the ATHENA™ Sustainable Materials Institute

CRADLE-TO-GATE LIFE CYCLE INVENTORY FOR EXTERIOR STUCCO FINISHES

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Preface

This report was commissioned as part of a continuing program to expand the knowledge base of the ATHENA™ Sustainable Materials Institute, a not-for-profit organization dedicated to helping the building community meet the environmental challenges of the future.

Our ultimate goal is to foster sustainability by encouraging building designs which will minimize life cycle environmental impacts. To achieve that goal the Institute has developed ATHENA™, a system model for assessing the relative life cycle environmental implications of alternative building or assembly designs. Intended for use by building designers, researchers and policy analysts, ATHENA™ is a decision support tool which complements and augments other decision support tools, such as costing models. It provides a wealth of information to help users understand the environmental implications of different material mixes or other design changes in all, or parts of, a building.

Two of the Institute's objectives are to increase awareness of the environmental impacts of buildings and the built environment, and to provide information and tools to help put the environment on a footing with cost and other traditional design criteria. To help achieve these objectives and to ensure transparency of our research and data development process, we make all of our reports available to Institute members.

Institute studies and publications fall into two general categories: investigative or exploratory studies intended to further general understanding of life cycle assessment as it applies to building materials and buildings; and individual life cycle inventory studies which deal with specific industries, product groups or building life cycle stages. All studies in this latter category are firmly grounded on the principles and practices of life cycle assessment (LCA), and follow our published Research Guidelines, which define boundary or scope conditions and ensure equal treatment of all building materials and products in terms of assumptions, research decisions, estimating methods and other aspects of the work.

The integration of all inventory data is a primary function of ATHENA™ itself and we therefore caution that individual industry life cycle study reports may not be entirely stand-alone documents in the sense that they tell the whole story about an individual set of products. ATHENA™ also generates various composite measures that can be best described as environmental impact indicators, a step toward the ultimate LCA goal of developing true measures of impact on human and ecosystem health.

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ATHENA™ SUSTAINABLE MATERIALS INSTITUTE

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1.0 Introduction

This report presents cradle-to-gate life cycle inventory (LCI) estimates for two typical, widely-used exterior stucco finishes, and explains how the estimates were developed. The work was commissioned by the ATHENA™[1] Institute as part of the continuing series of life cycle studies being done to support the ATHENA environmental decision support model.

ATHENA relies on LCI databases which include estimates of raw material, energy and water inputs as well as atmospheric emissions, liquid effluents and solid waste outputs per unit of product. The estimates encompass production activities of the individual components from raw materials extraction and processing through product manufacturing, including related transportation.

Exterior stucco finishes are produced "on site", using as their inputs cement, hydraulic lime and fine aggregate (sand), all products for which life cycle inventory data was developed in earlier ATHENA studies to various degrees of detail. The estimates developed by Venta, Glaser & Associates for exterior stucco finishes and presented here are therefore based to a large degree on three earlier ATHENA studies: "Raw Material Balances, Energy Profiles and Environmental Unit Factor Estimates: Cement and Structural Concrete" (1993)[2], "Cement and Structural Concrete Products: Life Cycle Inventory Update" (1999)[3], and "Life Cycle Analysis of Brick and Mortar Products" (1998)[4].

1.1 Research Guidelines

To ensure consistent and compatible approaches for all LCIs, all estimates have to be prepared in accordance with a set of research guidelines first issued in October, 1992 and subsequently revised as needs dictated. This research protocol defined information requirements and procedures for the study, such as the following:

- the specific building products;
- the content of general and detailed industry descriptions;
- the specific energy forms, emissions and effluents of potential interest;
- the treatment of secondary building components and assemblies;

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[1] ATHENA™ is a registered trademark of the ATHENA™ Sustainable Materials Institute.
[2] "Raw Material Balances, Energy Profiles and Environmental Unit Factor Estimates: Cement and Structural Concrete", prepared by CANMET and RADIAN Canada Inc. for ATHENA™ Sustainable Materials Institute, 1993.
[3] "Cement and Structural Concrete Products: Life Cycle Inventory Update", prepared by Venta, Glaser & Associates for ATHENA™ Sustainable Materials Institute, 1999.
[4] "Life Cycle Analysis of Brick and Mortar Products", prepared by Venta, Glaser & Associates for ATHENA™ Sustainable Materials Institute, 1998.

- preferred data types and sources (e.g. actual industry data and data from process studies);
- the analysis scope, including system boundaries and limits and the level of detail of the analysis;
- geographic divisions;
- transportation factors to be included when estimating transportation energy use; and
- a set of standard conventions for dealing with such aspects as non-domestic production, process feedstocks, in-plant recycling and multiple products.

In addition, the research guidelines provide a set of conversion factors and tables of standard factors for calculating energy contents and emissions by fuel type.

The analysis limits established for the project in the guidelines are similar to a Level II analysis for energy studies as determined by the International Federation of Institutes of Advanced Studies. These limits typically capture about 90% to 95% of the full impacts of an industry.

The life cycle analysis framework and other Institute studies are discussed in detail in other Institute publications, especially in the Summary Report, Phases II and III. That document includes the most recent (1997) version of the Research Guidelines and we have not, in this report, duplicated that material by explaining the rationale for all steps in the research and calculation process. For example, the Research Guidelines require that empty backhauls be included when calculating transportation energy use in certain circumstances. Our calculations therefore show the addition of such backhaul mileages without explaining why backhauls should be included. We have, however, provided full explanations wherever our calculations do not conform to the guidelines because of data limitations or for other reasons.

1.2 Report Structure

The ATHENA software requires LCI data for the following specific types of exterior stucco finishes:

- 3-coat Portland cement-based stucco over metal lath stucco base; and
- 3-coat Portland cement-based stucco over unit masonry solid stucco base.

The analysis procedures and calculations are described in detail in the relevant sections of this report.

The arrangement of the report basically parallels the study structure. Section 2 of the report provides the background information regarding the exterior stucco finishes. Sections 3 through 7 deal with various aspects of raw material balances, energy consumption and environmental issues related to exterior stucco finishes.

As indicated below, the basic progression involves an overview section followed by a series of sections dealing with each of the environmental impact areas (e.g. raw material use, energy use, emissions, etc.). Results are presented to show regional variations when available and, as necessary, by production stage (e.g. resource extraction, stucco components raw materials transportation, manufacturing, and transportation).

The report is organized as follows:

Section 2 presents an overview of the exterior stucco finishes, including a description of the process, and the general nature of resource and energy use, emissions and other wastes.

Section 3 details raw material use by type of finish on a regional basis, and discusses raw material transportation requirements.

Section 4 describes energy use for the finishes and presents the results by region, process stage, and type of energy used.

Section 5 deals with atmospheric emissions on a regional basis by production stage, including the analysis method and results.

Section 6 focuses on emissions to water.

Section 7 deals with solid wastes generated by the production of exterior stucco finishes.

2.0 Exterior Stucco Finishes – An Overview

This section provides an overview of the exterior stucco finishes. The basic flow chart for the production of exterior stucco finishes is shown and described. Related energy use, as well as emissions, effluents and waste outputs are also briefly discussed as an introduction to a more detailed description of these aspects and the development of appropriate LCI estimates in subsequent sections.

2.1 Background

Plastering finish of wall surfaces is one of the oldest ways of applying coatings and finishing to the outside of building structures.

Exterior plasters, usually called stuccos, are always cement-based, as opposed to interior plasters, which are mainly gypsum-based. For ease of application and plasticity, exterior stuccos always contain lime in addition to Portland cement. Masonry cements that are a mixture of Portland or blended hydraulic cement and plasticizing materials such as limestone, hydrated or hydraulic lime, can also be used instead of Portland cement.

Traditional stucco is a mix of cement, lime, sand and water. National Building Code of Canada (NBC) and ASTM specifications give ratios of individual dry constituents for different types of stuccos. Portland cement comprises about 20% of the finished product, and the bulk of the stucco is sand, which has to be clean, sharp and of a good quality/gradation, meeting ASTM C807 specifications.

Exterior stucco is usually applied as a three-coat system of the first (scratch), second (brown), and third (finish) coat over metal lath. The scratch and brown coats are proportioned and mixed on the job site. The finish coat can be either job-site prepared or supplied premixed, especially if pigmented. The ratio of the raw materials in each of the three coats is slightly different, because each has a different function in the system. The scratch coat serves as the foundation for the next two coats. It embeds the metal lath reinforcement and should be harder than the brown coat, which is achieved by using a richer mix. The brown coat is the leveling coat that provides the surface for the finished wall. It also adds strength and thickness, and in large part determines the quality of the finish. The finish coat provides the final texture and colour. The total thickness of a three-coat stucco is usually 15 mm to 22 mm.

