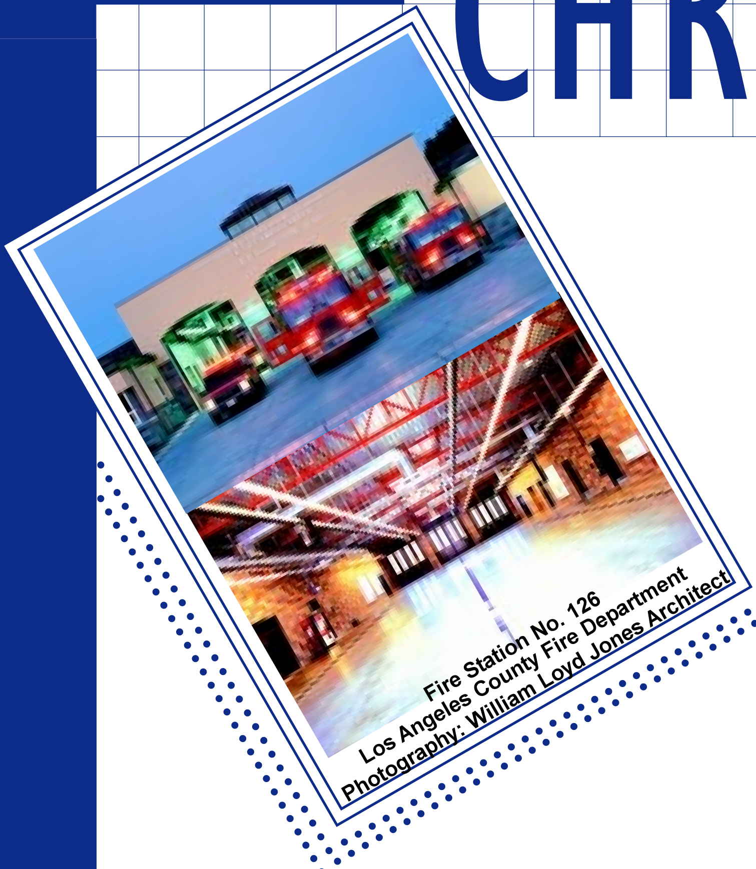
Engineering Notes For Design With Concrete Block Masonry

MASONRY CHRONICLES

Fall 2004



Fire Station No. 126
Los Angeles County Fire Department
Photography: William Loyd Jones Architect

Earth Rain Wind and Fire
Valuing Nature's Gifts

Introduction

Through the years Masonry Chronicles has delivered valuable engineering notes for design professionals working with concrete masonry units. Engineers working to improve practice and structural performance in buildings have sought to use CMU in an optimal manner based on the latest in building design and performance feedback.

Building performance is so critical today as sustainability over time and the secure investment of capital is mandatory. Communities can't afford to build structures that are at risk when it comes to nature and they must strive to achieve long term value in their decisions. Driven by current events and the new focus on the life cycle of buildings, this issue of Chronicles will focus on the critical economics inherent in CMU walls of the building envelope and their performance over time.

The timing is right for a concise financial valuation of our product as shortages of all the main structural building materials – cement, steel and wood, create cost and supply pressures. California should ensure, to the best of it's ability, that changes in the building code are for the better, maintaining life safety along with maximizing long term value with construction dollars. This emphasis will result in better construction in all communities and not just building segments covered by the CBC.

With the Pacific Rim economies thriving we can expect to experience some degree of these same conditions in the future and we must begin this discussion ensuring that the industry evaluate all options to maintain a balanced supply of the materials required to provide structure safely in the marketplace.

There is an optimal place for reinforced concrete masonry in building elements, and while this issue will focus on CMU in the building envelope, dividing walls for fire and acoustic considerations should be considered in all sensitive structures, such as multi-story (3 stories and up) residential structures.

Certain buildings such as the new fire station shown here are most functional with CMU providing permanence and utility to the community and providing low cost acoustic comfort, both for the outside community and the professional fire fighters resting when they can.

Evidence from Florida and the Southeast fosters a discussion of future risks associated with earthquakes, high winds and fire. As we have seen time and time again with wild fires in the Southwest and the dramatic hurricanes in Florida, nature's dynamic loading can be more forceful than we have ever seen or experienced.

