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Construction Engineering Research Laboratory

US Army Corps of Engineers®
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LBP Concerns in Producing Recycled Concrete Aggregate from Former Fort Ord Family Housing

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Final report

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Abstract: The presence of lead-based paint on concrete from demolition projects raises questions regarding suitable reuse or disposal. The regulatory environment is unclear on issues of reuse. This report attempts to correlate the concentration of lead on a painted building to the concentration of lead in aggregate produced from that building's demolition. This final concentration is the key metric in determining suitable end use. In this case of former Army family housing, the final lead concentration was found to be quite low.

(Cover photograph: Discharge conveyor from Kroeker concrete crushing plant, with Confidential Compliance Consultants sampling technician in foreground.)

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Preface

This study was conducted under the applied research program (6.2) in the solid waste program. A portion of this study was funded by the Construction Materials Recycling Association and the National Demolition Association. The technical monitor was Malcolm McLeod, Headquarters, U.S. Army Corps of Engineers.

The work was performed by the Environmental Processes Branch (CN-E) of the Installations Division (CN), Construction Engineering Research Laboratory (CERL). The CERL Principal Investigator was Stephen D. Cosper. Dr. Stephen W. Maloney is Acting Chief, CN-E, and Dr. John T. Bandy is Chief, CN. The Technical Director for the Environmental Quality/Installations business area is Martin J. Savoie. The Deputy Director of CERL is Dr. Kirankumar V. Topudurti, and the Director is Dr. Ilker Adiguzel.

The author would like to acknowledge the following for their contributions to the project and the contents of this report: Stan Cook, Fort Ord Reuse Authority; Kathleen Herzog, University of Illinois, Urbana-Champaign; Jeff Kroeker, Kroeker, Inc.; Alexis Rivera-Montalvo, University of Puerto Rico–Mayagüez; Mike Taylor, National Demolition Association; George Thomas, Confidential Compliance Consultants; and William Turley, Construction Materials Recycling Association.

CERL is an element of the U.S. Army Engineer Research and Development Center (ERDC), U.S. Army Corps of Engineers. The Commander and Executive Director of ERDC is COL Richard B. Jenkins, and the Director of ERDC is Dr. James R. Houston.

Unit Conversion Factors

Multiply	By	To Obtain
feet	0.3048	meters
mils	0.0254	millimeters
square feet	0.09290304	square meters

1 Introduction

Background

Environmental lead (Pb) comes from many sources and takes many pathways to human exposure. Pb has a myriad industrial uses, many of which have been curtailed due to human health and environmental risk. A lingering Pb-related concern is Pb from lead carbonate (PbCO3) paints used in wood and concrete buildings throughout most of the 20th century. When these buildings are still occupied, Pb exposure from the lead-based paints (LBP) is of particular concern as Pb interferes with neurological development. An entire regulatory regime, testing criteria, and abatement techniques have been developed to address the dangers of LBP in occupied housing.

When the building is no longer occupied and is ready for demolition, however, the presence of LBP becomes a question of worker safety and environmental protection. Occupational Safety and Health Administration (OSHA) regulations deal with worker protection; provisions in the Resource Conservation and Recovery Act (RCRA) deal with the disposal of Pb-containing wastes.

What if the project manager does not want to “dispose of” the Pb-containing demolition wastes? How to handle such waste has been a regulatory gray area for many years. CERL researchers have attempted to quantify Pb mass and concentrations from several demolition projects to help determine relative hazard, and to try to assess which environmental laws are applicable. Recycling and reuse of materials with LBP is of special interest because they are so pervasive in older Army building stock, much of which the Army is replacing.

Objective

The purpose of this study was to track the location and concentration of LBP through the demolition of a set of typical concrete Army buildings; and the subsequent crushing of the concrete for reuse. The project took place at Fort Ord, CA, which was closed under Base Realignment and Closure (BRAC) in 1991.

Paint Chemistry

Paint pigments are solid, uniform particles that are permanently insoluble in the paint (Gooch 1993). The main purposes of a pigment are to give color and opacity to the paint. White pigments are specially important because they provide the opacity (ability to hide what is under the paint), and a basis for other colors. PbCO3 was a very common white pigment in the mid-20th century. Its use was phased out as health and environmental problems became evident, and as other pigments were developed. Today, titanium dioxide is very prevalent.

Another potential source of Pb in paint are organic Pb compounds used as "driers" in paint. Driers are chemical paint additives that hasten drying. They pull oxygen through the wet paint film to oxidize and cure the paint. These driers include lead naphthenate, lead resinates, and lead linoleates (Gooch 1993). One of CERL's research partners is currently attempting to speciate Pb contamination found inside wood from a WWII-era Army building.