If a stucco base is sufficiently porous, as for example cast-in-place or precast concrete or unit masonry, a two-coat work, with only a scratch and a finish coat, is sometimes used.

This study deals only with the following two common systems, as specified by the standards:

- **3-coat Portland cement-based stucco over metal lath stucco base**
- **3-coat Portland cement-based stucco over unit masonry solid stucco base**

In the case of the metal (galvanized and/or painted steel) lath-containing system, the amount of metal lath, accessories and fasteners is provided. The ATHENA software then provides the appropriate LCI data based on separate studies of steel building products.

Data developed for Portland cement and fine aggregate (sand) in the Institute's 1999 Cement and Concrete study are used as inputs for the stucco LCA. Similarly, energy consumption, atmospheric, liquid and solid emissions developed in the Institute's Brick and Mortar LCA serve as inputs into the exterior stucco finishes LCI for hydrated lime.

2.2 Industry Structure

As already indicated, exterior stucco finishes are "on site", job-manufactured products. It is only at the construction job site that the three components of the stucco — cement, lime and sand — are proportioned and mixed both before and after water is added to produce the stucco mix. Stucco then has to be applied within three hours after the initial mixing.

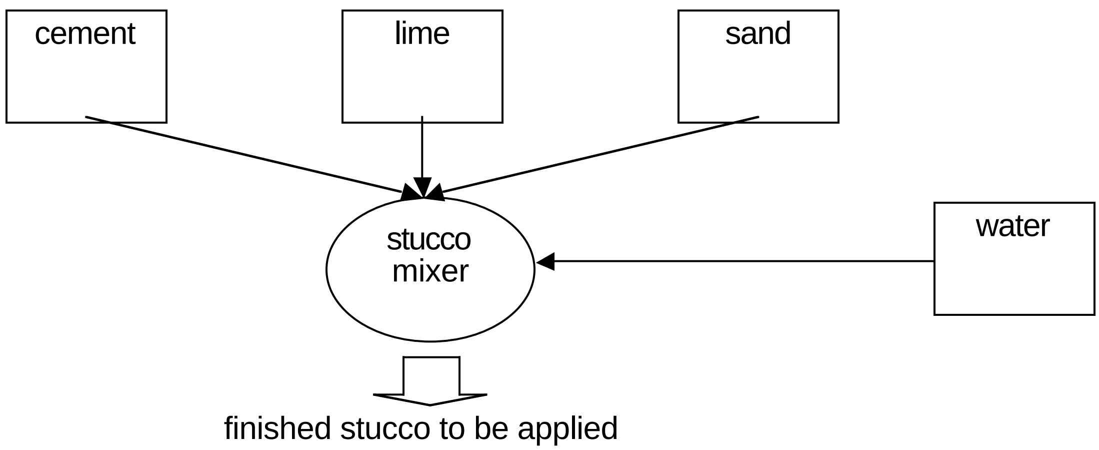

Fig. 2.1: Exterior Stucco Finishes Flowchart

One cannot, therefore, talk about the "stucco industry", but only about the different industries producing the three essential ingredients, i.e., the cement industry, the lime industry and the aggregates industry. The cement and aggregates industries were reviewed and discussed in both the 1993 Cement and Concrete study and the 1999 update to that report, while the lime industry was touched on in the Brick and Mortar study, in the context of calcium silicate bricks.

There are some similarities between the cement and lime industries (both using limestone as their basic raw material), although the production of lime, both in Canada and worldwide, is much less than that of cement. In Canada, lime is produced in six provinces (New Brunswick, Quebec, Ontario, Manitoba, Alberta, and British Columbia). The reported total capacity is close to 4 million tonnes/year. The heavily populated and industrialized provinces of Ontario and Quebec produce over 80% of Canada's total lime output, with Ontario contributing about two-thirds of that total.

2.3 Industry Standards

National Building Code

In Canada, Section 9.28 of the National Building Code[5] addresses exterior stuccos, and specifies the materials to be used as well as product application. Earlier subsections specify quality of stucco ingredients.

Subsection 9.28.3 deals with fasteners, specifying that these should be corrosion resistant, not made from aluminum. When nails are used, these should be not less than 3.2 mm in diameter with a head diameter of not less than 11 mm. Staples are also permissible, and they should be not less than 1.98 mm in diameter or thickness. Fasteners have to be of sufficient length to penetrate 25 mm into the framing members or to the full depth of sheathing.

Subsection 9.28.4 addresses stucco metal lath:

> 9.28.4.1: Materials: Rib lath or expanded metal stucco mesh shall be of copper-alloy steel coated with rust-inhibitive paint or shall be galvanized. Woven or welded wire mesh shall be galvanized.
>
> 9.28.4.3: Specifications (for vertical surfaces):
>
> - welded or woven wire: minimum wire diameter 1.19, 1.35 or 1.60 mm corresponding to 25, 38 or 51 mm maximum mesh openings.
> - stucco (diamond) mesh / expanded metal: maximum mesh opening: 25.8 cm^2, minimum mass: 0.98 kg/m^2 *(assumed to be "regular", not self-furring).*
>
> Joints in metal lath should be overlapped not less than 50 mm; at external corners additional reinforcement is required (150 mm on both sides of the corner).
>
> 9.28.4.4: stucco lath shall be held not less than 6 mm away from the backing by means of suitable self-furring devices *(such as self-furring mesh lath)*
>
> 9.28.4.6: Fastening (vertical): not fewer than 20 fasteners per m^2

Table 9.28.5A gives stucco mixes proportions in parts by volume as:

Portland cement:	1
Lime:	0.25 to 1
Aggregate:	3.25 to 4 parts per part of cementitious material

[5] National Building Code of Canada 1990 (10th edition), Section 9.28, "Stucco".

Stucco application is discussed in subsection 9.28.6 with the following stipulations:

> "Stucco shall be applied with not less than 2 base coats and one finish coat, providing a total thickness of not less than 15 mm, measured from the face of the lath or face of the masonry where no lath is used. First coat shall be not less than 6 mm. Second coat shall be not less than 6 mm. Finish coat shall be not less than 3 mm."

ASTM

Further and more detailed specifications are given by ASTM standards C926-98a[6] and C847-95[7] covering "Application of Portland Cement-Based Plaster", and "Metal Lath", respectively.

ASTM C926-98a "Standard Specification for Application of Portland Cement-Based Plaster" differentiates between exterior stucco over metal plaster lath, versus stucco over solid stucco base such as concrete masonry (blocks), cast-in-place or precast concrete. For vertical surfaces over metal stucco base, it specifies minimum thicknesses of 9.5 mm, 9.5 mm, and 3 mm respectively for the scratch, brown and finish coats, for a total of 22 mm, to ensure proper embedment of the lath. For a solid base, its requirement of 6 mm, 6 mm, and 3 mm for the three coats is the same as that specified as minimum by the National Building Code of Canada (Section 9.28, as referenced above).

Depending on the type of raw materials used (Portland cement, masonry cement, plastic cement, lime) and stucco base (metal lath, high absorption base, such as concrete masonry, or low absorption base, such as cast-in-place or precast concrete), ASTM allows various mixes. Considering the two exterior stucco systems selected for use in the ATHENA software, and the raw materials commonly used in Canada (i.e., Portland cement and lime), permissible PC/lime mixes and their proportions for both base (scratch and brown) and finish coats, as per ASTM, are shown in Table 2.1.

ASTM C926 also offers weights per cubic meter for the materials considered, factors important for data conversion. Appropriate densities are 1505 kg/m^3 for Portland cement, 640 kg/m^3 for hydrated lime, and 1280 kg/m^3 for dry sand.

[6] ASTM C926-98a, "Standard Specification for Application of Portland Cement-Based Plaster", Annual Book of ASTM Standards 2000, Volume 04.01.
[7] ASTM C847-95, "Standard Specification for Metal Lath", Annual Book of ASTM Standards 2000, Volume 04.01.

TABLE 2.1 BASE-COAT AND JOB-MIXED FINISH COAT PROPORTIONS AS PER ASTM C926-98A [PARTS BY VOLUME]

ASTM plaster type mix	Portland cement	lime	sand, per sum of CM	
			scratch coat	brown coat
C	1	0 - 0.75	2.5 - 4	3 - 5
CL	1	0.75 - 1.5	2.5 - 4	3 - 5
			finish coat, per sum of CM	
F	1	0.75 - 1.5	1.5 - 3	
FL	1	1.5 - 2	1.5 - 3	

Notes: 1) CM=cementitious materials
2) C, CL, F and FL are the four ASTM plasters considered in this study; C and CL are base coats, F and FL are finish coats.

ASTM C847-95 "Standard Specification for Metal Lath" gives nominal weights for both the US and Canadian metal lath (diamond mesh and flat rib). For the Canadian lath the nominal weights are 1.4, 1.6 or 1.8 kg/m^2 *(it is assumed these are self-furring)*. Nominal thickness of self-furring mesh is 7.9 mm, nominal thickness of regular mesh is 3.2 mm.

