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RECOMMENDED INVESTIGATION AND DESIGN GUIDELINES FOR FOUNDATIONS EXPOSED TO FIRE

February, 2025

This document is a compilation of two recommended guidelines with different objectives. The first presents criteria for the investigation of foundations exposed to fire, and the second presents design criteria for foundations exposed to fire. Discussion of concrete and masonry wall elements is also included. This document should not be taken as a general endorsement or encouragement to reuse any concrete or masonry element exposed to fire.

Additional geotechnical evaluation may be necessary to assess the feasibility of reusing any individual foundation, including retaining walls and their footings.

Additionally, plumbing, mechanical, electrical and any other systems passing through the foundation are beyond the scope of the structural assessment, however these systems should also be evaluated.

When considering rebuilding efforts, the impact of removing and reconstructing foundations on carbon pollution should not be ignored. It is recommended that the owner consult a design professional about the environmental impact of using or not reusing existing foundations.

Following the removal of debris, an assessment of the soil should be conducted to assess if the soil contains any contaminants. This assessment should follow local regulations and be performed by a licensed consultant.

It should be noted that reuse of an existing foundation may have an impact on eligibility to receive financial support from various federal, state, or private entities including but not limited to FEMA and insurance companies. Owners are advised to consult relevant agencies regarding whether reusing a foundation could affect eligibility for federal or state grants, insurance companies' funds, or other financial aid.

This document is based on the report document, "Investigation Guideline for Foundations and Soils Affected by Fire," dated 1/9/2019, which was prepared by Degenkolb Engineers and Ninyo & Moore Geotechnical & Environmental Sciences Consultants and presented to the City of Ventura in 2018, following the Thomas Fire of December 2017.

This document has been further modified by the Structural Engineers Association of California (SEAOC) Wildfire Task Group in January 2025 for specific distribution to Southern California Authorities Having Jurisdiction (AHJ's) in response to the fires around Los Angeles during January 2025.

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INVESTIGATION GUIDELINE FOR FOUNDATIONS EXPOSED TO FIRE

1. INTRODUCTION

Existing footings, slabs, and foundation systems in fire-destroyed buildings are NOT typically suitable for reuse. The effects of intense heat and fire on a foundation system may render exposed or relatively shallow foundations unusable or impractical for reuse. In addition, the soils adjacent to the structure and within the limits of the building pad may have been impacted by hazardous materials generated by the destruction of the structure and its contents.

These guidelines are intended to provide clear recommendations for licensed design professionals in their assessment and evaluation of existing building foundations and related elements that are intended to be reused to support a rebuilt or repaired structure, which an Authority Having Jurisdiction (AHJ) may adapt for its use in setting requirements in its jurisdiction. General guidance on debris removal and soil contamination testing requirements is also included.

Concrete or masonry elements extending above the foundation that are intended to be reused should also be investigated in a similar manner. Temporary shoring of elevated elements may be required.

A Civil or Structural Engineer licensed in the state of California (hereafter, "Project Engineer") should submit a Foundation Suitability Report for an existing foundation that is intended to be reused. Following removal of debris, a licensed consultant should also perform a Soils Contaminants Evaluation and submit a report.

Owners should be advised that this process of investigation and reporting does not guarantee the reuse of an existing foundation system. These guidelines are proposed to set forth a minimum level of investigation and documentation that the AHJ would accept. Additional investigations and/or testing may be directed by the Project Engineer at their discretion. In addition, based on its review of the Foundation Suitability and Soils Contaminants Evaluation reports, the AHJ would reserve the right to require additional inspections and/or testing where the report's findings are mixed, inconclusive, or disputed.

Reference is made herein to sections of the 2022 California Building Code (CBC) under the presumption that the objective of the existing foundation evaluation will be to show conformance to the requirements of the current building code for new structures. While this may be appropriate in cases where the superstructure is completely destroyed and is to be replaced with a new structure designed in accordance with the CBC or California Residential Code, the scope of fire damage to structures can range from complete destruction to moderate and repairable superstructure damage. For buildings with damage toward the latter end of the spectrum, the California Existing Building Code, in conjunction with any applicable local amendments, may permit certain existing, non-conforming conditions to remain or to be replaced in-kind. It is the intent of this guideline to outline an appropriate scope of existing foundation investigation for the licensed design professional, and not to recommend a standard for acceptance of those foundations that exceeds the requirements of the applicable building codes. The design

professional should use their judgment for the specific use case and the AHJ may wish to generalize the language herein as appropriate for such cases.