Regulation

Multiple federal agencies regulate Pb depending on the exact location and circumstance.

The U.S. Consumer Product Safety Commission (<http://www.cpsc.gov>) has banned the sale of LBP to consumers. The agency now limits the Pb concentration to 0.06 percent (600 ppm) in paints or painted items if they will be sold to the general public.

The U.S. Department of Housing and Urban Development and the U.S. Environmental Protection Agency (USEPA) jointly control household Pb exposure. The limit for Pb in soil is 400 ppm for bare surface soil in residential areas where child contact is likely. This limit increases to 1,200 ppm for areas with minimal potential for child contact.

Pb dust is a primary route of exposure in housing. The dust is generated from paint deterioration, renovations, or friction surfaces such as door jambs. The hazard limits for Pb in dust is 40 µg/ft^2 for floors, 250 µg/ft^2 for window sills, and 400 µg/ft^2 for window troughs. These levels are also used to determine where Pb abatement has been conducted.

OSHA regulates worker exposure to Pb dust (<http://www.osha.gov/SLTC/constructionlead/index.html>). The two numeric limits are both applicable over an 8-hr workday. The action level is 30 $\mu g/m^3$. The "action level" means employee exposure, without regard to the use of respirators. The permissible exposure limit (PEL) is 50 $\mu g/m^3$. No employee should be exposed to Pb over the PEL, calculated as an 8-hr time weighted average. Different levels for monitoring and worker protection are engaged when crossing these limits.

Under RCRA, a waste is considered hazardous if it contains more than 5 ppm Pb (throughout the entire bulk of the material) per the toxicity characteristic leaching procedure (TCLP). Note that RCRA governs the disposition of a material only if it is a "waste" and will not be reused. The following USEPA web site is a good place to review Federal Pb regulations and programs: <http://www.epa.gov/lead/index.html>.

Because this project took place in California, environmental regulations for that state are also of interest. A material is considered a California hazardous waste if the total Pb content is above 1,000 ppm.

Project description

Local governments have been redeveloping the former Fort Ord property for a variety of purposes, including "affordable" housing in a region with very high housing costs. One hundred acres of family housing were cleared in 2003. See the website of the Fort Ord Reuse Authority (FORA): <http://www.fora.org>.

As part of the reuse and redevelopment of the Fort Ord property, Kauffman & Broad Homes is building new homes on the site of the Hayes Park family housing area. Kauffman retained Kroeker, Inc. of Fresno, CA (<http://www.kroekerinc.com/>) to demolish 367 family housing units. The contract detailed specific requirements for dismantling all reusable or recyclable construction materials prior to structural demolition. Part of this pre-demolition work included the abatement of asbestos and LBP. Both of these materials are considered California Hazardous Wastes and must be disposed under strict regulatory controls, including full manifesting. These single and duplex homes were concrete block structures with stucco finish on slab foundations. After demolition, Kroeker was to crush the resultant concrete rubble (an estimated 70,000 tons) to be used later as fill, road base, etc., for other redevelopment work.

Kroeker used an Eagle Crusher, Model CV 1400; an Eagle triple deck screen, Model 65D006; and associated conveyors. Go to the Eagle website http://www.eaglecruser.com/?articleid=73 for an article with more specifics. Figure 1 shows the crusher plant in operation.

The goal of this study was to try to identify and quantify the disposition of LBP from the buildings through the entire process of demolition and crushing with the following steps:

- Measure Pb content on three study buildings at Hayes Park
- Monitor air emissions during demolition
- Monitor air emissions during crushing
- Sample soil near buildings and at crusher site
- Measure Pb concentration of crushed concrete product
- Compare predicted Pb concentration (based on building samples) to Pb concentration observed in crushed concrete product
- Draw conclusions on fate of LBP.

Figure 1. Overview of crusher plant.

Approach

The U.S. Army Engineer Research and Development Center's Construction Engineering Research Laboratory (CERL), in cooperation with the Construction Materials Recycling Association (CMRA, Eola, IL, <http://www.cdrecycling.org>) and the National Demolition Association (NDA, Doylestown, PA, <http://www.demolitionassociation.com/>) retained Confidential Compliance Consultants (CCC, Altadena, CA,

<http://www.confidentialcompliance.com/>) to assist with the sampling work. Prior to the execution of this study, all asbestos and LBP were reportedly abated. Structural demolition of the concrete structures remaining was well underway prior to sampling. Most of the interior walls were concrete and covered with a paint containing both Pb and asbestos. This paint was abated prior to demolition. The abatement activity was driven by the asbestos content.

