported to higher ground for safe keeping.

Other important lessons can be briefly outlined. The importance of a seasoned staff with previous flood experience can not be overestimated. It is also critical to be in contact with the National Weather Service and the U.S. Geological Survey for the latest rain and river crest forecasts. Once the water begins to rise, staff must be prepared to work fast in extreme climatic conditions to prevent debris from clumping into log-jams that can be destructive to buildings and other resources. Quick action after the flood is also essential in order to begin pumping flood mud when it is still in suspension, thus saving weeks of effort needed to shovel hardened mud out of basements. Finally, it is important to create a manifest during the evacuation phase so that items can be easily located during the weeks or months when the recovery process is underway.

The examples cited in this article represent only a small percentage of the flood sustainability measures implemented at Harpers Ferry NHP. While no flood can be reasonably expected to leave park resources completely unharmed, valuable steps have been taken to ensure that the extent of the damage is minimized and that the park can be reopened to the public in the shortest possible time. The lessons learned by the staff have provided clear benefits to the cause of resource preservation and can serve as a model to historic sites in flood prone areas across the United States and around the world.

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Left, water tunnels on Virginius Island nearly filled with flood debris, photo courtesy NPS. Right, same tunnels with debris removed as part of the 1996 flood recovery program, photo by the author.

Peter F. Dessauer and David G. Wright

Disaster Preparedness During Construction in Danger Areas

An emergency plan is essential in areas where floods, earthquakes, or fires are known but unpredictable threats to a historic resource. Typically, management teams associated with these historic resources have developed in-house programs to protect the public, the staff, and the resource in the event of disaster. However, little has been discussed in the literature concerning how to deal with these potential threats while the resource is undergoing major rehabilitation. Generally, during such projects, the areas receiving work are off limits to park personnel or the public. The control of the facility—and hence its protection—is in the hands of the general contractor, governed by the contract documents for the rehabilitation. While the normal, day-to-day protection of the resource is usually discussed—often in great detail—within the specifications for the project, the preparations and protections to be taken in the event of a major disaster are often completely overlooked.

Case Study

During the mid-1990s, Harpers Ferry National Historical Park undertook a significant restoration and rehabilitation project involving seven buildings within the McGraw Block of the Lower Town.[1] Division One of the specifications, "General Requirements," covered all normal circumstances associated with the protection of a construction project. Fencing was located and defined to secure the area of work and to protect the general public from exposure to construction hazards. Protection of archeological resources was addressed. Field offices and ancillary facilities were described and located. Cutting and/or patching of the historic fabric was discussed both in general terms under Division One and in specific terms within the other 15 divisions of the specifications, at the appropriate place for each of the materials involved, including brick, stone, stucco, wood, and metals.[2] Yet despite all the instructions, none of these "normal" sections of Division One of the specifications addressed what the park personnel knew could occur.

Park Flood History

Being a mill town that developed at the confluence of the Potomac and Shenandoah Rivers, Harpers Ferry has seen its share of floods. Since 1877, when flood recording for the area began in earnest; and 1993, when design for the rehabilitation began, there had been 37 storms exceeding "flood stage."[3] Since 1944, when the area was established as a national historical park, the park administration has been entrusted with restoring, maintaining, and interpreting cultural resources that sit in a flood plain. The specific site of the seven buildings within the Lower Town is within the 20-year flood plain.[4] Any storm with a water-level crest of more than 24.3 feet would begin to flood the first floor of the corner buildings.[5] Twelve such storms have occurred since 1877.

The park administration initially developed a series of site-specific protective measures to enact in the event of a flood. These measures have been updated over time[6] and structured into a two-phased sequence, based upon flood "watch" and flood "warning" as established by the U.S. National Weather Service. Certain very specific operations will be "triggered" with each level of danger. The chain of command for both internal and media communications is clearly established. The documents set procedures for closing the park to the public. The park promulgates the requirements with their Flood Emergency Response Plan and provides this to all park staff. The plan relies heavily on all park maintenance and safety personnel.

Project Design Phase

In order to provide a similar level of protection for the historic resource in the event of a flood during construction, the park and design team jointly developed a new specification section included in Division One, titled "Flood Contingencies." The requirements of this section included:

- development of a Contractor's Emergency Response Plan
- a process to allow the park to review, modify, and approve the plan
- a system to test the plan, in the field, on a regular basis

The design team and park felt that it was important that the contractor develop his own plan, rather than rely solely on the park's existing document. The purpose of this was two-fold: the park's plan was not geared to construction circumstances, and perhaps more importantly, the team felt that the contractor was in a better position, both experientially and legally, to generate the plan. Typically, the contractor is responsible for the site during construction, for the "means and methods" of construction, and by extension, its protection, safety, and security. The park's plan was, however, made available to the contractor, and its incorporation into that overall plan was mandated. This assured a level of coordination between plans that would facilitate everyone's work effort in the event of a disaster.

At Harpers Ferry, part of the anticipated process of rehabilitation included the removal and temporary storage of historic fabric into trailers. Material included wood trim, doors, windows, shutters, and hardware. To protect this material, the specification section required the contractor to address the stabilization, relocation, and/or removal of these mobile facilities in the event of flood.

The method of establishing a state of flood emergency was required of the contractor's plan. At Harpers Ferry, the contractor chose to parallel the park's own system, so that the two plans would be in force simultaneously. Furthermore, the contractor's plan called for "checks," including mock drills, to be established that would assure that all construction personnel would be aware of the plan, and versed in its requirements.

One additional contractor requirement established by the General Conditions proved significant. The "Supplementary Provisions" of the General Conditions required that the contractor carry flood insurance for the duration of the construction.

The design, itself, of the rehabilitation also anticipated a flood-prone environment. Finish materials were chosen for their moisture durability. First floors of wood plank were designed with several removable boards covering concrete troughs that sloped to sump pumps. After a flood, the boards could be lifted up, and the mud residue hosed to the pump. Major equipment, including elevator machines and electrical panel boxes, were universally located above the first floor.

Project Construction Phase

The Lower Town of Harpers Ferry was subjected to two significant floods in 1996 during the period of construction (see Noble, p. 16). The first flood was associated with an unusual 36-hour January thaw that melted much of the four feet of snow then on the ground. Water level crested at a height of 29.4 feet, rising approximately five feet up into the first floor of the Lower Town buildings. The second storm, a September hurricane, brought both significant water and wind within a two-day period. For this storm, water crested at 29.8 feet.