USG Gypsum Construction Handbook

Some industrial suppliers of the exterior stucco components and systems also offer basic mix proportions. USG, for example, sells self-furring diamond mesh, either 1.4 or 1.8 kg/m^2; packaging 686 mm wide by 2.4 m long; in bundles of 10 pieces covering 16.7 m^2. In its "Gypsum Construction Handbook"[8], it suggests basic mix proportions for the three-coat exterior stucco:

TABLE 2.2 USG RECOMMENDATIONS FOR BASE-COAT AND JOB-MIXED FINISHED COAT MIXES [PARTS BY VOLUME]

	cement [kg]	lime [kg]	sand [m^3]
scratch	43	18-23	0.14-0.17
brown	43	23	0.17-0.20
finish	43	45	0.20-0.28

Note: Upper end of the range for lime and sand is for use over concrete block where greater water retention and plasticity are required; lower end of the range is for use over metal reinforcing mesh. Sand quantity also varies depending on the shape and size of the sand particles.

[8] USG Gypsum Construction Handbook, 3rd edition, 1987, p. 378.

Water usage in exterior stucco mixes

The only other ingredient, apart from cement, lime and sand, that is used in exterior stucco mixes is water. Weber[9] discusses its quality and use:

> "It takes about 6 US gallons of clean, potable water per sack of cement, to make a workable mix when using good-quality sand. Poor quality sand may require more water, and up to 10.5 US gallons of water per sack of cement may be used when lime is added to the mix."

[9] R. Weber, "Top Quality Three Coat Stucco", Journal of Lightweight Construction, September 2000, pp. 81-86.

3.0 Raw Materials

This section provides a brief overview of raw material requirements for the two selected types of exterior stucco finishes. It also comments on transportation of the stucco components — finished products of the cement, lime and sand industries — from their point of manufacturing to the distribution centre/job site.

3.1 Raw Material Requirements

Exterior stucco finishes formulations are identical from one region of the country to another. Raw materials used, such as cement, lime and aggregate (sand), are available across the country.

Typical formulas for the two exterior stucco systems under consideration were developed in agreement with the requirements of the National Building Code of Canada (Section 9.28), with additional input, where required, from ASTM specifications (ASTM C926-98a and C847-95). Water requirements were based on Weber (as referenced on the previous page). The raw materials requirements for 3-coat Portland cement-based exterior stucco over metal lath are given in Tables 3.1 to 3.3 in parts by volume, in kg/m^3 of stucco mix, and in kg/m^2 of wall surface, respectively. The types and quantities of stucco metal lath and of fasteners per m^2 of wall surface are also provided in Table 3.3. Similarly, the raw materials requirements for the 3-coat Portland cement-based exterior stucco over unit masonry solid base were developed and are shown in Tables 3.4 to 3.6.

TABLE 3.1 3-COAT PC-BASED STUCCO OVER METAL LATH RAW MATERIALS REQUIREMENTS [PARTS BY VOLUME]

	Portland cement	lime	*sand, per sum of CM*[1]	sand	Water[2]	total volume
scratch coat	1	.75	*3.25*	5.6875	1.41	8.8475
brown coat	1	.75	*4*	7	1.41	10.16
finish coat	1	1.125	*2.25*	4.78125	1.57	8.47625

Notes: 1) CM = cementitious materials
2) Assumed 9 US gallons/sack of cement for scratch and brown coats, 10 US gallons/sack of cement for finish coat

TABLE 3.2 3-COAT PC-BASED STUCCO OVER METAL LATH RAW MATERIALS REQUIREMENTS [kg/m^3]

	Portland cem.	lime	sand	water	total kg/m3
scratch coat	170.10455	54.25261	822.83131	159.36705	1206.55552
brown coat	148.12992	47.24409	881.88976	138.77953	1216.04331
finish coat	177.55493	84.94322	722.01740	185.22342	1169.73898
sum	495.78940	186.43993	2426.73847	483.37000	3592.33781

TABLE 3.3 3-COAT PC-BASED STUCCO OVER METAL LATH RAW MATERIALS REQUIREMENTS [kg/m^2 OF WALL SURFACE]

	coat thickness [mm]	Portland cement	lime	sand	water	total
scratch coat	9.5	1.61599	0.51540	7.81690	1.51399	11.46228
brown coat	9.5	1.40723	0.44882	8.37795	1.31841	11.55241
finish coat	3	0.53266	0.25483	2.16605	0.55567	3.50922
sum	22	3.55589	1.21905	18.36090	3.38806	26.52391

Additional materials requirements for 3-coat PC-based stucco over metal lath:

1) 1.03 m^2 of medium weight (1.6 kg/m^2) stucco (diamond) reinforcing copper-alloy galvanized or painted steel mesh lath, i.e., 1.648 kg of reinforcing mesh lath per 1 m^2 of wall surface. The 3% increase accounts for mesh overlaps and the need for additional reinforcements at the corners.

2) 22 corrosion resistant fasteners (nails, 3.2 mm in diameter with a head diameter of 11 mm, 33 mm long minimum) per 1 m^2 of wall surface.

TABLE 3.4 3-COAT PC-BASED STUCCO OVER UNIT MASONRY SOLID STUCCO BASE RAW MATERIALS REQUIREMENTS [PARTS BY VOLUME]

	Portland cement	lime	*sand, per sum of CM*	sand	water	total volume
scratch coat	1	1	*4*	8	1.49	11.49
brown coat	1	1	*5*	10	1.49	13.49
finish coat	1	1.125	*2.25*	4.78125	1.57	8.47625

Note: 1) CM = cementitious materials
2) Assumed 9.5 USG/sack of cement for scratch and brown coats, 10 USG/sack of cement for finish coat

TABLE 3.5 3-COAT PC-BASED STUCCO OVER UNIT MASONRY SOLID PLASTER BASE RAW MATERIALS REQUIREMENTS [kg/m^3]

	Portland cem.	lime	sand	water	total kg/m3
scratch coat	130.98346	55.70061	891.20975	129.67798	1207.57180
brown coat	111.56412	47.44255	948.85100	110.45219	1218.30986
finish coat	177.55493	84.94322	722.01740	185.22342	1169.73898
sum	420.10252	188.08638	2562.07815	425.35359	3595.62064

TABLE 3.6 3-COAT PC-BASED STUCCO OVER UNIT MASONRY SOLID STUCCO BASE RAW MATERIALS REQUIREMENTS [kg/m^2 OF WALL SURFACE]

	coat thickness [mm]	Portland cement	lime	sand	water	total
scratch coat	6	0.78590	0.33420	5.34726	0.77807	7.24543
brown coat	6	0.66938	0.28466	5.69311	0.66271	7.30986
finish coat	3	0.53266	0.25483	2.16605	0.55567	3.50922
sum	15	1.98795	0.87369	13.20642	1.99645	18.06451

Note: In this as well as in earlier tables totals may not add due to rounding

3.2 Raw Materials Transportation

The raw materials, or components, used to produce exterior stucco are finished products of other industries: the cement, lime and aggregate industries. The weighted average transportation distances and modes of transport for finished cement, on a regional basis, are shown in Table 4.5 in the updated Cement and Concrete study.

In the "Life Cycle Analysis of Brick and Mortar Products", Section 3.2.2, we estimated that, in Ontario, lime is transported from a distance of 65 km away by truck (diesel road) with no backhaul. Therefore the lime transportation for the subsequent energy and emissions estimates is doubled to 130 km. There were no estimates developed for lime for other regions of the country, and it is beyond the scope of this work to develop a detailed lime LCI here. Therefore, we will assume that the situation is similar in the other regions of the country to that in Ontario. As there are lime operations in all regions of the country, any error introduced is probably rather small.

As in the Cement and Concrete update and the Brick and Mortar study, it is assumed in this report that sand comes from local sources, from within 30 km, due to its general availability. It is shipped by truck with no backhaul, resulting in a roundtrip of 60 km.

4.0 Energy Use

In this section, we explain and present the estimates of energy embodied in exterior stucco finishes. Energy is used in all stages of exterior stucco production: raw materials extraction and transportation of the three components (cement, lime and sand); their processing; and transportation of finished cement, lime and sand to the distribution centre/job site for stucco processing. Various tables show total energy use by region and process stage. We also show the breakdown by energy type because that information is directly relevant to the estimation of atmospheric emissions in a subsequent section of the report.

4.1 Cement

Energy estimates due to use of cement in exterior stucco finishes were derived from the "Cement and Structural Concrete Products: Life Cycle Inventory Update". They are shown there in Tables 4.7 and 4.9 in GJ/tonne (MJ/kg) of finished cement, by process stage and by energy form, respectively. Here the energy estimates from these two tables are converted to MJ/m^2 of finished stucco wall surface by multiplying the values for cement energy consumption in MJ/kg from Tables 4.7 and 4.9 by the total amount of cement needed for a square meter of 3-coat exterior stucco finish over metal lath from Table 3.3. Similarly, the mass of cement from Table 3.6 was used for 3-coat exterior stucco finish over unit masonry solid stucco base.