Three sample structures were chosen to study their LBP content. They were some of the last units to be demolished under the redevelopment project, and had already been stripped down to concrete walls. Two of these were duplex family housing units. The addresses were 223, 225-227, and 226-228 Napier Street. Figure 2 shows a map of the Hayes Park neighborhood. The numbers on the map are the Army real property building numbers. This report uses the common street addresses. Figure 3 shows a typical building in this neighborhood.

Figure 2. Hayes Park Army family housing.

Figure 3. Typical family housing unit.

2 Sampling Results

Interior wipe samples

Three of the Hayes Park buildings were selected as research structures. They were out of the way of the active demolition work, and they were among the last to be removed.

CCC took floor wipes at the three buildings. Table 1 shows the results. The results shown were the analytical results of composite wipe samples, where each structure had four single wipe samples submitted as a single composite sample.

Table 1. Interior floor dust wipe samples.

Building Number	Pb conc. (μg/ft^2)
223	1,957
225/227	356
226	179

Although these structures were not intended to be cleaned for Pb abatement clearance, one can compare the numbers in Table 1 to the HUD limit of 40 μg/ft^2 for interior floors. The presence of Pb in dust on the floor is not surprising considering the LBP found in the existing paint films within these structures. The most significant concern from this dust would be worker exposure. Prior to mechanical demolition of the buildings, workers stripped out doors, fixtures, wood partitions, etc., until only the concrete walls remained.

Crusher site wipe samples

The crusher site consisted of a large fenced staging area with an entrance for trucks, bringing concrete from the demolition site. A second gate allowed the trucks to exit without the need for backing into traffic.

An area was designated as the supply dump site. Here, after trucks dumped their loads, a front-end loader or a track-mounted excavator would load the rubble into the crusher's receiving hopper. A water tanker onsite supplied a much needed stream of dust control spray. The concrete rubble was crushed, screened, and stacked in large piles. Table 2 lists results of Pb wipe samples at the crusher site. Figure 4 shows a CCC staff member taking a wipe sample from a truck at the crusher site.

Table 2. Wipe samples at the crusher site.

Location	Pb conc. (µg/ft^2)
Crusher - left front	43
Crusher - left rear	<20
Crusher - right front	388
Crusher - right rear	64
Excavator – bucket	71
Excavator - left front	<20
Excavator - left rear	<20
Excavator - right front	23
Excavator - right rear	<20
Loader – bucket	<20
Loader - Left front tire	105
Loader - right side	81
Truck - left front	67
Truck - left rear	<20
Truck - right front	293
Truck - right rear	<20
Worker – gloves	46
Worker - hard hat	<20
Worker - left boot	<20
Worker - right boot	33

Figure 4. Dust wipe sampling.

The results show that the Pb dust levels are not altogether risky for workers in the immediate area. The amount of airborne dust is generally likely to pose a greater hazard than the small Pb content of the dust. A dust control spray system was used and worked well.

Soil samples

CCC took soil samples at the housing area, around the study buildings, and at the crusher site. Researchers wanted a better idea of Pb background information, even if not directly applicable to the estimate of Pb loadings transferred from the buildings to crushed concrete products.

Table 3 lists results of soil samples taken along the drip line of the study buildings. Four samples were taken from each building and combined into one composite from each building.

Table 3. Lead concentration in soil samples taken near buildings.

Building Number	Pb conc. (ppm)
223	60
225 / 227	30
226	30

Table 4 lists samples taken at the crusher site. The material taken was a mixture of soil and crushed concrete residue.

Table 4. Lead concentration in soil samples taken at crusher site.

Location	Pb conc. (ppm)
Near the crusher	30
Intermediate distance from the crusher	40
Distant from the crusher	30

Both Table 3 and Table 4 show some low level of Pb at these locations, but the values are much lower than the residential soil limit of 400 ppm.

Air samples

The collection of air samples was conducted over a period of several days, near various workers, conducting varied tasks. The PEL for Pb for construction workers is 50 μg/m^3. It is normally not anticipated that outdoor construction operations would generate these levels. The action level is 30 μg/m³, which is also uncommon for outdoor construction. California regulations require that a “risk exposure” be conducted to determine worker exposure to Pb-laden dust during construction projects where disturbance of known LBP exists. This demolition project was preceded by an “abatement activity” whereby all identified LBP was to be removed. However, the scope and effectiveness of this activity is questionable because of the LBP found in the study buildings, as described later in this report. Figure 5 shows interior demolition work. Table 5 lists airborne Pb exposure to workers at the demolition site.

Figure 5. Interior demolition.

Table 5. Worker exposure to airborne Pb at demolition site.