The General Contractor's Flood Response Plan worked well. The park administration and the contractor communicated to establish both the Phase One and Phase Two states of emergency. At the flood-watch state, all vulnerable areas of the existing historic construction were checked. Unfinished areas of roofs were protected

East elevation of buildings 32 and 33A following the January 1996 flood, looking west. Site debris was deposited as the water receded. The trees behind the buildings were lost.

Close-up of buildings 33 and 34 during the January 1996 flood, looking southwest along Shenandoah Street.

with securely fastened tarps. Open wall or window areas were blocked off. Word was spread throughout the contractor's many sub-contractors of the flood state. At the flood-warning state, vehicles, trailers, and major pieces of equipment were moved to high ground. New materials stored inside the building were lifted onto scaffolds to keep them off the ground. Buildings were locked and evacuated.

After the floods, damage was assessed and clean-up efforts commenced. The contractor's plan was proven effective, as there was minimal damage, the majority of which could not have been prevented regardless of planning efforts. Site landscaping suffered and two 60-year-old trees to the west of Market Street were damaged beyond salvage. Mud and floating debris were strewn throughout the site. Site fencing, custom designed to allow visitors glimpses into the work area, was destroyed in about half of its locations and some small tools were damaged or destroyed. With regard to the buildings, some existing exterior stucco, originally designated for salvage and patching, had to be completely replaced. Inside, some first-floor gypsum wallboard below the five-foot line also had to be replaced and interior plaster walls required patching. Ultimately though, the damage was clearly and significantly reduced as a result of the team's efforts to develop and implement the Contractor's Flood Emergency Response Plan. To cover the costs of lost equipment and to address the damages and repair to the building fabric and the landscaping, the contractor was able to receive insurance for the two occurrences.

Conclusion

Many NPS cultural resources are located in areas prone to severe natural disasters—floods, earthquakes, or fire. Thoughtful planning for natural disasters can reduce damage to those resources undergoing major rehabilitation. Existing procedures for safety and protection promulgated by the park should be integrated into a contractor-generated Emergency Preparedness Plan. Review and mock drills of the plan should be required on a regular basis. The contractor should be required to carry special additional insurance to protect both the work and supplies and equipment against damage that could occur from the natural disaster.

Notes

1 GWWO, Inc., Baltimore, Maryland, was the architect for the Project, HAFE Package 116. Peter Dessauer, park architect, served as the on-site park representative. Callas Contractors, Inc., Hagerstown Maryland, was the general contractor.

2 Package 116, Specification Section 01530 "Barriers," Section 01100 "Archeological Protection," Section 01590 "Field Offices and Sheds," Section 01045 "Cutting and Patching."

3 Defined as 18.5 feet above the Shenandoah River's mean high level.

4 Flood areas are defined in terms of storm severity. The most common term is based upon the "100-year" flood, that defines the storm severe enough that on-average it is only expected to occur once every 100-years. The level to which water rises during this magnitude of storm is defined as the 100-year flood plain. Typically, new construction cannot occur within the limits of the 100-year flood plain, to protect both people and the environment. A building in the 20-year flood plain is considerably more vulnerable to flooding than one in the 100-year flood plain.

5 Buildings 33, 33A, and 32.

6 The latest edition at the time of the project design was dated March 1993.

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Photos by Peter F. Dessauer, AIA.

Dirk H. R. Spennemann

The Creeping Disaster

Dryland and Urban Salinity and its Impact on Heritage

Natural and anthropogenic disasters exert a continual toll on our historic heritage buildings and it is only prudent to assess the extent and potential impact of these phenomena.[1] The effect of dryland and urban salinity on heritage places is a good example of initially slow acting and then exponentially accelerating anthropogenic disasters.

Human-induced dryland and irrigation salinity and the concomitant losses in agricultural production are problems in many countries of the world.[2] These have also been recognised as a major form of land degradation in rural areas, particularly in southeastern and western Australia.[3] Only recently have government administrators, councillors, and local politicians awakened to the fact that salinity is not just a "brown" (agricultural) issue, but that it also very much affects the towns and communities in rural Australia. Dryland salinity currently affects about 2.5 million hectares of land, mostly in southern Australia. The 1999 Salinity Audit for the Murray-Darling Basin, the largest river catchment covering most of southeastern Australia, found that the current economic impact of Aus$ 46 million (US$ 30 million) per year is likely to increase over the next century to Aus$80 million per year (1999 dollars).[4] Nationwide primary and secondary damage is expected to total Aus$300 million (US$200 million) per year in the next five years.

Nature of the Problem

The human-induced natural disaster is caused by alterations of the water regime of many catchments following either massive land clearing or artificial irrigation. Rising water tables dissolve salts trapped in the rock strata and soil column and create highly saline ground water conditions. Urban salinity has become recognised as a growing problem. Rising ground water tables, coupled with dissolved salts, pose a major threat to the structural integrity of our infrastructure, such as sewers, pipes, and roads, but also sporting fields and parklands.[5] Historic buildings, archeological sites, and now entire historic towns several hundred miles inland suddenly face marine decay conditions.

The walling of stone and brick structures is prone to the ingress of moisture into the fabric. Most frequent are rising damp, where ground moisture is drawn into the masonry surfaces and the mortar bonds by capillary action, falling damp (e.g., leaking roofs, etc.), and penetrating damp (vie dew deposition or ingress by wind pressure). The extent of the damp is determined by the hygroscopic indices of the constituent materials, the availability of moisture, and the degree of evaporation. The level of rising damp (head) can be as high as 4m above ground level.[6]

A damp-proof course is a course of stone or other material introduced between the foundation and the walling, and used to prevent intrusion of water into the wall by means of capillary action. Damp-proof courses were traditionally made of slate, but tar, bitumen, and (today) plastic lining were also used.[7] While these damp-proof courses can decay in their own right, due to chemical decomposition, they more commonly fail due to differential settling of the foundations or are by-passed by inappropriate building alterations or landscaping.