2. DEBRIS REMOVAL AND SOIL CONTAMINATION TESTING

Prior to the evaluation of the foundation system, the portion of the property affected by the fire should be clean and clear of burn debris, dust, and water to allow observation of the entire slab/foundation system by the Project Engineer. Debris removal should be performed by a licensed contractor in accordance with applicable local and state regulations and state guidance documents pertaining to conducting emergency debris, waste, and hazardous materials removals. This guidance addresses methods, health and safety requirements, best management practices (BMPs), and disposal requirements to protect response personnel, the surrounding community, public health, and the environment.

It is important to coordinate between federal, state, and local partners to facilitate a unified approach. Consideration should be given to identifying and protecting cultural preservation and environmental resources during debris removal.

Subsequent to the removal of debris, a Soil Contaminants Evaluation should be performed to evaluate the effectiveness of the debris removal, and a report should be provided.

3. FOUNDATION INVESTIGATION

A competent licensed professional should perform a preliminary evaluation of the condition of an existing foundation system and related elements to determine its potential for reuse. This evaluation would inform the Project Engineer's preliminary report, presenting the means and methods that would be relied upon to further evaluate the structural integrity of the foundation and elements. A certified testing laboratory should perform destructive and non-destructive testing as required.

The investigation should include the following assessments:

3.1 Visual Observations

Burn, scorch marks, cracks, and color changes should be observed, noted, and documented. Locations where concrete has changed in color (to pink, red, whitish gray, or buff) are to be identified and documented. Note that color change in concrete indicates a substantial loss in concrete strength. Spalls are to be documented and identified, including whether they are localized damage or more expansive. Existing conditions of cast-in anchor bolts are to be observed and documented. Any localized concrete spalling around bolts and the condition of exposed threads should be noted. Any cracking or signs of visual distress due to settlement or expansive soils should be observed and documented.

Table 1: Physical Effects of Temperature on Concrete⁽⁸⁾

Temperature	Color Change	Changes in Physical Appearance and Benchmark Temperatures	Concrete Condition
0 to 550 °F (0 to 290 °C)	None	Unaffected	Unaffected
550 to 1100 °F (290 to 590 °C)	Pink to red	Surface crazing: 570 °F (300 °C); Deep cracking: 1020 °F (550 °C); Popouts over chert or quartz aggregate: 1070 °F (575 °C)	Sound but strength significantly reduced
1100 to 1740 °F (590 to 950 °C)	Whitish Grey	Spalling, exposing not more than 25% of reinforcing bar surface: 1470 °F (800 °C); Powdered, light colored, dehydrated paste: 1650 °F (575 °C)	Weak and friable
1740+ °F (950+ °C)	Buff	Extensive spalling	Weak and friable

Nabi Yüzer, Fevziye Aköz, Leyla Dokuzer Öztürk, "Compressive strength-color change relation in mortars at high temperature," Cement and Concrete Research, Volume 34, Issue 10, 2004

As cited in Narendra K. Kosein, Ph.D., P.E., Ray F. Drexler, P.E., and Dilip Choudhuri, P.E., "Evaluation & Repair of Fire-Damaged Buildings," Structure Magazine, September 2008

3.2 Audible/Sound Observations

Non-destructive testing for delamination, spalling, and cracking should be performed using a rotary percussion delamination tool or sounding hammer (i.e. a framing hammer with a steel handle) throughout the entire slab/foundation system to identify areas of potentially weakened or delaminated concrete. This testing should be accomplished in accordance with ASTM D4580. In general, sound concrete will result in a high-frequency sound when struck, and concrete that has been damaged or is of poor-quality will have a dull/"thud" sound.

3.3 Fracture Mechanics Observations

Use a hammer to strike the edge or corner of a concrete surface with several hard blows. At least four locations throughout the foundation structure should be investigated, selected based on the appearance of worst-case conditions as determined by visual observations. Severely damaged concrete will fall apart with a few hard hammer strikes. Note that in heat-damaged or poor concrete, the fracture plane is typically through paste and not through aggregate. Document the ease or resistance of the concrete to fracture or crack when subjected to the hammer blows.