For example, in the case of 3-coat exterior stucco finish over metal lath, the energy embodied in cement raw materials extraction in the Vancouver area is estimated as follows:

0.04464 MJ/kg of finished cement [from Table 4.7 of the updated Cement report] **x 3.55589 kg/m^2** [mass of cement needed to produce one m^2 of 3-coat exterior stucco finish over metal lath from Table 3.3] = **0.1587 MJ/m^2**

TABLE 4.1 3-COAT PC-BASED STUCCO OVER METAL LATH WEIGHTED AVERAGE ENERGY USE IN CEMENT PRODUCTION BY PROCESS STAGE [MJ/m^2 OF STUCCO WALL SURFACE]

Region	City	Cement RM Extraction	Raw materials transport	Cement Processing	Cement transport	Total
West Ct	Vancouver	0.1587	0.3210	16.7642	0.4855	17.7295
Prairie	Calgary	0.1584	0.8018	15.3107	1.3280	17.5988
	Winnipeg	0.1584	0.8018	15.3107	4.5651	20.8359
Central	Toronto	0.1582	0.2387	15.1238	0.4931	16.0138
East	Montreal	0.1569	0.0856	18.6435	0.6191	19.5051
	Halifax	0.1569	0.0856	18.6435	0.9075	19.7934

TABLE 4.2 3-COAT PC-BASED STUCCO OVER METAL LATH WEIGHTED AVERAGE ENERGY USE IN CEMENT PRODUCTION BY ENERGY FORM [MJ/m² OF STUCCO WALL SURFACE]

Region	City	Diesel road	Diesel rail	H.F.oil marine	Nat. Gas	Coal	Oil	Coke	Waste	Electricity	Total
West Ct	Vancouver	0.6711	0.0020	0.2904	8.2647	5.2095	0.5441	0.7162	0.0000	2.0314	17.7295
Prairie	Calgary	1.6150	0.6704	0.0000	13.0371	0.0000	0.0000	0.0000	0.0000	2.2763	17.5988
	Winnipeg	0.2870	5.2354	0.0000	13.0371	0.0000	0.0000	0.0000	0.0000	2.2763	20.8359
Central	Toronto	0.6977	0.0213	0.1631	2.1763	7.4256	0.3536	2.3834	0.5704	2.2223	16.0138
East	Montreal	0.7554	0.0753	0.0264	2.8420	6.0934	2.2962	4.0470	1.2382	2.1313	19.5051
	Halifax	0.9927	0.0000	0.1527	2.8420	6.0934	2.2962	4.0470	1.2382	2.1313	19.7934

TABLE 4.3 3-COAT PC-BASED STUCCO OVER UNIT MASONRY SOLID STUCCO BASE WEIGHTED AVERAGE ENERGY USE IN CEMENT PRODUCTION BY PROCESS STAGE [MJ/m² OF STUCCO WALL SURFACE]

Region	City	Cement Extraction	Raw materials transport	Cement Processing	Cement transport	Total
West Ct	Vancouver	0.0887	0.1795	9.3722	0.2715	9.9118
Prairie	Calgary	0.0886	0.4482	8.5596	0.7424	9.8388
	Winnipeg	0.0886	0.4482	8.5596	2.5521	11.6485
Central	Toronto	0.0884	0.1335	8.4551	0.2757	8.9526
East	Montreal	0.0877	0.0478	10.4228	0.3461	10.9045
	Halifax	0.0877	0.0478	10.4228	0.5073	11.0657

TABLE 4.4 3-COAT PC-BASED STUCCO OVER UNIT MASONRY SOLID STUCCO BASE WEIGHTED AVERAGE ENERGY USE IN CEMENT PRODUCTION BY ENERGY FORM [MJ/m² OF STUCCO WALL SURFACE]

Region	City	Diesel road	Diesel rail	H.F.oil marine	Nat. Gas	Coal	Oil	Coke	Waste	Electricity	Total
West Ct	Vancouver	0.3752	0.0011	0.1624	4.6205	2.9124	0.3042	0.4004	0.0000	1.1357	9.9118
Prairie	Calgary	0.9029	0.3748	0.0000	7.2885	0.0000	0.0000	0.0000	0.0000	1.2726	9.8388
	Winnipeg	0.1605	2.9269	0.0000	7.2885	0.0000	0.0000	0.0000	0.0000	1.2726	11.6485
Central	Toronto	0.3901	0.0119	0.0912	1.2167	4.1514	0.1977	1.3325	0.3189	1.2424	8.9526
East	Montreal	0.4223	0.0421	0.0147	1.5888	3.4066	1.2837	2.2625	0.6922	1.1915	10.9045
	Halifax	0.5550	0.0000	0.0854	1.5888	3.4066	1.2837	2.2625	0.6922	1.1915	11.0657

4.2 Lime

Energy estimates for use of lime in exterior stucco finishes per m^2 of finished stucco wall were derived from Table 4.2.1 in the "Life Cycle Analysis of Brick and Mortar Products" in a similar manner as those for cement in the preceding section.

It should be noted that only lime produced in Ontario was considered in the brick study, as the only Canadian operation where calcium silicate bricks are produced is located there. As already mentioned, lime is produced across the country, in six different provinces, providing a good coverage and lime availability in all regions. Of course, there are a number of different types of lime kilns used, with various energy efficiencies and consumptions. However, as noted earlier, it is beyond the scope of this study to develop a full LCI of lime operations in different regions of Canada. Therefore, we will assume that energy embodied in lime production in all regions is the same as in Ontario.

**TABLE 4.5 3-COAT PC-BASED STUCCO OVER METAL LATH
WEIGHTED AVERAGE ENERGY USE IN LIME PRODUCTION (ONTARIO)
BY PROCESS STAGE [MJ/m^2 OF STUCCO WALL SURFACE]**

Extraction	RM transport	Processing	Lime transport	Total
0.0588	0.0042	8.1181	0.1870	8.3681

**TABLE 4.6 3-COAT PC-BASED STUCCO OVER METAL LATH
WEIGHTED AVERAGE ENERGY USE IN LIME PRODUCTION (ONTARIO)
BY ENERGY FORM [MJ/m^2 OF STUCCO WALL SURFACE]**

Natural Gas	Electricity	Diesel road	Total
7.8872	0.2351	0.2458	8.3681

**TABLE 4.7 3-COAT PC-BASED STUCCO OVER UNIT MASONRY SOLID STUCCO BASE
WEIGHTED AVERAGE ENERGY USE IN LIME PRODUCTION (ONTARIO)
BY PROCESS STAGE [MJ/m^2 OF STUCCO WALL SURFACE]**

Extraction	RM transport	Processing	Lime transport	Total
0.0421	0.0030	5.8183	0.1340	5.9974

TABLE 4.8 3-COAT PC-BASED STUCCO OVER UNIT MASONRY SOLID STUCCO BASE WEIGHTED AVERAGE ENERGY USE IN LIME PRODUCTION (ONTARIO) BY ENERGY FORM [MJ/m^2 OF STUCCO WALL SURFACE]

Natural Gas	Electricity	Diesel road	Total
5.6528	0.1685	0.1761	5.9974

4.3 Sand

Production of sand is assumed to require the same energy per tonne as fine aggregates. It was discussed in Section 11.1 of the 1993 Cement and Concrete report, and it is also shown in Table 4.2.2 of the Brick and Mortar report. The energy inputs per m^2 of stucco wall were estimated in a similar manner as those for cement and lime.