Moisture ingress, per se, does not present a major threat to a structure, but sets up conditions ripe for wet rot of timbers, flaking of renders, moulding of wall papers, and so forth. Compounding the problem of rising damp is that in urban salinity environments soluble salts from the ground water and soluble compounds from the material are carried with the rising moisture to the surface of the building material, adjacent to the external atmosphere. There, the water evaporates and the salts re-crystallise in the pore spaces or on the surface. As crystallised salts

occupy a greater space than dissolved ones they set up great mechanical stress exceeding 138,000 kPa (20,000 psi), causing internal rupturing of the building fabric.[8] In addition, salts attract moisture—and by implication more salts in solution— leading to the growth of salt crystals ("blooms"). Over time, the masonry elements collapse (spall), setting up conditions for structural failures to occur.[9]

Chloridation effects are not confined to structures but affect archeological sites and deposits as well. In general, all porous materials in contact with soil moisture are susceptible to salt attack. Unlike structures, however, small artefacts are usually so thin that the stresses created by the expansion of the salt can cause artefacts to break up. The artefactual material is at risk mainly during the initial moistening phase, when the ground is not yet perpetually waterlogged and the moisture levels in the ground are subject to fluctuations. Once the item has been removed from the saline environment and is allowed to dry, the salts will expand and cause the object to flake, eventually destroying it.[10]

There is a wide range of pottery in the European material culture in Australia, ranging from low-fired irdenware (glazed ceramics) to hard-fired, very homogeneous porcelain. The latter is very much evidence of the economically better off. Since porcelain is impermeable to moisture it will last in immersion in saline or even marine waters, while normal pottery decays in a similar way to bricks. Thus, over time, the salinity will further skew the social representation of our heritage.

Rising damp and salt attack, chimney of cook house, Murray Downs Homestead, Swan Hill, NSW. Note the salt efflorescence at the bottom and the extent of the mortar loss. Photo by the author.

The bulk of the artefactual material in the Aboriginal sites in much of southeastern Australia is comprised of quartz tools. The crystalline structure of quartz allows the ingress of moisture along fissure lines. Seasonal ground water fluctuations can lead to the crystallisation of saline moisture in the quartz resulting in increased fracturing of quartz artefacts while still in place. There is a real prospect of large-scale destruction of archeological material while still in the ground and seemingly protected.

In many cases the historic buildings cannot be divorced from their surrounds as some of the projected cultural values derive from their setting. These cultural landscapes can comprise rural portions, such as vineyards, orchards and field systems, or urban areas. The latter can range from fully-landscaped gardens to purpose-planting of food, herbal and utility trees around homesteads, and from botanical gardens to street tree plantings. In these situations, salinity is likely to have variable effects on the health and viability of individual trees, shrubs, and other plants. Depending on their salt tolerance, some plants will either grow more slowly and become stunted or die, but taken together these effects will demonstrably alter and most likely diminish the character of a heritage place.[11]

Extent of the Problem

Historic structures, which make up the streetscapes and hearts of most rural towns of the Murray-Darling Basin, are certainly at risk.[12] At present the extent of the problem is being analysed in greater detail. One case study has looked at the impact of urban salinity on the built environment of Wagga Wagga, a town situated on the western slopes of southern New South Wales (NSW) approximately 500km southwest of Sydney and 440km north of Melbourne.[13] Wagga Wagga has been one of the first NSW towns to suffer from the consequences of urban salinisation.[14] The extensive land clearing and the area's climate, topography, geology, soils, and vegetation have all contributed to the

increase in salinity in the region.[15] Approximately 60% of the urban area of Wagga Wagga is identified as being at risk of salinity damage.[16] The city's particular susceptibility to salinity problems has been attributed to its location in a constricted catchment and an unstable water table.

Mitigation Options

Historic buildings and monuments are the most immediate and visible aspects of our cultural heritage. They provide links to our shared past and act as emotional anchors in an ever-faster changing present. For that reason, conservation movements the world over are working to preserve those places deemed culturally, historically, and socially significant. It is imperative that the salinity-derived decay processes are halted before the building fabric is severely damaged, because the loss of significant cultural heritage places, which are emotional anchors to our past, has immense social costs.[17] If several less significant places in an ensemble are lost, the character of a town will change. Heritage buildings and streetscapes are tourist attractions which furnish revenue for several places.

The principles of moisture ingress and the impact saline solutions have on the structural integrity of building fabric are well understood.[18] A number of mitigation options exist before and after ingress of saline water has occurred. Most of the strategies are intrusive into the building's fabric, such as repair of a damp-proof course; electro-osmotic systems; high capillarity tubes; inserting moisture-impenetrable floors; injection of a moisture barrier; and perimeter drains.[19]

Institutional Attitudes

This, however, requires that government agencies, communities, and the individual householders are prepared to take action. While the current and projected costs are immense and should place salinity high on the public agenda,[20] many urban communities do not perceive salinity as a major problem,[21] despite public education programs.[22] Often outright denial occurs due to a perceived stigma and a real, or perceived, decline of property values. There is an urgent need for town planners and heritage managers to appreciate the potential dangers posed by dryland salinity and rising ground water tables. But does this happen?

Kristy Koen conducted a limited survey of town planners and heritage managers in the Southern Riverina to assess their awareness of the potential dangers posed by dryland salinity and rising ground water tables to heritage places. The survey encountered a generally low level of awareness, as well as denial that the problem existed in their shire, whilst it was well recognised in the neighbouring shire. Her findings demonstrated the need for a more systematic assessment of the problem across the entire Murray-Darling Basin.

This author carried out a survey of the perceptions of local government heritage managers related to the incidence of salinity and its impact on heritage in 149 local government areas in the Murray-Darling Basin. It showed that salinity is regarded primarily as a rural problem affecting predominantly agriculturally productive land. Urban areas were not seen at risk. In comparison to other threats potentially impacting on the cultural heritage places in the local government areas salinity was seen as one of the least significant threats; in Australia, only extremely rarely occurring earthquakes received a lower ranking.[23] The general level of apathy toward the issue is worrisome.

Outlook

Even though the process of salinisation is slower than that of most natural disasters, the same problems of disaster preparedness and mitigation occur. Because of the slow onset, the perceived stigma and associated loss of property values, most communities are in a state of denial, akin to the social phenomena observed for earthquake preparedness. Unfortunately, this state of denial also extends to the heritage professionals, who, at face value, rightfully contend that techniques exist to treat salt-affected buildings. What most professionals fail to recognise, however, is that the salinisation and rise of the urban water tables will not place one or two buildings at risk, but a large suite of significant structures in a town, and that successively several towns will be affected. Unless planning and mitigation of potential impacts occur before the structures exhibit signs of salinisation, much of the heritage of rural southeastern Australia may be damaged.