3.4 Concrete Strength Uniformity / Schmidt Hammer Testing

Use a Schmidt Hammer (i.e. rebound hammer or Swiss hammer) to test various portions of the slab/foundation structure to evaluate uniformity of concrete strength, following the methods of ASTM C805. Regions of testing should include areas where visual evidence suggests exposure to high heat and areas of low-to-no heat exposure. Areas that exhibit a 20 percent or greater reduction in concrete strength (versus the maximum strength identified via this test) are to be documented.

3.5 Concrete Slab Verification (If Applicable)

Determine existing slab thickness through review of as-built drawings, non-destructive testing/evaluation, or concrete coring. Determine if the slab complies with the minimum thickness required by the 2022 CBC (with relevant AHJ amendments)

Determine existing slab reinforcement size and layout through review of as-built drawings or rebar scanning. The Project Engineer should identify any proposed scan locations. Following a scan, the slab should be marked to illustrate the reinforcing pattern, and photographs should be submitted along with indications of the location on a plan. Determine if the slab complies with the minimum reinforcement requirements of the 2022 CBC with all applicable AHJ amendments

Determine the presence or absence of a vapor retarder/barrier (and its condition, if present) through the review of as-built drawings or field verification. If coring or saw cutting is used to verify the presence of a vapor barrier, the damaged vapor barrier should be repaired to provide an intact system.

3.6 Shallow Foundations: Concrete Footing Verification (If Applicable)

Determine the widths, thicknesses, and depths of footings below grade for comparison with the minimum requirements from Table 1809.7 of the 2022 CBC with all applicable AHJ amendments. Sizes can be verified through the review of as-built drawings or field verification through pothole excavations. If potholing is used, at least one location along the perimeter footings at each side of the structure and one location along an interior footing should be exposed and documented.

Determine if footing reinforcement, where required, complies with minimum requirements per Table 1809.7 footnote d and Section 1905 of the 2022 CBC with all applicable AHJ amendments. Reinforcement can be verified through review of as-built drawings, rebar scanning, or localized concrete cover removal. If rebar scanning is performed, scan at least two footings along the perimeter and one footing at the interior (if applicable). Locations of scanning and depths and sizes of reinforcement should be noted.

3.7 Concrete or Masonry Foundation Wall Verification (If Applicable)

Measure wall thicknesses through existing drawings or field verification. If field verification is used, at least one location along each wall segment should be measured and documented. Determine if wall thicknesses comply with the minimum requirements of the 2022 CBC with all applicable AHJ amendments. The Project Engineer should evaluate the structural stability of the wall based on the actual and proposed loading conditions.

Determine wall reinforcement size and layout. Reinforcement can be verified through the review of as-built drawings or rebar scanning. For rebar scanning of walls, scan at least one four-foot square area at each wall segment. Locations of scanning and the depths, sizes, and spacings of reinforcement should be noted. Determine if wall reinforcement complies with the minimum requirements of the 2022 CBC with all applicable AHJ amendments.

For masonry walls, the condition of existing masonry material should be classified as good, fair, or poor defined as described below. Any horizontal cracks in bed joints, vertical cracks in head joints and masonry units, and diagonal cracks near openings should be noted. Bulging or undulations in

walls should also be noted. Wall should be sounded for potential delamination and to determine if wall is partially or fully grouted.

- i. Good condition: Masonry found to have mortar and units intact with no visible cracking, deterioration, or deformation.
- ii. Fair condition: Masonry found to have mortar and units intact but with minor cracking (i.e. cracks under 1/16" in size), deterioration, or deformation.
- iii. Poor condition: Masonry found to have significant cracking, degraded mortar, degraded masonry units, and/or significant deformation.

Verify the design strength of walls being considered for reuse. This may be accomplished by review of as-built drawings or field sampling and testing by prism method as described in a subsequent section. The Project Engineer should identify locations of the wall(s) to be sampled. Sampling and testing procedures are described later in detail.