In California the event would be a large scale earthquake that would break water mains and distribution over a prolonged period, as it has in

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the past, and similar to the loss of electricity in Florida for weeks at a time. We would have to rely on non-combustible fire wall separation to protect lives and structures under these conditions to even have a chance of fire fighting in disaster conditions. And without higher ductile strength in walls, we would be just like Florida in high dynamic loading conditions, and worse in epicenter vicinities.

Relevant to this discussion are the state and national efforts to perform Life Cycle Cost Analysis and Assessments (LCC & LCA) on building elements, such as the CMU wall for the building envelope. We will use their criteria in calculating the value of the CMU wall element.

So as California approaches critical model building code processes, and to create the basis of current experience for structural and fire safety elements, we will foster this discussion of issues extremely important to all of us in California, and in fact the rest of the country.

Economics

Evaluating supply and demand for the main products used in structure, and the relative pricing of the products based on the supply/demand balance, is important for this review. Value over time and the sensitivity of this value to drivers in the market such as, booming economies in Asia, retirement of old cement and steel production capacity, the cost of transportation to California from imports by ship, rail or truck, imports from Mexico, and of course, local economies and their respective business activity.

In other words, the cost of these materials goes up when the demand pressures exceed the available supply of the product and conversely, goes down when supply pressures exceed demand. This year we have seen a dramatic increase in pricing and supply pressures of cement, steel and wood, the three major structural elements used in construction, as we have seen a decrease in imports to the California coast driven by high demand in the Pacific Rim attracting them away, and additionally, shipping rising towards $50 per ton as shipping capacity was tied up in the area.

Valuation of all structural materials in California will be impacted by supply and demand in the market, and also the surrounding markets of Arizona, Nevada and Pacific Rim Countries. Costs for cement, production and transportation make all these supply options possible, and while they have normally moved in a very slow and gradual manner, the eventual historical graphs will show a relatively sharp increase for 2004. Before this year, transportation of cement to California from Nevada was approximately $20 per ton, and from Arizona approximately $30 per ton, while cement by ship from the Far East had been around $10 per ton to facilities in San Diego, Los Angeles and the Bay Area. This year spiking cement demand in China has reportedly attracted all the shipping capacity and ship rates increased towards the $50 per ton mark.

Demand for cement is composed of 3 main construction segments, residential, commercial and public work. Demand remains strong because of a continued strong residential market, an improving commercial market and public work still being supported by State of California jobs still in process. Public work is very cement intensive and dependant on state funding.

We look at the basic dynamics of cement supply and demand in this review of valuation to ensure validity in recognizing the stability or instability of the main structural elements in our discussion and our preliminary results.

Valuation

Everything has a value, from the shirt you like to wear two times a week to the share of stock in a company, such as Enron, that the public market valued at $90 a share in 2000, but is now valued at $.05. You, the market, determines the value. What a huge difference in valuation for one of the largest corporate annual revenues, and assets ever, $100 billion in the late 1990's, but as we have since learned about Enron, the valuation was influenced by many fictitious market factors, most of which were hidden from the public. We can at least evaluate value based on best available evidence and will ensure that no fictitious market factors are used, only assumptions that can be measured against other competing and comparable elements.

Valuation based on a CMU element's performance in assumed risk, such as the dynamic loading conditions of earthquake or wind, or the dead loading conditions of moisture and fire, is relevant, and based on reality. Natural events impact the value of a building element and must be factored in.

Market Factors

There are certain market realities that we must consider in the valuation. Cement based construction provides structure in foundations, walls, roadways, bridge, water and other infrastructure that could not be replaced with any other material, at least on this planet and in the foreseeable future. Reinforced walls provide a solid mass that performs optimally for structural durability, thermal, acoustic, moisture and insect resistance, and of course, fire safety performance. The product and attributes demand extra value in the built form and being made locally, it is fundamental to our society.

From an environmental perspective cement carries an extra first cost due to the production of CO_2. To make 1 ton of cement the environment takes up about 1 ton of CO_2. So even though some level of cement capacity is required in every market, like California with current annual capacity at 14 million tons per year, and should be "Grandfathered" so to speak, we will attribute an extra first cost per square foot of CMU wall for this environmental cost.