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Giorgio Croci

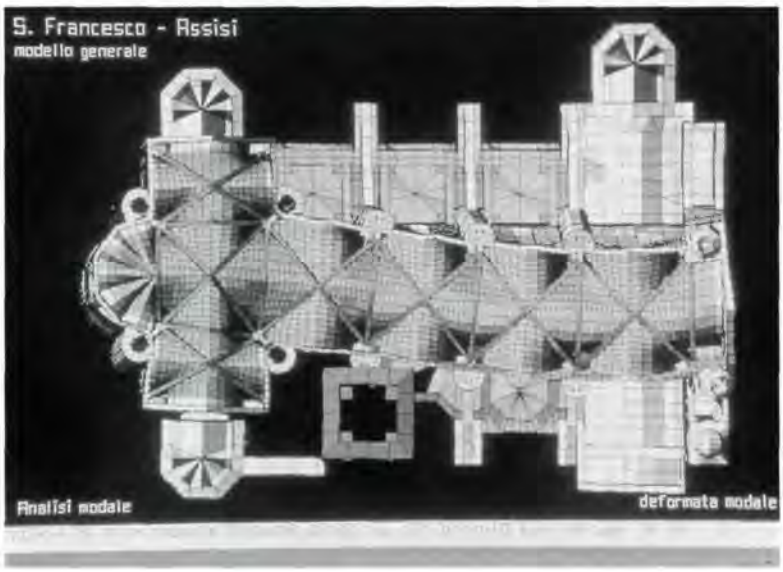
Restoring the Basilica of St. Francis of Assisi

The Basilica of St Francis in Assisi was severely damaged by earthquakes and aftershocks in September and early October 1997. After emergency measures had stabilized the structure (see *CRM* 23:6, 2000), a detailed monitoring and mathematical modelling study was carried out. This paper reports on these processes.

Seismic Forces and Mathematical Models

On September 26, 1997, the ground acceleration close to the basilica measured about 0.16g[1] in the direction of the longitudinal axis of the basilica nave and about 0.18g in the direction perpendicular to the nave. Considering a reasonable amplification factor for the vertical structures, it is likely that the top of the structure reached a transversal acceleration of around 0.36g.

Expected major earthquakes for the Assisi area are at least 1.5 times stronger than the earthquake of September 26, 1997. Moreover, the basilica nave and the monastery are located on a hill oriented in an east-west direction. In the north-south direction the nave is very tall and narrow which provides little resistance to seismic forces. This results in local amplifications and acceleration in case of north-south seismic forces larger than that in the center of the city of Assisi. These considerations bring us to take into account a possible maximum ground acceleration of around 0.3 to 0.35 g, in the perpendicular direction with respect to the basilica nave (longitudinal axis).



One of the modes of vibration of the global model.

The measurements taken on occasion of the numerous seismic events during 1998, show transversal acceleration at the top of the vaults from 3 to 8 times larger than those on the ground. These amplifications are much larger than that evaluated for the September 26 earthquake; therefore, two things must be considered: during stronger earthquakes, when parts of the structure exceeds the elastic limit, there is major energy dispersion and therefore the amplification is reduced; and the removal of the fill in the springer zones, as carried out as part of the emergency stabilization, increases the local amplification of the vaults.

On the basis of the previous considerations, and also considering the present damaged state of the vaults, it is prudent to take into account dynamic amplification (from the ground up to the top of the vaults) to a magnitude of four times. Based on this, the design for the reinforcements for horizontal transversal acceleration, at the level of the vaults, assumed an acceleration of 1.2 to 1.4g.

Structural Analysis

Various mathematical models have been prepared to study the structural behaviour under the worst scenario, the effect of seismic forces perpendicular to the axis of the basilica. The general model of the basilica shows that, in addition to the local effects due to the fill, the vaults close to the façade and the transept take supplementary stress caused by the restraint produced by façade and transept.

The model of a central module of the nave with the fill (situation before September 1997)

clearly shows that high tensile stress is produced in the ribs and the curvature is reduced even in static conditions under the effect of dead loads. A preliminary step-by-step analysis with horizontal statically equivalent forces shows that when seismic forces reach approximately 0.18g, cracks and permanent deformation occurs, and that with forces between 0.25 and 0.30g the vault may collapse. These values of the seismic forces are comparable with the values induced by the earthquakes of September 1997. The values also explain the great damage everywhere and how the vaults near the façade and near the transept, which received the additional stress, collapsed.

The model of a central module of the nave, without the fill refers to the deformed shape of the vaults, as it has been surveyed; however, it neglects the stress accumulated as a consequence of deformations. This approximation is partially justified by the presence of the cracks, but it would be impossible to evaluate this stress reliably. A first elastic analysis shows that stresses are significantly reduced after the removal of the fill. Considering horizontal statically equivalent forces, a second step-by-step analysis shows that great deformation develops when the horizontal seismic force on the vaults reaches approximately 0.4g (compared to 0.18g with fill). Collapse occurs between 0.6 and 0.7g (instead of 0.25g to 0.3 g with fill). This improvement, however, is not sufficient to deal with the maximum expected earthquake.

A step-by-step analysis of the model of the reinforced vault, taking into account the reinforcement ribs connected with the extrados of the vaults, shows that deformation is greatly reduced and the vault's behaviour is largely improved. When the horizontal statically equivalent force reaches the design value of 1.2g the stress in the reinforcements reaches half of the strength. The mathematical model also shows that large partialisations and deformations of the vaults occur only when the horizontal acceleration reaches 1.6g.

Research and Testing

The problem of the definitive restoration and consolidation of the basilica was complex. Because of the presence of the frescoes it was impossible to reduce the deformation and to re-establish an adequate curvature and autonomous bearing capacity. Different solutions were modelled to decide how to best strengthen the vaults and secure their stability over time, without creating a risk to the frescoes and without compromising the historical value of the original vault's structure. The option of building a reinforced concrete shell or reinforced concrete ribs on the extrados, was rejected *a priori*, as too heavy and incompatible with the historical value of the monument. The use of steel ribs was rejected as well because of the difficulty to follow the deformed shape of the vaults and, consequently, to obtain a continuous connection between ribs and vaults.

The solution chosen was to use composite materials to create a series of thin little ribs following a pattern typical of Gothic structures on the vault's extrados, leaving the original structure clearly visible. These ribs are built in situ, so that it is possible to follow the deformed shape of the vaults; while the width of the ribs remains constant, the height may then change in relation to the deformation of the vaults. In essence, the extrados of the ribs can follow a regular curve parallel to the original ideal surface of the undeformed vaults.

The ribs are made of aramid fibres bedded in epoxy resins around a central timber nucleus. These fibres are light but very strong.[2]

Samples of the constituent materials and of the composite ribs have been tested. As of 1997, there had been not much experience on the application of these products to consolidate historic masonry structures. The tests allowed refinement of the design of the ribs to improve their mechanical characteristics and to reduce their section to a minimum. The strength of the ribs was increased by inserting unidirectional aramid fibre bars in the intrados. Unidirectional glass fibre bars were inserted in the extrados because glass fibres have higher performance under compression stress.