3.8 Deep Foundations: Grade Beam and Caisson Verification (If Applicable)

Nondestructive testing to determine the type, condition, dimensions, material properties, and detailing of deep foundations and any connecting grade beams may be infeasible. As such, where compliance with the 2022 CBC is required by the AHJ, it is recommended that deep foundations be shown through review of the original design drawings to meet the minimum tensile and shear reinforcement requirements of Section 1810. Though deep foundations are typically well-protected from damaging heat, delamination and/or spalling depth for shallower portions of deep foundations should be evaluated for potential partial removal and replacement. Reused deep foundation elements are subject to the load testing requirements of Section 1810.1.2 of the 2022 CBC.

3.9 Concrete Compressive Strength Testing (If Applicable)

Concrete core samples and destructive laboratory testing for evaluation of compressive strength are not mandatory for reuse of an existing concrete foundation, but they are highly recommended and are likely to yield higher strength design values than default design values.

The locations of the proposed cores should be determined by the Project Engineer. Test locations and results should be documented and compared with results from throughout the structure. Uniformity of concrete compressive strength throughout the foundation system should also be evaluated by Schmidt Hammer testing per the methods of ASTM C805. The tested compressive strength of the cores should be compared with the Schmidt Hammer results to determine a correlation. This information should be used to identify potential areas for remediation.

Core sampling and testing should be performed by a certified testing laboratory. At least three core samples should be taken from the existing foundation, including at least two core samples taken from locations where visual inspection indicates that fire damage, if any, is most severe. If a slab depth is less than 6", a 3" diameter through-core should be tested. Otherwise, 4" diameter x 6" minimum depth cores should be tested. ASTM C42 procedures should be followed for removal of cores. If reinforcement is encountered during coring, that core should be abandoned, and the hole location should be shifted to avoid the reinforcement. Provide a minimum clear distance of three core diameters of sound concrete between the existing core and the replacement core.

Test each sample in accordance with procedures contained in ASTM C42 and C39 or C496. The compressive strength and unit weight of each sample should be included within a complete testing report.

3.10 Sill Anchor Bolt Testing (If Applicable)

Where cast-in anchor bolts are intended to be reused sill anchor bolt testing is required. Existing post-installed anchors (e.g. adhesive, expansion, or screw anchors) or cast-in mud sill anchors should not be permitted to be reused.

Existing anchor bolts should be pull-tested by a certified testing laboratory according to the methods of ASTM E3121. The tension test load should be a minimum of 1,000 pounds of force, applied using a hydraulic ram. The anchors should maintain the test load for a minimum of 15 seconds and should exhibit no discernable movement during the tension test. The frequency of testing should be as follows:

- For less than five anchor bolts to be reused, all anchor bolts should be tested.
- For more than five bolts to be reused, five anchor bolts plus a minimum of 25 percent of the remaining anchor bolts (selected at random) should be tested. If any anchor fails testing, all anchor bolts should be tested unless twenty (20) consecutive anchors pass testing; after this, the initial test frequency may be resumed.

A summary of test results should be provided, including a plan drawing that shows the locations of anchor bolts tested, the test load, and an indication of pass or fail for each. Failing bolts should not be permitted to be reused.

3.11 Holddown Anchor Bolt Testing (If Applicable)

Holddown anchor rod testing is required where anchor rods are intended to be reused. Existing post-installed anchors (e.g. adhesive, expansion, or screw anchors) or strap-tie holddowns should not be permitted to be reused.

Existing anchor rods should be pull-tested by a certified testing laboratory according to the methods of ASTM E3121. The rods should be pull tested with a hydraulic ram to either twice the maximum allowable tension load required by a redesign OR one and a quarter times the maximum design strength of anchors as provided in an ICC-ESR or determined in accordance with Chapter 17 of ACI 318. The anchors should maintain the test load for a minimum of 15 seconds and should exhibit no discernable movement during the tension test. Every holddown anchor bolt intended for reuse should be tested.

A summary of test results should be provided, including a plan drawing that shows the locations of anchor rods tested, the test loads, and an indication of pass or fail for each. Failing anchor rods will not be permitted to be reused.

3.12 Masonry Prism Compression Testing (If Applicable)

Masonry prism compression testing is not mandatory to reuse an existing masonry wall, but it is recommended, and it should be noted that prism test results can yield higher strength design values than the default design values given in a subsequent section.