Sample Date	Location	8-hr Time Weighted Average (μg/m³)
10/Feb/2003	Bobcat operator	<1.67
10/Feb/2003	Interior demolition	<1.67
10/Feb/2003	Interior demolition	<1.67
10/Feb/2003	Outside laborer	<1.67
11/Feb/2003	Interior demolition	<1.67
11/Feb/2003	Interior demolition	<1.67
11/Feb/2003	Exterior worker	<1.67
11/Feb/2003	Bobcat operator	<1.67
20/Feb/2003	Excavator operator	<1.67
20/Feb/2003	Waterman	<1.67

As evident from the results in Table 5, between the Contractor's use of water spray from tanker trucks for dust control (Figure 6), and the heavy, humid air of the rainy season conditions, the levels of air-borne, lead-laden dust were below normally detectable levels. These combined factors produce a very low risk of worker exposure to lead-laden dust at the demolition site.

General working conditions at a concrete crushing plant normally produce a dusty work environment. Dust control water spray systems are a necessity. Dust control was used while the following air samples were collected (Table 6), both from equipment operators and downwind from the crushing plant.

Figure 6. Dust control truck.

Table 6. Air monitoring at crusher site.

Sample Date	Location	8-hr Time Weighted Average (µg/m³)
21/Feb/2003	Excavator operator #1	<1.67
21/Feb/2003	Water hose operator #1	<1.67
21/Feb/2003	Excavator operator #2	<1.67
21/Feb/2003	Water hose operator #2	<1.67
21/Feb/2003	High volume air sampler downwind #1	<1.67
21/Feb/2003	High volume air sampler downwind #2	<1.67

As can be seen in Table 6, the levels of worker and ambient exposure to air-borne lead-laden dust are nondetectable. These sample results were consistent with the worker results collected from the demolition site. Over the entire period of sample collection, not a single sample revealed a Pb level above detectable limits. Therefore, no additional air monitoring was performed.

Paint samples

As mentioned previously, interior paints had an asbestos component, as well as Pb content. Because of the asbestos, all interior wall surfaces were scraped, and most walls were covered in a sealant material, which is a sign of abatement completion. Some paint still remained on interior walls (Figure 7), and exterior paint remained intact. CCC sampled all wall surfaces for Pb content. The purpose was to help calculate the overall Pb content of the structures. CERL also took concrete samples, as described in the next section. The results of the Pb content of the paint samples are included in Table 7.

Figure 7. Remaining coating on interior walls.

Table 7. Paint sampling data.

House Number	Sample Location	Pb Concentration in paint (ppm)	Mass Pb per wall area (g/ft^2)
223	Living room, 4 wall composite	2,210	0.0024
223	Kitchen, 3 wall composite	1,280	0.0014
223	Bathroom, 3 wall composite	2,290	0.0026
223	Bedroom #1, 4 wall composite	1,120	0.0013
223	Bedroom #2, 2 wall composite	1,330	0.0014
223	Hall	720	0.0008
223	Exterior wall #1	3,060	0.0036
223	Exterior wall #2	4,040	0.0046
223	Exterior wall #3	8,220	0.0094
223	Exterior wall #4	3,240	0.0037
223	Exterior wall #5	3,200	0.0036
223	Exterior, CERL sample 26	3,800	*
225/227	Living room, 4 wall composite	2,860	0.0034
225/227	Kitchen, 3 wall composite	3,090	0.0034
225/227	Bathroom, 3 wall composite	2,640	0.0026
225/227	Bedroom #1, 3 wall composite	2,120	0.0031
225/227	Bedroom #2, 3 wall composite	2,290	0.0025
225/227	Hall, 2 wall composite	2,880	0.0034
225	Interior, CERL sample 29	5,900	*
225/227	Exterior wall #1	3,040	0.0035
225/227	Exterior wall #2	2,860	0.0033
225/227	Exterior wall #3	3,170	0.0037
225/227	Exterior wall #4	4,940	0.0056
225/227	Exterior wall #5	16,550	0.0198
225	Roof deck, CERL sample 28	3,900	*
226	Living room, 4 wall composite	2,350	0.0009
226	Kitchen, 3 wall composite	780	0.0028
226	Bathroom, 3 wall composite	870	0.0013
226	Bedroom #1, 3 wall composite	1,070	0.0010
226	Bedroom #2, 3 wall composite	1,050	0.0012
226	Utility room	2,900	0.0032
226	Interior, CERL sample 32	330	*
224	Exterior, CERL sample 30	5,100	*
226	Exterior wall #1	3,070	0.0035
226	Exterior wall #2	4,070	0.0047
226	Exterior wall #3	3,670	0.0042
226	Exterior wall #4	1,270	0.0015
226	Exterior wall #5	11,500	0.0133
CERL sample 16	Low density concrete roof deck	3,000	*
CERL sample 17	Low density concrete roof deck	1,700	*

* Not measured.