TABLE 4.9 3-COAT PC-BASED STUCCO OVER METAL LATH AVERAGE ENERGY USE IN SAND PRODUCTION BY PROCESS STAGE [MJ/m^2 OF STUCCO WALL SURFACE]

Extraction	Processing	Transport	Total
0.4957	0.5949	0.6500	1.7406

TABLE 4.10 3-COAT PC-BASED STUCCO OVER METAL LATH AVERAGE ENERGY USE IN SAND PRODUCTION BY ENERGY FORM [MJ/m^2 OF STUCCO WALL SURFACE]

Electricity	Diesel road	Total
0.5949	1.1457	1.7406

TABLE 4.11 3-COAT PC-BASED STUCCO OVER UNIT MASONRY SOLID STUCCO BASE AVERAGE ENERGY USE IN SAND PRODUCTION BY PROCESS STAGE [MJ/m^2 OF STUCCO WALL SURFACE]

Extraction	Processing	Transport	Total
0.3565	0.4279	0.4675	1.2520

TABLE 4.12 3-COAT PC-BASED STUCCO OVER UNIT MASONRY SOLID STUCCO BASE AVERAGE ENERGY USE IN SAND PRODUCTION BY ENERGY FORM [MJ/m^2 OF STUCCO WALL SURFACE]

Electricity	Diesel road	Total
0.4279	0.8241	1.2520

4.4 Energy consumption in stucco mixing

Mixing on the job site simply involves mixing of the three dry stucoo components — cement, lime and sand — with water. The type of mixer and the mixing method are the same as those used for production of cement mortar (see section 11.4 in the 1993 Cement report), i.e. a 3 cubic foot (0.085 m^3) mixer driven by a 3/4 HP electric motor, with a mix time of 10 minutes. That gives the estimate of total electrical energy use of 3.95 MJ per m^3 of stucco. To convert to energy use per m^2 units of stucco wall for the two cases under consideration, the above value is multiplied by volumes of the two respective stuccos per m^2 of wall:

3-coat PC-based stucco over metal lath:
3.95 MJ/m^3 x 0.022 m^3/m^2 of stucco surface = 0.0869 MJ/m^2

3-coat PC-based stucco over unit masonry solid stucco base:
3.95 MJ/m^3 x 0.015 m^3/m^2 of stucco surface = 0.05925 MJ/m^2

4.5 Total energy – exterior stucco

Total energy embodied in production of exterior stucco finishes is obtained by combining the above estimates for energy consumption for embodied energy in production of the three dry components of the stucco finishes and the energy input for stucco mixing. The totals for the two types of exterior stucco finishes under consideration are shown below in Sections 4.5.1 and 4.5.2, respectively. In both cases, the total energy inputs are tabulated in three different forms – by components, by process stage, and by energy form. They are all expressed in MJ per m^2 of stucco surface.

As in other cement-containing products, energy embodied in cement production represents the highest fraction of the total, due to the high energy consumption in the cement manufacturing stage. Lime accounts for the second highest fraction of total energy.

4.5.1 3-coat PC-based stucco over metal lath

TABLE 4.13 ENERGY USE IN PRODUCTION OF 3-COAT PC-BASED STUCCO OVER METAL LATH BY RM COMPONENT [MJ/m^2]

Region	City	Cement	Lime	Sand	Stucco processing	TOTAL
West Ct	Vancouver	17.7295	8.3681	1.7406	0.0869	27.9251
Prairie	Calgary	17.5988	8.3681	1.7406	0.0869	27.7944
	Winnipeg	20.8359	8.3681	1.7406	0.0869	31.0315
Central	Toronto	16.0138	8.3681	1.7406	0.0869	26.2094
East	Montreal	19.5051	8.3681	1.7406	0.0869	29.7007
	Halifax	19.7934	8.3681	1.7406	0.0869	29.9891

TABLE 4.14 ENERGY USE IN PRODUCTION OF 3-COAT PC-BASED STUCCO OVER METAL LATH BY PROCESS STAGE [MJ/m^2]

Region	City	Components RM extraction	Components RM transport	Components manufacturing	Components transport	Stucco processing	TOTAL
West Ct	Vancouver	0.7132	0.3253	25.4772	1.3225	0.0869	27.9251
Prairie	Calgary	0.7129	0.8060	24.0237	2.1649	0.0869	27.7944
	Winnipeg	0.7129	0.8060	24.0237	5.4020	0.0869	31.0315
Central	Toronto	0.7126	0.2430	23.8368	1.3301	0.0869	26.2094
East	Montreal	0.7114	0.0898	27.3565	1.4561	0.0869	29.7007
	Halifax	0.7114	0.0898	27.3565	1.7445	0.0869	29.9891

TABLE 4.15 ENERGY USE IN PRODUCTION OF 3-COAT PC-BASED STUCCO OVER METAL LATH BY ENERGY FORM [MJ/m^2]

Region	City	Diesel road	Diesel rail	H.F.oil marine	Natural Gas	Coal	Oil	Coke	Waste	Electricity	TOTAL
West Ct	Vancouver	2.0626	0.0020	0.2904	16.1520	5.2095	0.5441	0.7162	0.0000	2.9483	27.9251
Prairie	Calgary	3.0065	0.6704	0.0000	20.9243	0.0000	0.0000	0.0000	0.0000	3.1933	27.7944
	Winnipeg	1.6785	5.2354	0.0000	20.9243	0.0000	0.0000	0.0000	0.0000	3.1933	31.0315
Central	Toronto	2.0892	0.0213	0.1631	10.0635	7.4256	0.3536	2.3834	0.5704	3.1392	26.2094
East	Montreal	2.1469	0.0753	0.0264	10.7292	6.0934	2.2962	4.0470	1.2382	3.0483	29.7007
	Halifax	2.3842	0.0000	0.1527	10.7292	6.0934	2.2962	4.0470	1.2382	3.0483	29.9891

4.5.2 3-coat PC-based stucco over unit masonry solid stucco base

TABLE 4.16 ENERGY USE IN PRODUCTION OF 3-COAT PC-BASED STUCCO OVER UNIT MASONRY SOLID STUCCO BASE BY RM COMPONENT [MJ/m^2]

Region	City	Cement	Lime	Sand	Stucco processing	TOTAL
West Ct	Vancouver	9.9118	5.9974	1.2520	0.0593	17.2204
Prairie	Calgary	9.8388	5.9974	1.2520	0.0593	17.1474
	Winnipeg	11.6485	5.9974	1.2520	0.0593	18.9571
Central	Toronto	8.9526	5.9974	1.2520	0.0593	16.2613
East	Montreal	10.9045	5.9974	1.2520	0.0593	18.2131
	Halifax	11.0657	5.9974	1.2520	0.0593	18.3743

TABLE 4.17 ENERGY USE IN PRODUCTION OF 3-COAT PC-BASED STUCCO OVER UNIT MASONRY SOLID STUCCO BASE BY PROCESS STAGE [MJ/m^2]

Region	City	Components RM extraction	Components RM transport	Components manufacturing	Components transport	Stucco processing	TOTAL
West Ct	Vancouver	0.4874	0.1825	15.6183	0.8730	0.0593	17.2204
Prairie	Calgary	0.4872	0.4513	14.8057	1.3439	0.0593	17.1474
	Winnipeg	0.4872	0.4513	14.8057	3.1537	0.0593	18.9571
Central	Toronto	0.4871	0.1365	14.7012	0.8772	0.0593	16.2613
East	Montreal	0.4864	0.0509	16.6689	0.9476	0.0593	18.2131
	Halifax	0.4864	0.0509	16.6689	1.1089	0.0593	18.3743

TABLE 4.18 ENERGY USE IN PRODUCTION OF 3-COAT PC-BASED STUCCO OVER UNIT MASONRY SOLID STUCCO BASE BY ENERGY FORM [MJ/m^2]

Region	City	Diesel road	Diesel rail	H.F.oil marine	Natural gas	Coal	Oil	Coke	Waste	Electricity	TOTAL
West Ct	Vancouver	1.3754	0.0011	0.1624	10.2732	2.9124	0.3042	0.4004	0.0000	1.7913	17.2204
Prairie	Calgary	1.9031	0.3748	0.0000	12.9413	0.0000	0.0000	0.0000	0.0000	1.9283	17.1474
	Winnipeg	1.1607	2.9269	0.0000	12.9413	0.0000	0.0000	0.0000	0.0000	1.9283	18.9571
Central	Toronto	1.3903	0.0119	0.0912	6.8694	4.1514	0.1977	1.3325	0.3189	1.8980	16.2613
East	Montreal	1.4225	0.0421	0.0147	7.2416	3.4066	1.2837	2.2625	0.6922	1.8472	18.2131
	Halifax	1.5552	0.0000	0.0854	7.2416	3.4066	1.2837	2.2625	0.6922	1.8472	18.3743

5.0 Atmospheric Emissions

This section addresses emissions to air associated with the production of exterior stucco finishes in all their processing stages, from the extraction and transportation of raw materials of the individual components through stucco mixing on the job site.

Like any energy-using production process, exterior stucco finishes, regardless of the type, number of coats, or method of production of their constituent raw materials, generate common air pollutants including carbon dioxide (CO_2), sulfur oxides (SO_X) — primarily sulfur dioxide (SO_2) — nitrogen oxides (NO_X), volatile organic compounds (VOC), methane (CH_4), and carbon monoxide (CO). These energy-related emissions are termed "fuel emissions".

The emissions from fuel combustion were estimated based on energy consumption developed in Section 3 for various stages of cement, lime and sand production, as well as in the stucco processing, using the environmental emission factors as provided by the Institute's *Research Guidelines*. These emission factors are shown below. The manner in which the fuel emission estimates were developed was discussed in detail in the appropriate Institute reports (the 1993 and 1999 Cement and Concrete studies, and the Brick and Mortar report).