Sampling and testing should be performed by a certified testing laboratory according to the methods of ASTM C1314 and in accordance with the current code-adopted edition of ACI 530.1/ASCE 6/TMS 602 Specifications for Masonry Structures. At least one sample should be taken for every 1,500 sf of wall area, and a minimum of two total tests should be performed. At least 50% of the samples tested should be taken from locations where visual inspection indicates fire damage, if any, is most severe. All masonry test prisms should be at least two units high with a height-to-thickness ratio between 1.3 and 5.0. These samples should be at least four inches long and free of reinforcing. The testing laboratory should apply correction factors for different sample h/t aspect ratios per ASTM C1314.

The compressive strength and unit weight of each sample should be submitted in a complete testing report.

4. FOUNDATION SUITABILITY REPORT

The Project Engineer should prepare a Foundation Suitability Report summarizing the findings from the site investigation and any additional testing that was performed. The report should follow the following outline and be stamped and signed by a licensed California Civil or Structural Engineer.

- **Title Page:** Report title, property owner's name, property address, APN; author's name, title, professional engineering registration seal, signature, and date.
- **Project Description:** Purpose and scope, including statement of intent to reuse either entire or partial foundation. Type of foundation system.
- **Observations, Findings, and Test Results:** Visual inspection records, non-destructive testing records and results, complete destructive testing records and results (if applicable), complete laboratory testing records and results (if applicable). Include date(s) of site visit(s) and tests performed as well as location(s) of laboratory testing. Photographic documentation, including both overall site photos and close-up detailed photos of pertinent conditions.
- **Sketches/Drawings:** A sketch of the foundation layout identifying elements required by this report (e.g. locations of the damaged and discolored areas noted during visual observation, locations and types of testing (e.g. Schmidt hammer test, pull test, coring, etc.). If reliable structural as-built drawings are not available, include foundation extents, footing geometries, and reinforcement identified by testing.
- **Evaluation of Findings and Test Results:** Engineering assessment of results.
- **Conclusions:** Clear statements addressing the following:
 - Whether the foundation's structural integrity is compromised, and if so, where.
 - Whether the foundation's durability is compromised, and if so, where and how.
 - Whether the foundation (in part or as a whole) is deemed suitable for reuse.
 - Which sill anchor bolts and/or holdown anchor rods (if any) are deemed suitable for reuse.
- **Recommendations:** Clear recommendations describing any necessary remedial work needed to address the defects identified in the report, with reference to remediation details required within the engineered plans. Include a summary of recommended structural observations and special inspection requirements.
- **Tables and References:** As needed.

DESIGN CRITERIA FOR FOUNDATIONS EXPOSED TO FIRE

1. FOUNDATION EVALUATION

These guidelines recommend minimum design checks and minimum design criteria the AHJ should accept for the reuse of an existing foundation and corresponding anchorage for structures destroyed by fire to be rebuilt to meet the requirements for new buildings in accordance with the 2022 CBC and all applicable AHJ amendments. Existing foundations should not be considered for reuse unless they have already been investigated and determined to be suitable for reuse by a licensed California Civil or Structural Engineer.

Please refer to the introduction (Section 1.0) of the preceding *Investigation Guideline for Foundations Exposed to Fire* for additional background information on the guideline design criteria below.

1.1 Design Loads and Detailing Requirements

Existing foundations and anchors should be shown through engineering calculations to have the capacity to support the new structure, considering dead, live, soil, wind, earthquake, and all other applicable loads as calculated per the 2022 CBC with all applicable AHJ amendments. In addition to having sufficient strength, existing foundation elements are also required to meet the detailing requirements of the 2022 CBC with all applicable AHJ amendments.

1.2 Existing Materials

Testing results from the Foundation Suitability Report and/or values taken from the original design drawings may be used to determine existing material strength, as modified and described below.

a. Concrete Compressive Strength:

The following table may be used to determine the concrete compressive strength, based on the availability of original drawings and the time period when the existing foundation was built.

TESTING AND DRAWINGS AVAILABILITY	f'c VALUE BASED ON YEAR OF CONSTRUCTION			
	1920-1949	1950-1969	1970-2000	2001-present
No drawings, or drawings do not show material strengths. No testing performed.	1125 psi	1875 psi	2250 psi	3000 psi
Drawings available. No testing performed.	0.9 x Drawing value	0.9 x Drawing value	0.9 x Drawing value	Drawing value
Testing performed.	Mean-1 Std. Dev. of tested value ²	Mean-1 Std. Dev. of tested value ²	Mean-1 Std. Dev. of tested value ²	Mean-1 Std. Dev. of tested value ²

¹ Values may be appropriate when there is no visual damage to the concrete; however, visual damage to the concrete may indicate lower f'c.