To be conservative, we will use an aggressive current market value of cement in place of $100 per ton to equate to the cost of the CO_2 embodied in a square foot of the CMU wall. At $100 per ton the value of cement per pound is $.05, and with approximately 10 pounds of cement in a square foot of CMU wall, that equates to an extra first cost of CMU wall per square foot of $.50. We will use this as the embodied energy cost of a square foot of CMU wall element in our LCC.

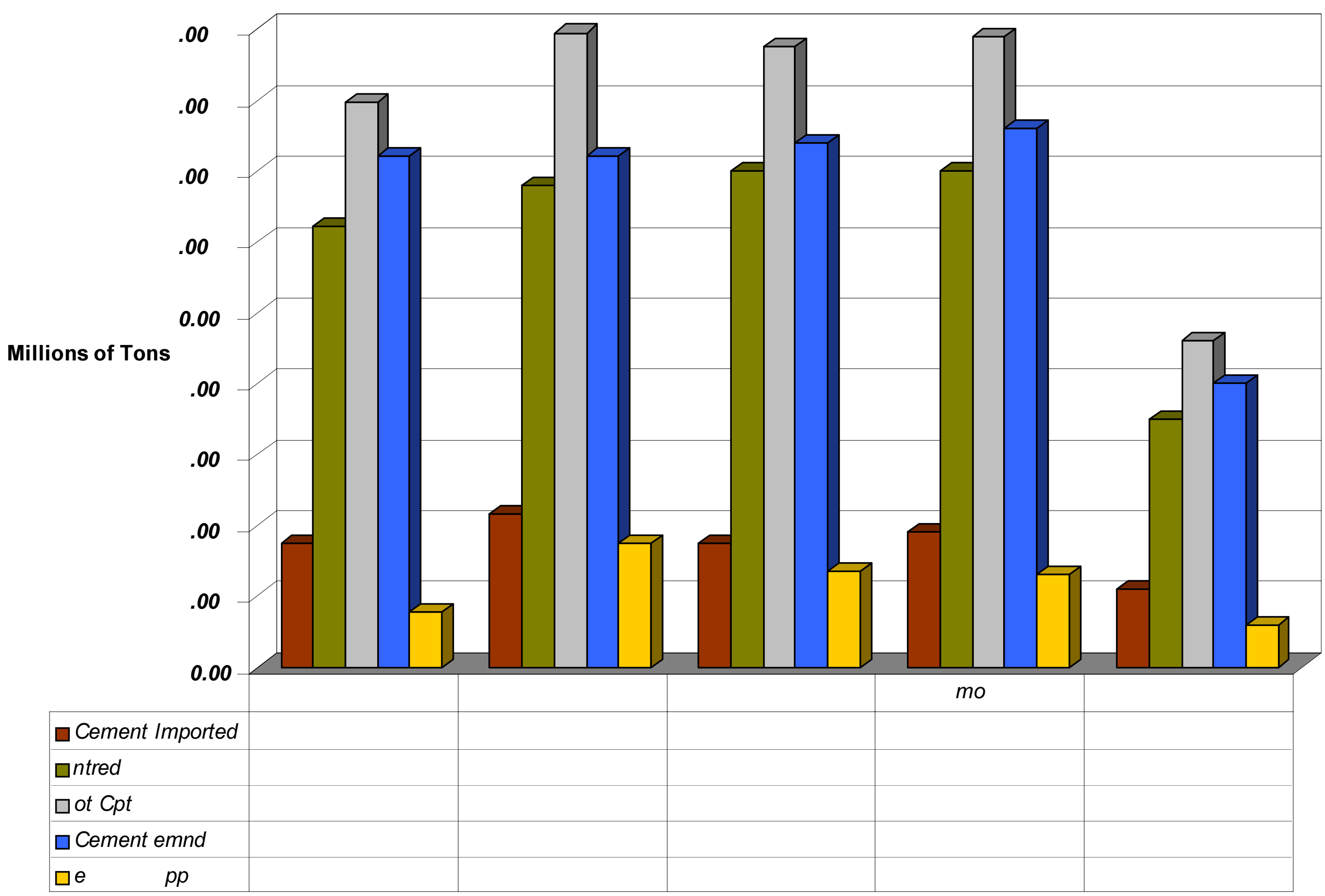
Cement Supply and Demand

Working in cement sales in the western markets of California, Arizona and Nevada from the mid 1980's through 2001, I have developed a pretty good feel for the marketplace, as far as understanding the uses of the product, where it is coming from and the sensitivity of the consuming industries to supply ups and downs. In recessions, supply pressure has always pushed pricing down and I don't remember a short supply condition like 2004 in my 20-year career.