Table 8 summarizes the data in Table 7 by averaging the values by building and by location.

Table 8. Paint sample data summary.

House Number	Sample Location	Pb Concentration (ppm)	Mass Pb per wall area (g/ft^2)
223	Interior	1,492	0.0017
223	Exterior	4,260	0.0050
225/227	Interior	3,111	0.0031
225/227	Exterior	6,112	0.0072
226	Interior	1,336	0.0017
226	Exterior	4,780	0.0054
any	roof deck	2,867	0.0033

Due to the presence of Pb in the paint, workers inside these type of buildings should wear appropriate respiratory protection, especially when performing dust-generating demolition tasks.

Concrete samples

In addition to the CCC paint samples described in the previous section, CERL also took several samples for Pb analysis from the housing site and the crusher site. These samples represented the range of materials (Figure 9 for example) that would be combined at the crusher site to produce the recycled concrete aggregate (Figure 9) for use as road base and other products. CERL took 34 samples, and subjected them to various combinations of Pb analysis. Table 9 summarizes analytical results from these samples.

Figure 8. Painted concrete piece.

Figure 9. Finished recycled concrete aggregate.

Table 9. Summary of CERL concrete samples.

Material	Total Pb (ppm)	Density (lb/ft³)
Crushed concrete product, old	17.0	62.89
Crushed concrete product, recent	16.7	55.37
Asphalt concrete, from street	1.5	
Asphalt concrete, from driveway	17.0	
Floor slab	2.4	142.80
Light concrete, painted, before crushing	305.0	90.38
Exterior wall	248.1	
Interior wall	250.7	
Roof deck	560.0	
Concrete pavement	<1.0	148.77
Fines from under conveyor	110.7	58.68

Concrete density was determined using American Society for Testing and Materials (ASTM) method C642-9 (ASTM 1997). In addition to the analyses listed here, at least one sample from each material type was subjected to the TCLP test for Pb. In every case, the result was less than 0.010 ppm.

SI Consulting (Mill Valley, CA) took 50 core samples from 25 of the Hayes Park buildings (Kroeker 2002). The core samples had a range in total Pb concentration between 18 and 160 ppm, with an average of 51.

3 Modeling

Approach

One goal of this study was to demonstrate a method for accurately predicting Pb concentration in recycled concrete aggregate (RCA) product based on measurements of LBP concentrations and building dimensions, before the demolition work proceeded.

The previous chapter listed the LBP and concrete sampling results. The next step is to construct models of the buildings to estimate the mass and surface of each of the building components (e.g., interior walls or pavement). The modeling is done using the "reverse quantity take-off" method, which means estimating the quantity of materials that go into a building, based on observation and measurement of a standing building.

Figures 10, 11, and 12 show line drawings of buildings 223, 224, and 225 Napier Street based on field measurements. House 224 is half of a duplex with 226; 225 is duplexed with 227. Each side is a mirror image. It is assumed that paint measurements for building 224 will be valid for 226.

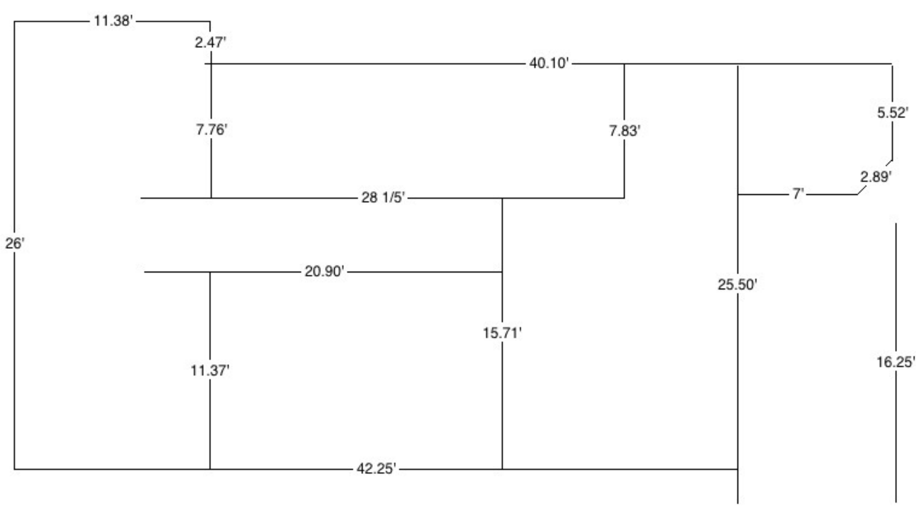

Figure 10. Line drawing of 223 Napier Street.