ENVIRONMENTAL EMISSIONS FACTORS [g/MJ]

	CO_2	SO_2	NO_x	VOC	CH_4	CO
natural gas	49.700	0.0002	0.0590	0.00120	0.00130	0.01500
diesel road	70.700	0.1020	0.8070	0.08690	0.02170	0.44300
diesel rail	70.700	0.1020	1.4000	0.07000	0.00780	0.05700
H.F. oil marine	74.000	0.4500	0.2000	0.36000	0.04000	0.00740
H.F.oil industrial	74.000	0.8375	0.1600	0.00290	0.00082	0.01440
coal - W.Coast	94.300	0.4400	0.2500	0.00150	0.00054	0.09300
coal - Prairie	94.300	0.4400	0.2500	0.00150	0.00054	0.09300
coal - Central	87.600	0.8360	0.2500	0.00150	0.00054	0.09300
coal - East	85.333	1.7278	0.2500	0.00150	0.00054	0.09300
coke	86.000	1.1500	0.2400	0.00140	0.00051	0.08800
waste	67.500	n/a	0.1200	0.00120	0.00110	n/a
electricity	0.000	0.0000	0.0000	0.00000	0.00000	0.00000

As in other Institute reports, emissions related to the generation of electricity used in the production of the components and processing of exterior stucco finishes are not included in the tables that follow. Therefore, there are no tables for lime transport, sand processing and stucco mixing, all of which use only electricity. These electricity-related emissions are calculated separately within the ATHENA software for all the products considered, i.e., the estimates of electricity use for production of stuccos presented in this report are translated into the mix of primary energy forms used to generate the electricity for the relevant regional electrical system; corresponding atmospheric emissions are then added to the other emissions estimated in this study.

The ATHENA software also factors in pre-combustion energy use and related emissions (i.e., the energy use and related emissions to produce and transport energy).

The specific characteristics of both cement and lime, and the nature of high temperatures encountered in their processing, result in both positive and negative "processing" atmospheric emission effects that are in addition to the "fuel" emissions. There is significant "calcination CO_2" contribution due to the decomposition of limestone in the manufacturing of both cement and lime, as well as "thermal" and "prompt" NO_x contributions, usually outweighing the "fuel" NO_x. On the positive side, cement has the ability during its production to absorb (scrub) almost all SO_x generated from both raw materials and fuels used, allowing the use of high sulfur content fuels that could not be used in other processes. These aspects of cement and lime process emissions, as opposed to fuel emissions, were discussed in more detail in the Institute's Cement and Brick reports.

Particulate matter (TPM) emissions are also generated in various stages of production.

Process emissions

In the Tables below concerning cement (Tables 5.3, 5.4, 5.29 and 5.30) and lime (Tables 5.10, 5.11, 5.36 and 5.37) processing, we separated the fuel related emissions from the processing ones, such as calcination CO_2, thermal and prompt NO_x, negative (scrubbed) SO_x. Fuel emissions are those caused by burning fossil fuels. These are estimated as a product of the quantity and type of fuels used and an appropriate emission factor. Process emissions are any other emissions caused by the material processing, related to the chemical nature of the raw materials used and the process itself.

In the case of cement processing, as discussed in detail in the 1993 Cement and Concrete report, the process affects the CO_2, NO_x, and SO_2 emissions. There are no VOC, CH_4, or CO processing emissions.

CO_2: The processing, or calcination CO_2 is generated in the kiln during pyroprocessing. Calcium carbonate ($CaCO_3$) contained in limestone breaks down to calcium oxide (CaO) and carbon dioxide (CO_2) that is released into the atmosphere. This can be easily calculated from stoichiometry of limestone decomposition, as shown in the above-mentioned report. Over the last few decades, the cement industry made great strides in improving its energy efficiency. Consequently, the ratio between the calcination CO_2 and fuel CO_2 has shifted from about 50/50 to closer to 60/40. The exact ratio depends on the type of fuel used and efficiency (type, age) of the kiln.

NO_x: There are three mechanisms of NO_x formation: thermal NO_x, prompt NO_x, and fuel NO_x. NO_x emissions from cement kilns have been found to depend on both the kiln type and fuel type. In general, preheater and precalciner kilns have lower NO_x emission rates than long dry and wet kilns due to the higher fuel efficiency and lower firing rates in the kiln firing zone. Due to the high temperatures in cement kiln processing, the thermal and prompt portion of the pyroprocessing NO_x is substantially higher than its fuel NO_x portion.

SO_2: The Portland cement industry is in an unusual position of being able to utilize high sulfur content fuels while still maintaining low SO_2 emissions due to the scrubbing effect (the reaction of the SO_2 with CaO formed during the calcination process through disassociation of limestone).

This scrubbing effect results in negative processing SO_2 emissions. Consequently, the total processing SO_2 released as gaseous emissions to the atmosphere is substantially lower than SO_2 estimated on the basis of fuel and raw materials sulfur uptake, on average reduced by 96.12%.

Similarly, in lime processing, in addition to the fuel emissions there are calcination CO_2 and thermal/prompt NO_x emissions, as discussed in more detail in Brick and Mortar report.

5.1 3-coat stucco over metal lath

5.1.1 Air emissions from cement production

The sources of fuel and process emissions from various stages of cement production were discussed in detail and their estimates developed in the 1993 Institute report on Cement and Structural Concrete, and updated in the 1999 report. Here in the Tables below the estimates from those cement LCIs were converted and expressed in g/m^2 of the stucco wall finish.

We show here the emissions due to cement production on a regional basis, perhaps in more detail than necessary, for all the processing steps. The fuel versus process emissions, both in the manufacturing step and in the total emissions, are also highlighted.

TABLE 5.1 CEMENT RAW MATERIALS EXTRACTION EMISSIONS [g/m^2 OF 3-COAT STUCCO OVER METAL LATH]

Region	City	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
West Ct	Vancouver	11.22263	0.01619	0.12810	0.01379	0.00344	0.07032	1.81350
Prairie	Calgary	11.19994	0.01616	0.12784	0.01377	0.00344	0.07018	1.81350
	Winnipeg	11.19994	0.01616	0.12784	0.01377	0.00344	0.07018	1.81350
Central	Toronto	11.18142	0.01613	0.12763	0.01374	0.00343	0.07006	1.81350
East	Montreal	11.09374	0.01601	0.12663	0.01364	0.00341	0.06951	1.81350
	Halifax	11.09374	0.01601	0.12663	0.01364	0.00341	0.06951	1.81350

TABLE 5.2 CEMENT RAW MATERIALS TRANSPORTATION EMISSIONS [g/m^2 OF 3-COAT STUCCO OVER METAL LATH]

Region	City	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
West Ct	Vancouver	23.53131	0.13363	0.08256	0.10703	0.01222	0.01415	0.00000
Prairie	Calgary	56.48935	0.08150	1.04233	0.05810	0.00802	0.09519	0.00000
	Winnipeg	56.48935	0.08150	1.04233	0.05810	0.00802	0.09519	0.00000
Central	Toronto	16.65244	0.05844	0.13810	0.04708	0.00655	0.05036	0.00000
East	Montreal	5.81412	0.01744	0.04937	0.01424	0.00224	0.02440	0.00000
	Halifax	5.81412	0.01744	0.04937	0.01424	0.00224	0.02440	0.00000

TABLE 5.3 CEMENT PROCESSING – FUEL EMISSIONS [g/m^2 OF 3-COAT STUCCO OVER METAL LATH]

Region	City	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
West Ct	Vancouver	1003.86792	3.57312	2.04893	0.02031	0.01437	0.67931	0.00000
Prairie	Calgary	647.94313	0.00261	0.76919	0.01564	0.01695	0.19556	0.00000
	Winnipeg	647.94313	0.00261	0.76919	0.01564	0.01695	0.19556	0.00000
Central	Toronto	1028.29320	9.24536	2.68186	0.01880	0.00897	0.93806	0.00000
East	Montreal	1262.74758	17.10552	3.17827	0.02636	0.01229	0.99852	0.00000
	Halifax	1262.74758	17.10552	3.17827	0.02636	0.01229	0.99852	0.00000

TABLE 5.4 CEMENT PROCESSING – PROCESS EMISSIONS [g/m^2 OF 3-COAT STUCCO OVER METAL LATH]

Region	City	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
West Ct	Vancouver	1772.02384	-3.43439	14.01562	0.00000	0.00000	0.00000	1.71771
Prairie	Calgary	1772.02384	-0.00241	17.03634	0.00000	0.00000	0.00000	3.33542
	Winnipeg	1772.02384	-0.00241	17.03634	0.00000	0.00000	0.00000	3.33542
Central	Toronto	1772.02384	-8.88655	4.66319	0.00000	0.00000	0.00000	1.21014
East	Montreal	1772.02384	-16.44173	7.38084	0.00000	0.00000	0.00000	3.06955
	Halifax	1772.02384	-16.44173	7.38084	0.00000	0.00000	0.00000	2.14420