The cement supply/demand balance in California over the last 5 years is shown below and reflects a stable balance. The producing industry works to ensure adequate supply is available in the market to cover estimated needs. Production has increased to 14 million tons to support demand, and import capacity has also increased to almost 4.5 million tons. Total cement supply capacity of 18.5 million tons is then only subject to pressures from imported sources, local production or exports to other markets like Arizona and Nevada. The net calculated excess supply as shown above, 1.2 million tons through the 6 months ending June 30th is what was supplied to the growing markets of Arizona and Nevada. As sales become more attractive in California this cement will trend to stay in state.

For the 6 months of 2004, demand has trended even higher, while production and imports were stable. The market supply problem, which materialized mid-year, is attributable to lower imports and continued shortage of bulk ships from the Far East.

5 Year California Cement Supply/Demand



If demand remains high in developing countries this supply/demand model will remain very tight.

While there are various factors driving this balance, cement remains the most stable and locally available building material, and cement has experienced the least price volatility of the 3 structural materials during 2004.

There are currently 2 new cement production projects being talked about, a new plant in Southern Nevada, which would take the pressure off 1 to 1.5 million tons presently moving to Nevada from California, and a proposed modernization of the Oro Grande plant of Texas Industries, which could add another 1 million tons of cement. These projects will relieve supply pressure and maintain high levels of modern capacity in the state as older productive capacity is considered for retirement in the next decade.

Cement based construction products such as CMU wall elements are probably the most stable from a supply perspective and their manufacture takes place almost entirely within the state supporting the local economies. This factor is fundamental when considering changes in practice and building codes that would effect demand for these structural materials.

Life Cycle Cost Analysis

Certain assumptions need to be made in our life cycle cost analysis and the following key components must be determined to complete the calculation. Estimates will be used, and while they are estimates, they are intended to be as close to actual as this writer can calculate in an initial discussion.

Time Frame or Life

The basis for a LCC in the “valuation” of anything, computer, car or building is of course a financial measurement of annual cash flows over some time frame. For our purpose, while the use of CMU walls in the building envelope could be measured over 100 years or more, and probably is in Europe and other countries, it is reasonable and conservative to assume a 50 year time frame for the CMU wall envelope in the building. Most other elements with CMU will also have at least this useful life or time frame of measurement, but will have entirely different LCC due to the specific CMU, element of the building, and performance of the specific element.

Building Element

The building envelope as a single element must be fairly measured to compare against an equal element, or the comparative element in performance, with all things considered. Apples to apples to the extent we can, with all the costs of the element considered. Again, for this exercise and discussion of valuation we will only talk about a reinforced vertical exterior CMU wall, the building envelope.

First Cost

The first cost must include all materials, labor and overheads, plus profit, essentially the market first cost. Including everything in the building wall envelope, such as siding, paint, adhesives, hardware, insulation, moisture barriers, framing and drywall, and we must agree on a unit, or measure of value for these in place building elements. In this case we will measure in terms of the envelope wall area, and will utilize the following approximate current market first costs for CMU walls, keeping in mind that certain designs are more detailed requiring multiple architectural units and more labor, while some just require standard 8 x 8 x 16 precision units. Others might require more reinforcing steel and so forth. We will utilize 2,500 square feet of constructed wall as our unit size for this LCC analysis.

Building Segment	First Cost Per Sq. Ft. of Wall
High Architectural Detail	$21.00
Big Box – Strip Center	$12.00
Public School	$18.00
Small Building	$11.80
Industrial Storage	$11.10

Annual Values

The annual cash flow to measure, or annual economic value, is the total of all the fairly measurable factors that can be differentiated between comparable elements. Such as, energy cost, regular maintenance associated with the exposed wall element, major maintenance such as painting or resealing, and a value for risk. There may be others of minor impact but for this exercise we will use these line items that make up the majority of annual cash flow either positive or negative.