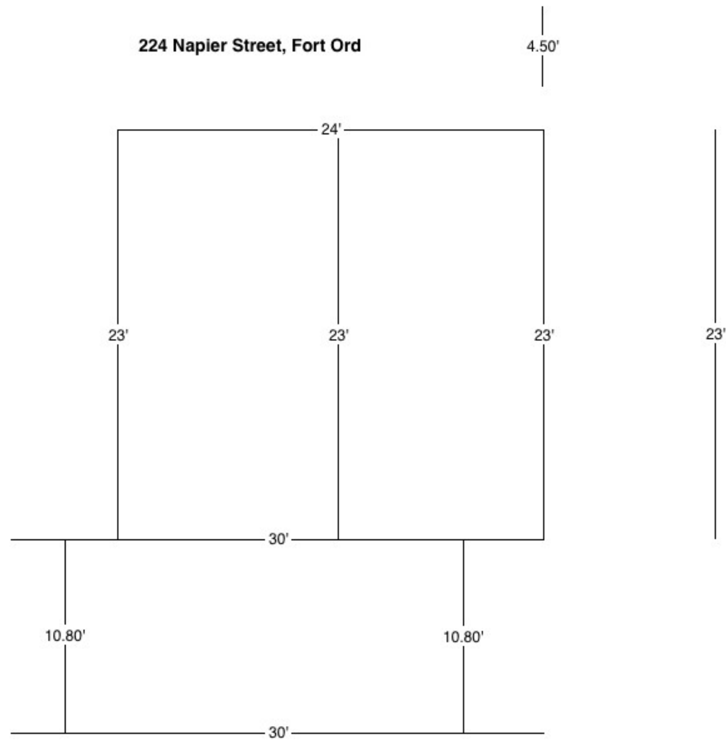

Figure 11. Line drawing of 224 Napier Street.

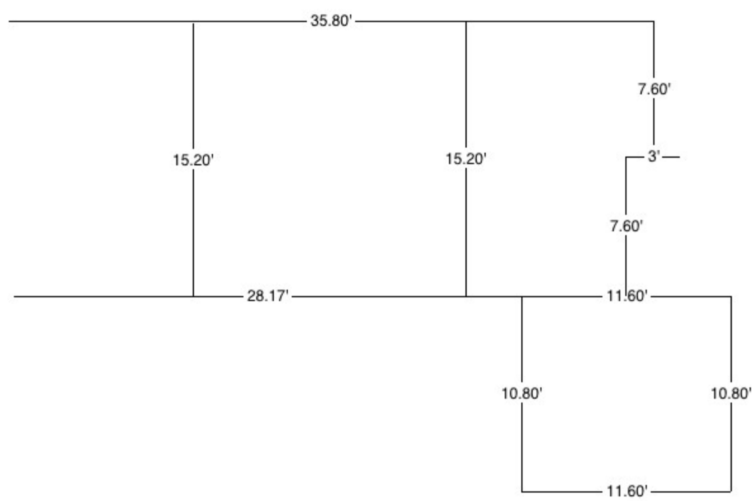

Figure 12. Line drawing of 225 Napier Street.

Calculations

Based on Figures 10–12 and some design assumptions for residential-scale construction, CERL developed surface area models for each of the three structures, as summarized in Table 10. Mass calculations are highlighted.

Table 10. Reverse quantity take-off.

Location	223	224	225
Interior wall surface area (ft^2)	2,955.8	1,236.2	1,018.8
Exterior wall surface area (ft^2)	1,499.7	1,577.6	734.0
Wall volume (ft^3)	855.3	667.8	377.0
Wall concrete density (pounds/ft^3)	90.0	90.0	90.0
Wall mass (g)	34.9E+6	27.3E+6	15.4E+6
Roof deck exterior area (ft^2)	1,497.2	1,366.0	783.7
Ceiling area (ft^2)	1,090.0	876.0	646.6
Roof deck volume (ft^3)	748.6	683.0	391.9
Roof deck density (pound/ft^3)	45.0	45.0	45.0
Roof deck mass (g)	15.3E+6	14.0E+6	8.0E+6
Floor area (ft^2)	1,090.0	876.0	646.6
Floor slab volume (ft^3)	471.7	376.8	298.2
Floor slab mass (g)	30.6E+6	24.5E+6	19.4E+6
Concrete footers (ft^3)	155.8	122.8	110.7
Density floor and footer (pound/ft^3)	143.0	143.0	143.0
Mass footer (g)	10.1E+6	8.0E+6	7.2E+6
Carport concrete volume (ft^3)	144.9	155.7	141.6
Concrete apron on drive volume (ft^3)	29.4	49.3	52.8
Asphalt drive volume (ft^3)	30.8	58.7	44.8
Mass asphalt drive (g)	1.8E+6	3.5E+6	2.6E+6
Asphalt street volume associated with this building (ft^3)	198.5	125.5	174.5
Concrete curb volume (ft^3)	36.7	22.8	18.5
Concrete sidewalk volume (ft^3)	102.1	154.5	98.6
Density for all exterior pavement (incl. carport, apron, curb, and sidewalk) (pound/ft^3)	150.0	150.0	150.0
Mass exterior concrete (g)	21.3E+6	26.0E+6	21.2E+6
Density asphalt (pound/ft^3)	130.0	130.0	130.0
Mass of asphalt street, per building (g)	11.7E+6	7.4E+6	10.3E+6
Total mass of material to crush, per building (g)	125.8E+6	110.6E+6	84.1E+6