The decision to utilize a central nucleus was made because this guarantees higher resistance and energy dissipation and prevents any buckling of the thin webs of aramidic fabric. In addition, the ribs could be built faster with a central nucleus.

Several different materials were tested for the nucleus: rigid foams, different types of wood, and composites of wood plus foam. Mahogany nautical plywood was chosen stratifying several layers of plywood each over the other. The use of cross-directional plywood, instead of layers of simple wood, reduces the transversal core expansion under load action. Very homogeneous

mahogany wood guarantees high resistance and stiffness to compression while the nautical treatment, according to the strictest standards, results in a wood of high durability and very resistant to decay. The wooden layers, glued on site, permit following the deformed shape of the vaults.

Pull tests were performed to verify the adhesive capacity between composite elements and masonry both in the case of direct gluing and through aramid fibre pivots. Cyclical tests have shown good conservation of bearing capacity beyond the yield point with good ductile behavior.

Reinforcement of the Vaults

The strengthening of the vaults consists of the new ribs connected at the extrados; the anchorage of the ribs at the roof; the grouting of the cracks; the connection of the arches, which support the roof, to the perimetral walls; and the steel beam placed in the nave over the cornice of the walls.

The Ribs

The rib pattern consists of:

- a couple of ribs placed parallel to the transversal arches, the most sensitive and weak in an earthquake because of their reduced or missed curvature
- a series of ribs placed just over the diagonal arches
- smaller ribs placed over the webs
- longitudinal ribs placed on the vault crowns and at mid height of the vaults

These ribs are fabricated in place in layers of various materials. The construction phases are:

- On the vault extrados surface, after an adequate cleaning, the first four-directional (0°, ±45°, 90° angle ply) tissue of aramid fibre of 230gr/m^2 is glued using epoxy resin.
- Over this first layer, the pultruded[3] flat aramid fibre bars are glued and covered by a second tissue of aramid fibres.
- Subsequent strata of mahogany plywood layers are placed to create the rib core.
- The wooden core is then covered by a third four-directional aramid fibre tissue 360gr/m^2, heavier than the previous ones, as it is expected to be part of the stratification of the composite lateral walls of the rib.
- At this point, the pultruding flat fibre glass bars are glued.
- Finally, everything is covered with another four-directional aramid fibre tissue of 360gr/m^2.

The reconstruction of the vault.

Anchoring the Ribs

The ribs are connected to a system of tie bars, which are anchored to the roof. Each tie bar includes a spring, similar to the solution adopted for emergency stabilization measures. This reinforcement reduces the deformation under seismic forces.

Grouting the Vaults

The reinforcement of the vault's cracked structure, where continuity has been compromised, has been created using a specifically formulated mortar. This mortar is salt-free and compatible with the frescoes, sufficiently fluid to penetrate into all the cracks and micro-cracks; capable of being injected in dry masonry (no use of water is allowed), and possesses good strength and bond capacity establishing structural continuity through the cracks.

Anchoring the Main Arches

The masonry arches supporting the roof stand on little vaults, which are situated over the springers of the main vaults without any structural connection and with a certain eccentricity with respect to the main pillars. Therefore, it was decided to anchor the base of the arches at the walls and the towers behind them, which in this very peculiar Italian Gothic structure, have the function of abutments. The anchoring consists of a steel belt and pre-stressed horizontal bars.

Trussed Beam

Over the centuries, the frescoes on the walls have frequently suffered damage and cracks due to the deformation caused by earthquakes, even if, fortunately, the wall resisted and never collapsed. To limit this phenomenon, a horizontal

The cylinders that contain the special anchorages connecting the tympanum and the roof.

steel trussed beam has been placed over the cornice of the walls inside the basilica (immediately below the stained glass windows), to stiffen and strengthen the walls covered with Giotto's frescoes. The connection between this beam, which runs along the perimeter, and the walls has been created with special viscous devices which allow relative displacements due to thermal effects, but become rigid under dynamic forces and provide full strength in the event of earthquakes (shock transmitter).

Reconstructing the Vaults

The reconstruction of the collapsed vaults was a major problem. Fortunately, after painstaking research, several frescoed bricks were identified that could be re-used to re-build the vaults.

The operation has been particularly successful with regard to the pieces of ribs, which have maintained a good bond between the bricks, forming voussoir-like elements, even though they fell 25 meters. In the laboratory it was possible to re-assemble the broken parts of ribs in such a way as to create voussoirs 40 to 60 cm long. These voussoirs were then placed on a provisional centering to rebuild the ribs.

It has not been possible, on the other hand, to recover significant elements of the webs, so that new bricks, especially made to have the same substance and similar characteristics of the originals, had to be used. The reconstruction of the vaults took into account the problem of re-establishing not only a structural, but also a stress continuity between the new and the original portions of the vaults. To compensate the deformation, including the shrinkage of the mortar, and to calibrate stress distribution, a system of jacks was placed in a provisional joint on the crown of the new vaults.

Reconstructing the Tympana

The restoration of the basilica was completed with the reconstruction of the collapsed portion of the left tympanum and the removal of the deformation that both the transept tympana suffered. Stones from the original quarry were used.

To reduce seismic forces transmitted to these tympana, which although consolidated remain delicate structures, the connection between it and the roof was created interposing special steel devices, composed of shape memory alloy, able to dissipate a certain amount of energy.

Conclusions

The operations to save and then to consolidate and restore the Basilica of St Francis of Assisi have all followed the same philosophy:
(1) to place the most up-to-date techniques and technologies at the service of culture in order to respect the historic value of the ancient building and (2) to obtain adequate safety levels while changing as little as possible the original design. Some of these technologies, never applied before in the field of restoration, were studied specifically for this occasion, offering new and interesting possibilities for the safeguarding of our architectural heritage.

Notes

1 g being equal to the force of gravity.

2 The tensile strength of the aramid fibre used is 30,000 kg/cm2 and that of the fibre with resin is about 14,000 kg/cm2. It is less stiff than steel, the elasticity modulus of the fibre being 1,200,000 kg/cm2 and that of the fibres with resin 600,000 kg/cm2.

3 Pultrusion is a manufacturing process for producing continuous lengths of reinforced plastic structural shapes with constant cross-sections.

4 The study and the project have been prepared in collaboration with architect Paolo Rocchi, and the participation of engineer G. Carluccio, under the supervision of Dr. Antonio Paolucci, the artistic coordinator of the Ministry of Cultural Heritage, architect Costantino Centroni, superintendent of Umbria and Dr. Giuseppe Basile, of the Italian Institute of Restoration and frescoes expert. The mathematical models have been prepared with the cooperation of engineer Fabio Sabbadini, engineer Alessandra Carriero, engineer Marco Losappio and Architect Herzalla Aymen. engineer Alberto Viskovic has also participated in the testing of the new materials and the design of the reinforcements.