TABLE 5.5 CEMENT PROCESSING – TOTAL EMISSIONS (FUEL + PROCESS) [g/m^2 OF 3-COAT STUCCO OVER METAL LATH]

Region	City	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
West Ct	Vancouver	2775.89176	0.13873	16.06456	0.02031	0.01437	0.67931	1.71771
Prairie	Calgary	2419.96697	0.00019	17.80553	0.01564	0.01695	0.19556	3.33542
	Winnipeg	2419.96697	0.00019	17.80553	0.01564	0.01695	0.19556	3.33542
Central	Toronto	2800.31704	0.35881	7.34506	0.01880	0.00897	0.93806	1.21014
East	Montreal	3034.77142	0.66379	10.55911	0.02636	0.01229	0.99852	3.06955
	Halifax	3034.77142	0.66379	10.55911	0.02636	0.01229	0.99852	2.14420

TABLE 5.6 FINISHED CEMENT TRANSPORTATION EMISSIONS [g/m^2 OF 3-COAT STUCCO OVER METAL LATH]

Region	City	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
West Ct	Vancouver	34.32799	0.04953	0.39183	0.04219	0.01054	0.21510	0.00000
Prairie	Calgary	93.88619	0.13545	1.07166	0.11540	0.02882	0.58828	0.00000
	Winnipeg	322.74935	0.46564	6.39108	0.31955	0.03561	0.26021	0.00000
Central	Toronto	35.06886	0.07214	0.35982	0.06000	0.01185	0.19109	0.00000
East	Montreal	43.77102	0.06315	0.54426	0.05253	0.01239	0.24521	0.00000
	Halifax	64.57648	0.13653	0.65566	0.11336	0.02200	0.34699	0.00000

TABLE 5.7 TOTAL EMISSIONS DUE TO PRODUCTION OF CEMENT [g/m^2 OF 3-COAT STUCCO OVER METAL LATH]

Region	City	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
West Ct	Vancouver	2844.97368	0.33808	16.66706	0.18333	0.04056	0.97888	3.53121
Prairie	Calgary	2581.54245	0.23330	20.04735	0.20291	0.05722	0.94921	5.14893
	Winnipeg	2810.40561	0.56348	25.36677	0.40707	0.06401	0.62113	5.14893
Central	Toronto	2863.21976	0.50553	7.97060	0.13962	0.03080	1.24957	3.02364
East	Montreal	3095.45030	0.76038	11.27936	0.10677	0.03033	1.33764	4.88305
	Halifax	3116.25576	0.83376	11.39076	0.16760	0.03994	1.43941	3.95771

TABLE 5.8 BREAKDOWN OF CEMENT CO_2, SO_2 AND NO_x FUEL AND PROCESS EMISSIONS [g/m^2 OF 3-COAT STUCCO OVER METAL LATH]

Region	City	Fuel CO_2	Process CO_2	Total CO_2	Fuel SO_2	Process SO_2	Total SO_2	Fuel NO_x	Process NO_x	Total NO_x
West Ct	Vancouver	1072.94985	1772.02384	2844.97368	3.77247	-3.43439	0.33808	2.65143	14.01562	16.66706
Prairie	Calgary	809.51861	1772.02384	2581.54245	0.23571	-0.00241	0.23330	3.01101	17.03634	20.04735
	Winnipeg	1038.38177	1772.02384	2810.40561	0.56590	-0.00241	0.56348	8.33043	17.03634	25.36677
Central	Toronto	1091.19592	1772.02384	2863.21976	9.39208	-8.88655	0.50553	3.30740	4.66319	7.97060
East	Montreal	1323.42646	1772.02384	3095.45030	17.20211	-16.44173	0.76038	3.89852	7.38084	11.27936
	Halifax	1344.23192	1772.02384	3116.25576	17.27549	-16.44173	0.83376	4.00992	7.38084	11.39076

5.1.2 Air emissions from production of lime

Atmospheric emissions associated with various stages of lime production, based on lime production in Ontario, were discussed in detail and their estimates developed in the Institute report on Brick and Mortar Products. Here in the Tables below the estimates from those lime LCIs were converted and expressed in g/m^2 of the stucco wall finish. As with cement emissions in Section 5.1.1, these are shown here by process stage, highlighting again the fuel versus process emissions in both the processing stage and in total lime emissions.

TABLE 5.9 LIME RAW MATERIALS EXTRACTION EMISSIONS [g/m^2 OF 3-COAT STUCCO OVER METAL LATH]

Region	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
Canada	4.15377	0.00599	0.04741	0.00511	0.00127	0.02603	0.62172

TABLE 5.10 LIME PROCESSING – FUEL EMISSIONS [g/m^2 OF 3-COAT STUCCO OVER METAL LATH]

Region	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
Canada	391.99598	0.00158	0.46535	0.00946	0.01025	0.11831	0.00000

TABLE 5.11 LIME PROCESSING – PROCESS EMISSIONS [g/m^2 OF 3-COAT STUCCO OVER METAL LATH]

Region	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
Canada	956.95425	0.00000	1.00563	0.00000	0.00000	0.00000	1.45591

TABLE 5.12 LIME PROCESSING – TOTAL EMISSIONS (FUEL + PROCESS) [g/m^2 OF 3-COAT STUCCO OVER METAL LATH]

Region	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
Canada	1348.95023	0.00158	1.47098	0.00946	0.01025	0.11831	1.45591

TABLE 5.13 FINISHED LIME TRANSPORTATION EMISSIONS [g/m^2 OF 3-COAT STUCCO OVER METAL LATH]

Region	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
Canada	13.22104	0.01907	0.15091	0.01625	0.00406	0.08284	0.00000-

TABLE 5.14 TOTAL EMISSIONS DUE TO PRODUCTION OF LIME [g/m^2 OF 3-COAT STUCCO OVER METAL LATH]

Region	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
Canada	1366.32505	0.02664	1.66930	0.03082	0.01559	0.22718	2.07763

TABLE 5.15 BREAKDOWN OF LIME CO_2, SO_2 AND NO_x FUEL AND PROCESS EMISSIONS [g/m^2 OF 3-COAT STUCCO OVER METAL LATH]

Region	Fuel CO_2	Process CO_2	Total CO_2	Fuel SO_2	Process SO_2	Total SO_2	Fuel NO_x	Process NO_x	Total NO_x
Canada	409.37080	956.95425	1366.32505	0.02664	0.00000	0.02664	0.66367	1.00563	1.66930

5.1.3 Air emissions from production of sand

The sources of emissions from various stages of fine aggregate/sand production were discussed in detail and their estimates developed in the three previously referenced Institute studies. In the Tables below, the estimates from these sand LCIs were converted and expressed in g/m^2 of the stucco wall finish.

TABLE 5.16 SAND EXTRACTION EMISSIONS
[g/m^2 OF 3-COAT STUCCO OVER METAL LATH]

Region	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
Canada	35.04913	0.05057	0.40007	0.04308	0.01076	0.21961	0.91805

TABLE 5.17 FINISHED SAND TRANSPORTATION EMISSIONS
[g/m^2 OF 3-COAT STUCCO OVER METAL LATH]

Region	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
Canada	45.95330	0.06630	0.52453	0.05648	0.01410	0.28794	0.00000

TABLE 5.18 TOTAL EMISSIONS DUE TO PRODUCTION OF SAND
[g/m^2 OF 3-COAT STUCCO OVER METAL LATH]

Region	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
Canada	81.00243	0.11686	0.92460	0.09956	0.02486	0.50755	0.91805

5.1.4 Air emissions from stucco processing

Stucco mixing on the job site results in emissions from the generation of electricity and particulate emissions. The electricity-related emissions, as already noted, are calculated separately within the ATHENA software. The particulate emissions due to stucco processing are assumed to be the same as those for cement mortar mixing, as the same type of mixer, the same processing conditions and the same raw material components are used. The three previously referenced Institute studies, based on Environment Canada data, show 120 g/m^3 of mix TPM releases due to materials handling and mixing. By multiplying this release by the volume of stucco mix per square meter of finished stucco wall (0.022 m^3/m^2), it is converted and expressed as 2.64000 g/m^2 of the stucco.

5.1.5 Total air emissions – 3-coat PC stucco over metal lath

Emissions from the production of dry components (cement, lime and sand) of 3-coat PC exterior stucco applied over metal lath and stucco mixing from Sections 5.1.1 through 5.1.4 were combined to estimate total emissions associated with this stucco. The total emissions are shown in Tables 5.19 to 5.26 on a regional basis by process step. The fuel and process emissions are broken down where appropriate.