² If the coefficient of variation between test specimen strengths is greater than 20%, additional tests should be performed until the coefficient of variation is equal to or less than 20%. If additional testing does not reduce the coefficient of variation below 20%, the concrete strength value should be multiplied by a 0.75 reduction factor.

b. Reinforced Masonry Compressive Strength:

The following table should be used to determine the masonry compressive design strength based on the availability of original drawings and the type of masonry unit. Unreinforced masonry reuse is not permitted unless allowed by the AHJ and fully retrofitted to current CBC requirements.

TESTING AND DRAWINGS AVAILABILITY	f'm VALUE BASED ON MASONRY UNIT TYPE	
	CLAY UNIT	CONCRETE UNIT
No drawings, or drawings do not show material strengths. No testing performed.	675 psi	910 psi
Drawings available. No testing performed.	0.9 x Drawing value ¹	0.9 x Drawing value ¹
Testing performed.	Mean-1 Std. Dev. of tested value ²	Mean-1 Std. Dev. of tested value ²

¹ If the masonry element was built after 2000, the compressive strength shown on the design drawings may be used without the 0.9 reduction factor.

² If the coefficient of variation between test specimen strengths is greater than 25%, the number of tests should be doubled. If additional testing does not reduce the coefficient of variation below 25%, the masonry strength value should be multiplied by a 0.75 reduction factor.

c. Steel Reinforcement:

Existing steel reinforcement strengths specified in design drawings may be used as the design strengths in evaluation and design. If design drawings are not available, default yield strength should be taken as 40 ksi.

d. Existing Cast-in-place Sill Anchor Bolts and Holdown Anchor Rods:

Any existing anchor bolts and anchor rods deemed satisfactory in the Foundation Suitability Report should be evaluated and/or designed per the requirements of the 2022 CBC with all applicable AHJ amendments.

e. Allowable Bearing Pressure:

Values should be obtained from a site-specific soils report or from presumptive load-bearing values per the 2022 CBC Section 1806 with all applicable AHJ amendments.

1.3 Construction Documents

In addition to the AHJ standard building plan submittal requirements, the following should be clearly noted in the construction documents:

- The extent and geometry of existing foundations and reinforcement are to be shown on the drawing plans and sections.
- Existing anchor bolts and anchor rods that are proposed to be reused and those which are to be abandoned should be clearly identified and noted on the foundation plan.

1.4 Calculation Package

A structural calculation package should be prepared by a licensed California Civil or Structural engineer and submitted in accordance with AHJ requirements. The calculation package should clearly demonstrate that the existing foundation elements meet the requirements of the 2022 CBC with all applicable AHJ amendments.

Select References

ACI 530.1/ASCE 6/TMS 602 Specification for Masonry Structures

ASTM International, various standards as referenced within this document, including: C39, C42, C496, C805, C1314, D4580, E3121.

Cal OES Governor's Office of Emergency Services, Debris Operations Plan for the Wind Complex Incident Counties of Butte, Nevada and Yuba, California, dated 10/26/2017.

County of Sonoma, Technical Bulletin B-43, Foundation Reports for Fire Damaged Structures, dated 12/5/2017.

Degenkolb Engineers and Ninyo & Moore Geotechnical & Environmental Sciences Consultants, Investigation Guideline for Foundations and Soils Affected by Fire, dated 1/9/2019.

Geosyntec, Table 1 – Sampling Site Information, County of San Diego Post-Fire Sampling, Table 2- Laboratory Analytical Matrix, County of San Diego Post-Fire Sampling, Table 3 – Summary of Analytical Results Metals, Asbestos and pH, County of San Diego Post-Fire Sampling, Table 4 – Summary of Analytical Results PAHs, PCBs, Herbicides and Pesticides, County of San Diego Post-Fire Sampling, undated.

Narendra K. Kosein, Ph.D., P.E., Ray F. Drexler, P.E., and Dilip Choudhuri, P.E., Evaluation & Repair of Fire-Damaged Buildings, Structure Magazine, September 2008 issue.