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Illustrations by the author.

June Taboroff

The World Bank and ProVention

International Disaster Relief and Protection of Cultural Heritage

When disaster strikes in the developing world, chances are that the World Bank and the ProVention Consortium will be on the scene. With their central mission to alleviate poverty and promote socio-economic development, these two organizations inevitably are called upon to provide assistance. In many cases cultural heritage is damaged. As part of its disaster response and when requested, the Bank will work with governments and communities to protect and rehabilitate key cultural assets.

The poor are particularly vulnerable to loss when natural disasters strike. In historic cities where cultural sites are dense, whether in Mexico City or Tblisi, Georgia, low income households are often proportionally over-represented and thus are more likely to suffer when disaster hits. They are also less likely to be able to mobilize the resources needed to repair damaged historic buildings. Natural disasters often aggravate already vulnerable situations. Chronic lack of maintenance of historic buildings and inadequate infrastructure services exacerbate damage from disasters. In the case of the historic center of Tblisi, buildings already weakened by water damage from leaking pipes and inadequate maintenance were dealt a death blow by earthquakes which brought historic buildings down on their inhabitants heads

Reconstruction of traditional housing. Photo courtesy Donald Hankey.

The World Bank is the largest of the international development agencies; and the ProVention Consortium is a global coalition of governments, international organizations, academic institutions, the private sector, and civil society organizations aimed at reducing disaster impacts.

The World Bank's Experience

The World Bank has extensive experience in reconstruction after disasters. Since 1980, the Bank financed some 200 disaster-related projects of which about half were for reconstruction (over US$7.5 billion lending) and half included components for mitigation (over US$6.5 billion lending). Over time, the Bank's understanding of the importance of the built historic environment and its experience in heritage conservation have grown, and consequently disaster projects today are more likely to include measures to rehabilitate cultural heritage.

Emergency projects account for about 70% of the reconstruction operations approved by the Bank since 1980. Borrowers generally give a high priority to housing reconstruction after a natural disaster, but Bank projects focus more on repairing infrastructure and damaged community facilities as well as economic recovery through emergency import support.

Reducing Losses

The Bank and borrowers are now developing a greater awareness of the need to mitigate or reduce the adverse effects of natural disasters before they strike. Most of the natural disaster mitigation projects have addressed three likely weather-related events: floods, forest fires, and droughts. Institutional development is extremely important for mitigation to promote disaster awareness, planning, and early warning systems. As part of institutional development, the enforce-

ment of land-use and building codes to avoid settlement in areas prone to hazards or in vulnerable structures has been widely pursued by these projects.

The Bank has financed a number of projects in historic cities. For example, in 1996 the Government of China requested the World Bank's assistance after an earthquake in Lijang, Yunnan province. The cultural heritage component of the project concentrated on the rehabilitation, reconstruction, and conservation of the historic town and traditional buildings in the province (especially Lijang and Dayan City), paying particular attention to improving the safety of traditional buildings.

The Chinese were very eager to make immediate repairs, and the Bank worked with their counterparts and the Lijang municipal government to ensure adequate control of the quality of work and materials so that work would be carried out in a manner to reduce the impact of future disasters, introduce improved sanitation and services into housing, safeguard the historic environment in Lijang and elsewhere, and provide training for local residents and construction industry to disseminate best practice in earthquake resistant building techniques. The project is now in the final stages of implementation and Lijang has been proposed for listing under the World Heritage Convention.

Projects such as the El Nino Emergency Assistance in Bolivia or the Georgia Cultural Heritage Project have helped rehabilitate historic towns damaged by natural disasters. The Bank also has many post-conflict projects that help repair countries destroyed by civil strife. Bosnia, West Bank-Gaza, and Romania are cases in which cultural heritage conservation activities have been undertaken. A series of projects that have supported national inventories of cultural heritage, in such countries as Tunisia, Yemen, and Georgia, represent Bank financing for planning tools that will be useful in the case of a disaster.

Priority Issues

There are many imperatives that can be drawn from Bank experience of natural disasters that are relevant to the goal of sustainable development and to improving protection of cultural heritage:

- Incorporate disaster management into development planning;
- Assess natural disaster damage and loss potential as part of overall development work;
- Calculate the costs and benefits of natural disaster management and use to weigh decisions;
- Share the costs and benefits of natural disaster management with potential victims;
- Get the appropriate incentives for disaster management—and get them right.

We may well ask why mitigation measures have not been incorporated into national policy. There are three major constraints that hinder mitigation investment in developing countries. These constraints are also opportunities for conserving cultural heritage by adapting traditional building materials and methods.

Affordability. Low-income urban families find it difficult to afford investments to strengthen their dwellings to make them more disaster resistant. Thus, raising their incomes through economic and social development must remain a top priority and the availability of low-cost technologies to reinforce dwellings can be beneficial. It is also important for governments to review legislation and regulations that effectively encourage lack of maintenance. For example, controls setting ceilings on rental payments leave landlords without the means to pay the proper maintenance of their properties so that structures deteriorate and become vulnerable to disasters.

Cost effectiveness. Emphasis on lowest cost solutions for construction may not always lead to disaster resistant structures. Mitigation must be factored into cost effectiveness, which may often lead to the use of local materials and technologies, when proven to be resistant to further damage from disasters.

Short attention spans. In the immediate aftermath of a disaster, with images of human and material losses vivid, mitigation investment is a high priority in both the eyes of communities at risk and local and central governments. This fades quickly with time. It is imperative that decision makers have rapid access to information about the cultural heritage and traditional building materials and techniques of proven durability.

While constraints to mitigation investment should be removed to ensure that incentives are in place, they need to be financially worthwhile. For example, if a government rewards a household with a new dwelling to replace a poorly maintained historic one lost in an earthquake, it is an incentive for other households to disregard necessary maintenance. To compound this wrong message, authorities sometimes overlook households that take mitigation measures to reduce the

Tblisi, Georgia, earthquake damage. Photo by the author.

risk of losses. Similarly if the amount of multilateral assistance offered to disaster-struck countries is proportional to the losses and damages they suffer, then countries have no incentive to mitigate their vulnerability to natural disasters.