The next step is to combine the material quantities in Table 10 with the paint sampling data to compute an expected overall Pb concentration in RCA when the entire mass of the building is crushed together. This includes walls, foundation, pavements, street, etc. These calculations are shown in the following three tables. Tables 11, 12, and 13 calculate the overall Pb concentration per building based on the surface Pb measurements taken by CCC. These calculations are repeated, first based on solid concrete samples, and second based on paint concentrations collected by CCC, multiplied by an assumed paint thickness of 10 mils, to get a Pb loading rate. Table 14 summarizes the results of all three methods.

Table 11. Overall Pb computation for building 223.

Item	Mass (g)	Bulk Pb conc (ppm)	Mass Pb (g)	Painted Surface area (ft^2)	Pb paint (or dust) conc (g/ft^2)	Mass Pb from paint (g)	Total mass Pb (g)
Interior walls	34.9E+6			2,956	0.0017	5.0	5.0
Exterior walls				1,500	0.005	7.5	7.5
Ceiling	15.3E+6			1,090	0.0017	1.9	1.9
Floor	30.6E+6	2.4	73	1,090	0.001957	2.1	75.6
Roof deck exterior				1,497	0.0033	4.9	4.9
Footing	10.1E+6	0	0				0.0
Exterior concrete	21.3E+6	0	0				0.0
Asphalt drive	1.8E+6	17	31				30.9
Asphalt street	11.7E+6	1.5	18				17.6
Total ppm Pb	1.14						

Table 12. Overall Pb computation for building 224.

Item	Mass (g)	Bulk Pb conc (ppm)	Mass Pb (g)	Painted Surface area (ft^2)	Pb paint (or dust) conc (g/ft^2)	Mass Pb from paint (g)	Total mass Pb (g)
Interior walls	27.3E+6			1,236	0.0017	2.1	2.1
Exterior walls				1,578	0.0054	8.5	8.5
Ceiling	14.0E+6			876	0.0017	1.5	1.5
Floor	24.5E+6	2.4	59	876	0.000179	0.2	58.9
Roof deck exterior				1,366	0.0033	4.5	4.5
Footing	8.0E+6	0	0				0.0
Exterior concrete	26.0E+6	0	0				0.0
Asphalt drive	3.5E+6	17	59				58.9
Asphalt street	7.4E+6	1.5	11				11.1
Total ppm Pb	1.32						

Table 13. Overall Pb computation for building 225.

Item	Mass (g)	Bulk Pb conc (ppm)	Mass Pb (g)	Painted Surface area (ft^2)	Pb paint (or dust) conc (g/ft^2)	Mass Pb from paint (g)	Total mass Pb (g)
Interior walls	15.4E+6			1,019	0.0031	3.2	3.2
Exterior walls				734	0.0072	5.3	5.3
Ceiling	8.0E+6			647	0.0031	2.0	2.0
Floor	19.4E+6	2.4	46	647	0.000356	0.2	46.7
Roof deck exterior				784	0.0033	2.6	2.6
Footing	7.2E+6	0	0				0.0
Exterior concrete	21.2E+6	0	0				0.0
Asphalt drive	2.6E+6	17	45				44.9
Asphalt street	10.3E+6	1.5	15				15.5
Total ppm Pb	1.43						

Table 14. Comparison of total Pb calculations.

Building/sample	Pb conc (ppm)
223 with CCC paint data	1.14
224 with CCC paint data	1.32
225 with CCC paint data	1.43
223 with CERL concrete data	138.66
224 with CERL concrete data	133.68
225 with CERL concrete data	100.36
223 with assumed paint thickness	5.23
224 with assumed paint thickness	5.33
225 with assumed paint thickness	5.41

Comparison of calculations

Of all the measurements of Pb in concrete presented in this report, the direct measurement of Pb in aggregate listed in Table 9 (e.g., about 17 ppm for RCA product) is the most accurate. However, these results are after demolition and crushing; therefore, it would be desirable to be able to predict this concentration using the estimates described above. The three types of paint data used in the previous section are:

- Pb concentration from scraping walls, grams of Pb per square foot of wall surface
- Overall Pb concentration throughout a solid surface (wall cross section), ppm Pb

- Pb concentration from other discrete paint samples, collected from walls or large painted pieces of demolition debris.