Energy Performance

Solid mass CMU walls provide high thermal performance and contribute to optimal indoor comfort levels. For this exercise we will assume that energy cost savings of $500 per year can be attained for every 2,500 sq. ft. unit of wall element. This is an annual positive cash flow.

Maintenance

To be conservative we will assume long term maintenance for the CMU wall element of $.50 per foot, for resealing every 5 years of life. This should eliminate annual maintenance completely. This is a negative cash flow and we will assume no moisture events requiring material remediation or replacement for CMU as compared to other wall elements. Value attributed to CMU and moisture resistance will be recognized under the risk line item.

Midway High School, Dallas-Fort Worth, Texas
Christopher M. Huckabee, AIA, Fort Worth, Texas

McColl Home, Harbison Canyon, San Diego County

Risk Assessment

Risk management includes the process of estimating the possible events that cause loss of financial value in an asset, like your car or house, or the incurring of financial liability, such as personal injury, mold growth or structural failure, or both, and valuing the premiums required to cover estimated losses and to make a profit after loss payments. Man made events are probably easier to estimate and value risk on a relatively small scale. Natural events however are more difficult to quantify, at least until a major event like the series of hurricanes in Florida and the Southeast when we find out what actual losses are. Then we can estimate what losses will be in a large scale dynamic loading event similar to an earthquake, especially to light frame construction.

Here is a high school in Texas constructed entirely of CMU walls, exterior, load-bearing, and interior non load-bearing. The architect, Chris Huckabee uses nothing but CMU, because it is reliable structurally, has low if any risk of fire and moisture events, man-made or natural, and provides high indoor air and acoustic quality, low energy use and maintenance, and is additionally termite resistant. No wonder he uses CMU for all his projects.

Moisture or fire events should be assessed both for frequency and impact. Wind driven rains will enter most wall systems during their existence and the financial impacts can be significant, and as we have seen in recent years, wild fires are a fact of life in California and will probably impact most areas of new development just as they did in the San Diego area in 2003. CMU walls are more forgiving than wood, or even steel frame construction for the building envelope, with exposure to water or fire minor cleanup is required compared to major remediation or replacement. The following picture is of a CMU home in San Diego County that was covered with a 100 foot wall of flame at one point. Fire burned all around the house and the intense heat cracked some of the dual-paned windows, while no damage to the CMU envelope was recognized.

While not all wall elements will be at risk of burning, or wind damage over their life, or being damaged by moisture to the point of major repairs or replacement, a great deal of new construction will be subject to these risks. We must measure this annual risk value for a fair LCC and we will assume a lower risk, or insurance cost of $750 a year for the 2,500 sq. ft. unit of measure, a positive cash flow.

The building envelope is a critical investment decision for owners. First cost of 18% to 23% of the total cost of a building produces 95% of future liability. We are certain more information is coming in this area of risk management as the growing communities of California are impacted by natural events both here and in other markets.

LCC Model

The following is a net present value model for an assumed 10,000 square foot wall element with the annual cash flows over an assumed 50 year life for the highest level of CMU wall, the high architectural detail building with first cost at $21 per foot.

Description	Data
Annual Discount Rate	5%
Period - Years	50
Sq. Ft. Wall Area	10,000
First Cost of Wall @ $21	($210,000)
Embodied Energy @ $.50	($5,000)
Annual Cash Flow - Energy	$2,000
Annual Cash Flow - Risk	$3,000
5 year Cash Flow – Maintenance	($5,000)
Net Present Value for Wall	**($140,239.68)**
LCC for Wall Per Sq. Ft.	**($14.02)**

The LCC analysis for the above wall element with a first cost of $21 per foot is $14.02 per foot. This is a high performance wall system with long term values making the product very economical.

Preliminary Valuations

The model for LCC, or net present value analysis includes assumptions that will vary by building segment. The following table highlights the different segments for the assumed 10,000 square feet of wall area and reflects an even lower LCC value for the lower first cost building segments. The LCC analysis essentially produces a higher affordability for performance and utility in the broader building segments than the more architecturally detailed buildings.