ProVention Consortium

Recognizing disaster risk reduction as a feature of sustainable economic and social development has motivated changes in the way in which disasters will be handled. The World Bank's Disaster Management Facility was established in July 1998, to provide proactive leadership in introducing disaster prevention and mitigation practices into development-related activities and improving emergency response. A year later this was followed by the first meeting of the Consortium on Natural and Technological Catastrophes (now ProVention) which gave impetus to the formulation of a comprehensive and coordinated approach to disaster management. The Consortium functions as a network to share knowledge and to connect and leverage resources to reduce disaster risk.

ProVention Consortium projects focus on the links between disasters, poverty, and the environment and fall into three general categories: hazard and risk identification, risk reduction, and risk sharing/transfer. Some projects involve a mix of such activities. Outputs include research projects, pilot and demonstration projects, education and training activities, and workshops and conferences. From the outset, the importance of cultural assets has been noted.

The Consortium aims to mainstream disaster reduction best practice into donor and beneficiary policies, disseminate best practice to government and institutions, strengthen specialized institutions in the developing world, and expand knowledge on disaster prevention. Constituted by more than 70 organizations, it shares worldwide experience on policies and practices to reduce vulnerability and negative impacts of natural and technological disasters in disaster-prone developing countries. To reduce losses from natural and technological disasters, ProVention concentrates on four complementary actions: donor coordination; promotion of a culture of safety through education, training, and dissemination; forging links among public, private, and civil society and between the scientific community and policy makers; and support for pilot projects.

The Developing World

There is a pattern of high vulnerability of cultural heritage in the developing world to natural disasters, a weak record of implementation of protective measures to control or limit damage, exacerbated negative impacts, and lengthy recovery time. Among the causes of this vulnerability is the inadequate knowledge of appropriate mitigation measures and of the assets themselves.

Bridging the worlds of international development, disaster relief, construction industries, and cultural resource management can result in real advances in protecting the historic built environment. But it entails adjustment in key policies:

Knowledge. Inventories of cultural heritage need to be compiled, and cost effective products and techniques for mitigation and reconstruction of historic buildings need to be developed.

Delivery. Knowledge about reducing vulnerability of historic buildings needs to be transferred from experts to the people affected.

Decisions. Policy makers will need to be convinced of the importance of adopting vulnerability reduction measures and make decisions accordingly. A quantitative framework is useful for evaluating options. Relatively simple loss estimation techniques could have important roles in defining cost-effective and appropriate strategies.

Those responsible for cultural resources in the developing world may wish to work with the World Bank and ProVention in order to reduce disaster risks and impacts.

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Randolph Langenbach

A Rich Heritage Lost
The Bhuj, India, Earthquake

Last March I flew into Bhuj, the city in Gujarat, India, that was the center of the area devastated by the earthquake of January 26, 2001. From the air the view of Bhuj belied its true condition. From that distance the city seemed quite normal—with many tall blocks of apartments seemingly standing unharmed. On the ground, however, the scene was quite different. The first close-up view of those same large apartment blocks showed them to be leaning at odd angles, with their first floors collapsed and their upper walls laced with cracks like a crazed china pot.

While the city now contains many modern reinforced concrete buildings, Bhuj was originally an ancient walled city, and it still has both part of its original fortifications and many historical buildings within the city core. Some of the fort walls had survived the vicissitudes of time, only to now be heavily damaged by the earthquake. The battlements had fallen. Large areas of the facing stone had come off. In some places only the inner rubble stone core remained standing.

The first view of the inner precincts of the walled city of Bhuj was shocking. In the area immediately inside the city gate, the buildings had almost totally disappeared into rubble piles that lay along either side of the road like great waves. Riding on these "waves" were the still whole pieces of the upper floors of broken newer concrete buildings.

City Palace, Bhuj, India.

These waves of rubble were the result of the first phase of plowing of the rubble to clear the streets–which were still only narrow tracks between the piles. The scene was so awesome and foreign to one's experience that the only familiar metaphor that came to mind was a scene further north after a great blizzard when the streets are first cleared, leaving mountainous piles of snow as walls on either side. This rather benign image, by comparison, came to mind largely because the comprehension of the vastness of the total devastation of this section of the city had no precedent. Earthquakes seen before in the United States, and even in Yugoslavia, El Salvador, and Mexico City, had left damaged or even collapsed buildings here and there. Here, by contrast, one was confronted with a view of total devastation. As far as one could see, everything within view had either totally or partially collapsed.

This same scene was repeated in the nearby smaller cities of Bachau and Anjar, and in many of the smaller villages of the Kutch District of Gujarat. The city of Bachau was even worse off—there, close to 100% of the buildings in the city had collapsed, killing approximately 25% of the population. Stone and timber or reinforced concrete–it did not seem to matter; the earthquake destroyed them all.

Earthquakes have visited this district of Kutch repeatedly over the centuries. The last great earthquake was in 1819, but smaller ones have damaged and destroyed buildings a number of times in the 20th century. The area is also rich with cultural heritage, and the earthquake was particularly cruel to many of the architectural relics that embody that heritage. Many of the cities and towns across western Gujarat had been independent princely states, each with its own Maharaja, with palaces and all the trappings of royal kingdoms. Since India's independence in 1947, these palaces became the private homes of the now powerless Maharaja families. Despite the

Surviving house, Anjar, India.

fact that they remained full of the art and culture of the region, nowadays they are not under any heritage protection and often they are not maintained. Now, the earthquake has turned many of these former palaces into ruins.

From the technical standpoint, the survey of the ruins of both houses and palaces revealed some interesting facts about the older traditional construction. What seemed most startling was the fact that, despite the local history of seismic risk, there was so little evidence of any mitigation of that risk. Of those buildings that were not now formless heaps and thus could be examined, it almost seemed that they were designed to fall down. The walls were constructed mostly of random stone rubble rather than bedded ashlar. They were laid up with mud mortar with little keying together at the corners and no through-wall bond courses. These walls sometimes were extended up to over 15 feet in unbraced height, simply to support the ridge of the roof to avoid the use of wood necessary to build a roof truss. Floor joists were often laid into the walls in pockets only a few inches deep, so that collapse was inevitable with only the slightest of sway.

The construction near the earthquake's epicenter in Kutch contrasted with that found in nearby Ahmedabad, where the construction tradition more closely resembled that found in Turkey, and even in Kashmir. In Ahmedabad, many of the traditional buildings within the Old Walled City area had timber lacing in the walls, and exhibited other elements that have proven to make them more resistant to earthquake damage than the stone construction found in Kutch. As a result, only one building is reported to have collapsed in the Old City of Ahmedabad, and the damage there was far less (although the shaking of the earthquake was significantly less than in Kutch, but nonetheless strong enough to collapse a number of reinforced-concrete high rise apartment buildings of recent construction, with high rates of casualties).