The first and third methods should be numerically similar with variation due to differences in specific starting samples. These results may slightly underestimate the actual value because all of the Pb from a surface may not be removed during the sampling activity.

The second method (concentration of solid samples) seems to overestimate the actual end value, as sampled at the crusher site. This result is probably due to difficulty in obtaining and preparing solid samples that are truly representative of, for example, the entire cross section of a wall.

4 Conclusions

Comparison of modeling and sampling

To perform total Pb analysis, an environmental chemistry laboratory requires only a few grams of material. A representative sample from a concrete demolition project might be several kilograms. The problem arises when trying to prepare a representative subsample. This is a long recognized problem with determining overall Pb concentration for building debris when trying to take representative samples for TCLP for RCRA hazardous waste determination (Figure 13).

Therefore, based on this exercise, the author recommends a systematic, representative sampling plan utilizing paint samples, as opposed to solid debris samples. Of course, this applies only to painted surfaces. In the case of this study project, only solid samples can be taken from nonpainted materials such as pavements.

Figure 13. LBP covered concrete in mixed debris pile.

General work site assessment

Based upon several weeks of worker observation, including monitoring of demolition contractor dust control procedures, worker practices, and analytical evaluation of samples collected during actual demolition and concrete recycling operations, these are the key observations:

- During the overall personnel monitoring of various worker activities, no recordable levels of Pb were identified
- Analysis of soils collected at the designated test structures showed no appreciable levels of Pb
- Levels of Pb found in the processed concrete compared favorably with the average levels identified at the test structures (i.e., no significant variations of recycled concrete Pb levels compared to soil Pb levels prior to demolition)
- Samples collected from within the abated structures revealed significant levels of LBP remaining on the wall surfaces.
- Wipe samples from the interior surfaces also showed high levels of Pb.

The following conclusions were drawn based on careful review of the sample data and photographs documenting worker practices:

The low levels (nondetectable) of worker Pb dust exposure can be largely attributed to the Contractor's attention to dust control. Additionally, the demolition activities were conducted during a time when seasonal rains and heavy, humid air prevailed. This obviously contributed to low worker exposure to airborne Pb dust.

The levels of Pb at the recycling facility were directly related to high levels of Pb found at the structures prior to demolition. However, these levels were diluted at the crushing plant as the concrete was processed and the Pb-bearing surfaces were mixed throughout the bulk of the concrete. Although dilution is not normally embraced as a solution to Pb abatement, it appears to be reasonable in this case and, therefore, likely an acceptable practice. The low levels of Pb found in the processed concrete would further be stabilized when reused as road base, as was the intent of this project. As road base, the risk of exposure to children would be very low.

Results summary

Eight paint samples were taken from the three study buildings on Napier Street and the crusher site. The average total Pb concentration in the paint was 3,700 ppm. This number is very reasonable and expected.

Eleven samples of crushed concrete product were taken from various locations around the finished RCA pile at the crusher site. The average total Pb concentration was 17 ppm. Seventeen is a little above the expected background number. Given the source and intended application as a road base, however, the concentration is quite low and should not be an impediment to using RCA. TCLP Pb extractions were performed for two of the RCA samples with the highest total Pb concentration. In both cases, the result was less than 0.01 ppm — far below the RCRA limit of 5.

Three samples of fines from under the crusher were taken one evening as the crew was cleaning up. The average total Pb concentration was 111 ppm. It appears that this type of location is a major sink for LBP particles (Figure 14). Through the crushing process, loose paint flakes off and enters the fines waste stream. The Pb concentration in the fines is below the USEPA limit for Pb-in-soil for residential application. Because the fines are respirable as workers move around and clean up, appropriate personal protective equipment is recommended. CERL performed TCLP for Pb on the two samples with the highest total Pb (160 and 130 ppm). As with the crushed RCA product, the result was less than 0.01 ppm. The Pb in the fines would

Figure 14. Fines sample location.

be expected to be more “leachable” because more surface area is exposed to interaction with the acid test solution. However, much more concrete surface area is also exposed, which will neutralize the extracting solution.

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14. ABSTRACT

The presence of lead-based paint on concrete from demolition projects raises questions regarding suitable reuse or disposal. The regulatory environment is unclear on issues of reuse. This report attempts to correlate the concentration of lead on a painted building to the concentration of lead in aggregate produced from that building's demolition. This final concentration is the key metric in determining suitable end use. In this case of former Army family housing, the final lead concentration was found to be quite low.

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