Building Segment	First Cost of Wall	LCC Cost of Wall
High Architectural Detail	$21.00	$14.02
Big Box – Strip Center	$12.00	$5.02
Public School	$18.00	$11.02
Small Building	$11.80	$4.82
Industrial Storage	$11.10	$4.12

Life Cycle Analysis of the CMU wall element highlights how affordable the system really is when properly valuing performance and acknowledging the many attributes the wall system delivers. More and more owners and decision makers are choosing CMU for these reasons and the market will continue to make the ultimate decision on what value is attributed to the product. For our purpose we must incorporate this valuation and economic analysis in important public decision processes.

As designers and suppliers of fundamental structures in our built environment, we have an important responsibility to review and ensure these processes are valid and in the market's best interest. Design standards and building code change in California requires a balance of the current standards, advancements in construction techniques and products, more than a healthy dose of experience based on real performance in the market, and the important economic realities.

Summary

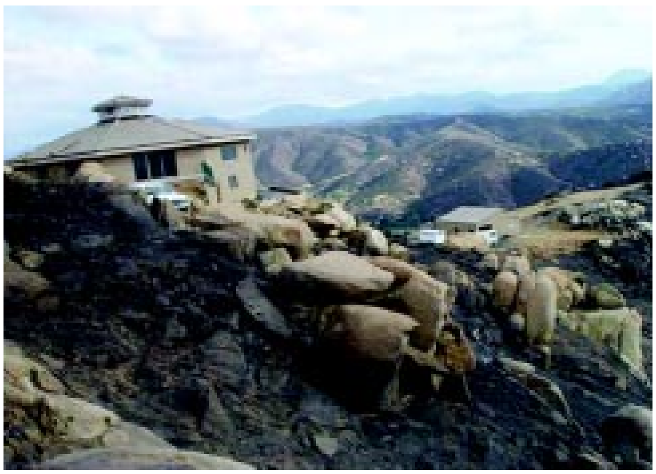
All things considered – market size and expectations, cement capacity and stability, structural strength and durability, energy, acoustic, maintenance, insect and fire safety performance, and valuation, concrete masonry walls are clearly an optimal choice for the building envelope, and actually payback over time.

While it looks like an early rain will help minimize fire risk in the fall of 2004, don't let the passing of time allow you to forget the past, growing communities in California and the anticipation of higher densities in metro areas will test the new built environment in ways we have not yet experienced. There is an appropriate place for all structural systems and elements and the design of a mass wall with steel reinforcement is an excellent option for the building envelope.

By now you are probably wondering about this issue's title – "Earth, Rain, Wind and Fire". No, it's not a new singing group or theme song for concrete masonry. These abundant elements make up the reinforced concrete masonry wall system and through natural events they test our built environment to the fullest. All building elements must be measured and valued under similar conditions. With this issue of "Masonry Chronicles" we begin this discussion in support of an efficient process for evaluating built systems and hopefully to support and continue to make reinforced concrete masonry construction the pinnacle of choice in maximizing building performance and value.

This issue of "Masonry Chronicles" was written by Paul D. Bambauer, Executive Director of Concrete Masonry Association of California and Nevada.

2004 Concrete Masonry Design Award Winning Middle School Utilizes CMU in Multiple Elements, Taking Advantage of All Performance Benefits



El Cerrito Middle School
Corona, California
WLC Architects, Inc.
Photography: Daly Architectural Photography

About the Author

Paul D. Bambauer is the Executive Director of Concrete Masonry Association of California and Nevada. Paul joined CMACN in June of 2003 after 20 years in the cement and concrete products industry. Consulting in areas of strategic market development for various concrete wall systems in 2002, Paul was previously Western Region Vice President of Sales for Southdown Cement, covering all issues of cement sales, distribution and consumption in the California, Arizona and Nevada markets. As Southdown's representative on various market development boards and committees, nationally and locally, Paul held leadership positions in most areas of product promotion and has a broad range of experience. Paul earned his Bachelor of Science in Business Administration from the University Of Arizona in Tucson in 1977.

References

1. U. S. Geological Survey, Mineral Industry Surveys and Annual Cement Reports, Hendrick G. van Oss, Cement Commodity Specialist

2. 2004 CMACN Architectural Seminar Series, Christopher M. Huckabee, AIA

3. Observations from the 2003 Southern California Wildland Fires, Mark Kluver, P.E., Manager of Regional Code Services – Portland Cement Association, Building Safety Journal, March-April 2004

Look for future issues on low-rise buildings of three-stories and above.

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