Even in Kutch, however, there were a number of interesting anomalies. In Bhuj, while certain areas were totally leveled, even a few blocks away one can still enter parts of the city that were comparatively unscathed. The only explanation can be local differences in the ground shaking. Another interesting observation is that buildings with balconies often did dramatically better than ones without. In a scene which was repeated a number of times, lightly damaged balconied walls overlooked a sea of rubble of collapsed buildings around them. The only plausible explanation for this is that the floor joists, which extended through the rubble stonewalls to support the balconies, were more successful at stabilizing the walls than were joists terminating in pockets.

What these surviving buildings illustrate is that, in the end, a significant amount of seismic mitigation can be achieved from small differences in construction methods. These few surviving structures were not strengthened with shotcrete, and they lacked the strong diaphragms and wall ties that even the most basic upgrade requirement in the United States would mandate, but seismic safety does not depend on absolutes. It exists as a continuum. When one looks at the vastness of the problem of dealing with seismic safety in poor regions of the world, high-tech and expensive techniques are worthless if they cannot be executed because of their cost and disruption. The buildings with balconies that survived are just one example where one can learn that seemingly slight differences in construction can lead to significant differences in behavior. It is knowledge and recognition of these differences that may in the end be most useful in saving lives and preserving the cultural heritage of seismically active regions of the world.

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Photos by the author.

Rosemary Hollow and Dirk H. R. Spennemann

Managing Sites of Human Atrocity

Natural disasters, large scale industrial accidents, and acts of human atrocity initiate a strong emotional response in the community immediately affected by the events. In the current age dominated by extensive media coverage of all "spectacular" events, the localised impact is quickly one of regional, national, and even international proportions. The terrorist attacks on the World Trade Center and the Pentagon illustrate this all too well.

The immediate response of those affected may be to remove all traces of the event, but heritage managers need to consider preserving the physical remains of at least some of the sites as evidence of the events that occurred. We will address this issue by discussing the management of sites of human atrocity.

The management of an atrocity site raises a number of complex questions for cultural heritage managers. Can and should the site be preserved? Who should be consulted about decisions on the site? Who has responsibility for decisions about the site? Should events at the site be interpreted?

The management of atrocity sites is not a new topic. There are the cemeteries in Europe marking the sites of the atrocities of the Great War. Historic churches bombed out during World War II are conserved in their state as ruins in many German communities as reminders of the atrocities of war. In both instances the majority of decision makers decided on community memorials.

The remains of the concentration camps at Auschwitz and Dachau are reminders of the destruction wrought on the Jews in Europe in World War II. However these areas were not managed as heritage sites until some time after the atrocities had occurred. With more recent atrocities, decisions about the management and conservation of these sites had to be made while the survivors and the families of the victims were still coming to terms with the tragedies that had occurred.

The 21st century opened with terrorist attacks on New York City and Arlington, Virginia, where three civilian airliners were crashed into occupied buildings, resulting in a death toll exceeding 5,000 people. In view of the sheer magnitude of these events, previous occurrences, which are the focus of this paper, almost pale in significance.

At the end of the 20th century there were three massacres at three different sites on three different continents. In Oklahoma City in April 1995, 168 people were killed by an explosion from a homemade bomb in the Murrah Office Building; in Dunblane, Scotland, 16 children and their teacher were killed by a single gunman in March 1996; and in April 1996, at Port Arthur Historic Site in Australia, 35 people were killed by a single gunman. How have these sites been managed—as sites of atrocities and because of these atrocities—sites that are now part of our heritage?

In both Oklahoma and Port Arthur there was public consultation about the future of the sites. The issue of consultation raises the question about who has the responsibility for decisions about the site. Is it the actual owners of the site, the survivors and families of the victims, the local community, or the broader national or international community? The immediate response to all three massacres indicated a huge community concern about the atrocities. The areas became sites of collective mourning. Consultation with survivors, families of victims, and the broader community—those who feel some ownership of the site—is an important part of the healing process.

At Port Arthur, 20 of the victims had been killed at a café at the historic site. The immediate response of the staff at the site (some of whom were related to or had worked with some of the victims) was that the building should be demolished. The building was left standing until the trial of the gunman. After the trial, some of the building was demolished. However, following concerns by members of the community and heritage professionals, the Australian Government's Heritage Commission intervened and the walls were left intact while a conservation study of the site was undertaken.

In Oklahoma City, over 300 buildings were damaged by the explosion. Many buildings were

structurally damaged and, along with the Federal Office Building where the explosion occurred, were demolished. As happened at Port Arthur, there was debate about clearing away the evidence of the atrocity that occurred as part of the rebuilding and healing process. A façade of a building which faced the Federal Office Building has been left intact as evidence of the effect of the bombing on the wall. The massacre at Dunblane occurred in the gymnasium in the primary school. The gymnasium was demolished shortly after the event, and the school continues to operate in the surrounding buildings.

The management of an atrocity site will impact not only the survivors and their families, but also on the public memory of the event. The significance of these sites to the community may change over time as healing about the events progresses. The passage of time has seen the sites of concentration camps and atomic bomb explosions take on international significance and be declared World Heritage areas.

Preservation of the sites can be important not only for maintaining the physical evidence at the site, but also for interpretation of the atrocities. One of the most evocative reminders of the atrocities of World War II is the village of Oradour-sur-Glane in France, where 642 people were killed by German troops in June 1944. The survivors chose to leave the village as it was on the day that the massacre occurred; burned out buildings were left standing, abandoned cars and personal effects left where they were. These remains tell the story far more effectively than any signs or displays could.

The memorials established on site are not only part of the healing process, but can be part of the interpretation of the site. At all three sites memorial gardens have been established to provide peaceful areas where dreadful atrocities occurred, and areas where survivors and families can go and reflect on the events. In Oklahoma, the survivors' names are inscribed on a low wall; a more poignant reminder are nine rows of 168 stone and glass chairs, with 19 child-size chairs for the children who were killed. At Port Arthur, the remains of the café where 20 of the 35 were killed have been incorporated in a garden which includes a reflective pool.

Heritage managers at all sites of major atrocities have a responsibility to ensure that the site is conserved and presented appropriately not only for the survivors and their families but also for future generations. Just as we are now consciously managing the heritage of atrocity sites, we should consider managing the heritage of disasters. After all, heritage sites are the physical rem(a)inders of a shared collective experience and remembrance of past events.

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This article was written well before the terrorist attacks on the World Trade Center and the Pentagon and has been adjusted to make reference to these events.

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