The ATHENA software adds emissions associated with the use of electricity in various stages, based on the appropriate grid, as well as those associated with pre-combustion fuel use. Emissions related to incorporation of metal stucco mesh and nails to fasten the mesh to the substrate will also be calculated by the ATHENA software (the quantities of the mesh and fasteners per m^2 of stucco wall are given in Section 3.1.1), based on the steel products LCI incorporated in the software.

TABLE 5.19 ALL COMPONENTS RAW MATERIALS EXTRACTION EMISSIONS [g/m^2 OF 3-COAT STUCCO OVER METAL LATH]

Region	City	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
West Ct	Vancouver	50.42552	0.07275	0.57558	0.06198	0.01548	0.31596	3.35326
Prairie	Calgary	50.40284	0.07272	0.57532	0.06195	0.01547	0.31582	3.35326
	Winnipeg	50.40284	0.07272	0.57532	0.06195	0.01547	0.31582	3.35326
Central	Toronto	50.38431	0.07269	0.57511	0.06193	0.01546	0.31570	3.35326
East	Montreal	50.29663	0.07256	0.57411	0.06182	0.01544	0.31515	3.35326
	Halifax	50.29663	0.07256	0.57411	0.06182	0.01544	0.31515	3.35326

TABLE 5.20 ALL COMPONENTS RAW MATERIALS TRANSPORTATION EMISSIONS [g/m^2 OF 3-COAT STUCCO OVER METAL LATH]

Region	City	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
West Ct	Vancouver	23.53131	0.13363	0.08256	0.10703	0.01222	0.01415	0.00000
Prairie	Calgary	56.48935	0.08150	1.04233	0.05810	0.00802	0.09519	0.00000
	Winnipeg	56.48935	0.08150	1.04233	0.05810	0.00802	0.09519	0.00000
Central	Toronto	16.65244	0.05844	0.13810	0.04708	0.00655	0.05036	0.00000
East	Montreal	5.81412	0.01744	0.04937	0.01424	0.00224	0.02440	0.00000
	Halifax	5.81412	0.01744	0.04937	0.01424	0.00224	0.02440	0.00000

TABLE 5.21 ALL COMPONENTS PROCESSING – FUEL EMISSIONS [g/m^2 OF 3-COAT STUCCO OVER METAL LATH]

Region	City	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
West Ct	Vancouver	1395.86391	3.57470	2.51428	0.02978	0.02462	0.79762	0.00000
Prairie	Calgary	1039.93912	0.00418	1.23454	0.02511	0.02720	0.31386	0.00000
	Winnipeg	1039.93912	0.00418	1.23454	0.02511	0.02720	0.31386	0.00000
Central	Toronto	1420.28919	9.24694	3.14721	0.02826	0.01923	1.05637	0.00000
East	Montreal	1654.74357	17.10710	3.64362	0.03583	0.02255	1.11682	0.00000
	Halifax	1654.74357	17.10710	3.64362	0.03583	0.02255	1.11682	0.00000

TABLE 5.22 ALL COMPONENTS PROCESSING – PROCESS EMISSIONS [g/m^2 OF 3-COAT STUCCO OVER METAL LATH]

Region	City	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
West Ct	Vancouver	2728.97809	-3.43439	15.02126	0.00000	0.00000	0.00000	3.17362
Prairie	Calgary	2728.97809	-0.00241	18.04197	0.00000	0.00000	0.00000	4.79134
	Winnipeg	2728.97809	-0.00241	18.04197	0.00000	0.00000	0.00000	4.79134
Central	Toronto	2728.97809	-8.88655	5.66883	0.00000	0.00000	0.00000	2.66605
East	Montreal	2728.97809	-16.44173	8.38647	0.00000	0.00000	0.00000	4.52546
	Halifax	2728.97809	-16.44173	8.38647	0.00000	0.00000	0.00000	3.60011

TABLE 5.23 ALL COMPONENTS PROCESSING – TOTAL EMISSIONS (FUEL + PROCESS) [g/m^2 OF 3-COAT STUCCO OVER METAL LATH]

Region	City	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
West Ct	Vancouver	4124.84199	0.14031	17.53554	0.02978	0.02462	0.79762	3.17362
Prairie	Calgary	3768.91720	0.00177	19.27651	0.02511	0.02720	0.31386	4.79134
	Winnipeg	3768.91720	0.00177	19.27651	0.02511	0.02720	0.31386	4.79134
Central	Toronto	4149.26728	0.36039	8.81603	0.02826	0.01923	1.05637	2.66605
East	Montreal	4383.72166	0.66536	12.03009	0.03583	0.02255	1.11682	4.52546
	Halifax	4383.72166	0.66536	12.03009	0.03583	0.02255	1.11682	3.60011

TABLE 5.24 ALL FINISHED COMPONENTS TRANSPORTATION EMISSIONS [g/m^2 OF 3-COAT STUCCO OVER METAL LATH]

Region	City	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
West Ct	Vancouver	93.50233	0.13490	1.06728	0.11493	0.02870	0.58588	0.00000
Prairie	Calgary	153.06054	0.22082	1.74710	0.18813	0.04698	0.95906	0.00000
	Winnipeg	381.92370	0.55101	7.06652	0.39229	0.05377	0.63099	0.00000
Central	Toronto	94.24321	0.15752	1.03526	0.13273	0.03001	0.56187	0.00000
East	Montreal	102.94536	0.14852	1.21970	0.12526	0.03055	0.61599	0.00000
	Halifax	123.75082	0.22190	1.33110	0.18610	0.04017	0.71777	0.00000

EMISSIONS DUE TO STUCCO MIXING

Emissions due to the mixing of stucco are calculated to be 2.64000 kg/m^2 of 3-coat stucco over metal lath.

TABLE 5.25 TOTAL EMISSIONS DUE TO PRODUCTION OF STUCCO [g/m^2 OF 3-COAT STUCCO OVER METAL LATH]

Region	City	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
West Ct	Vancouver	4292.30116	0.48159	19.26096	0.31371	0.08101	1.71362	9.16688
Prairie	Calgary	4028.86992	0.37681	22.64125	0.33330	0.09767	1.68394	10.78460
	Winnipeg	4257.73308	0.70699	27.96067	0.53745	0.10446	1.35587	10.78460
Central	Toronto	4310.54723	0.64904	10.56449	0.27000	0.07125	1.98430	8.65932
East	Montreal	4542.77777	0.90389	13.87326	0.23715	0.07078	2.07237	10.51873
	Halifax	4563.58323	0.97727	13.98466	0.29798	0.08039	2.17414	9.59338

TABLE 5.26 BREAKDOWN OF TOTAL CO_2, SO_2 AND NO_x FUEL AND PROCESS EMISSIONS [g/m^2 OF 3-COAT STUCCO OVER METAL LATH]

Region	City	Fuel CO_2	Process CO_2	Total CO_2	Fuel SO_2	Process SO_2	Total SO_2	Fuel NO_x	Process NO_x	Total NO_x
West Ct	Vancouver	1563.32307	2728.97809	4292.30116	3.91598	-3.43439	0.48159	4.23970	15.02126	19.26096
Prairie	Calgary	1299.89184	2728.97809	4028.86992	0.37922	-0.00241	0.37681	4.59928	18.04197	22.64125
	Winnipeg	1528.75499	2728.97809	4257.73308	0.70941	-0.00241	0.70699	9.91870	18.04197	27.96067
Central	Toronto	1581.56915	2728.97809	4310.54723	9.53559	-8.88655	0.64904	4.89567	5.66883	10.56449
East	Montreal	1813.79969	2728.97809	4542.77777	17.34562	-16.44173	0.90389	5.48679	8.38647	13.87326
	Halifax	1834.60515	2728.97809	4563.58323	17.41900	-16.44173	0.97727	5.59819	8.38647	13.98466

5.2 3-coat stucco over unit masonry solid stucco base

Air emissions associated with 3-coat PC stucco over unit masonry solid base were developed in the same manner as those for 3-coat PC stucco over metal lath in Section 5.1 above, and are presented in Tables 5.27 to 5.52 on a regional basis, first for the individual components of the stucco, secondly in total. As in Section 5.1, the process emissions versus fuel emissions are highlighted, where applicable.

Emissions from production of dry components (cement, lime and sand) of 3-coat Portland cement exterior stucco applied over unit masonry solid base and stucco mixing from Sections 5.2.1 through 5.2.4 were combined in total emissions associated with this stucco. The total emissions are shown in Tables 5.45 to 5.52. The ATHENA software will add emissions associated with the use of electricity in various stages, based on the appropriate grid, as built into the model.

5.2.1 Air emissions from cement production

TABLE 5.27 CEMENT RAW MATERIALS EXTRACTION EMISSIONS [g/m^2 OF 3-COAT STUCCO OVER UNIT MASONRY SOLID BASE]

Region	City	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
West Ct	Vancouver	6.27410	0.00905	0.07162	0.00771	0.00193	0.03931	1.01385
Prairie	Calgary	6.26142	0.00903	0.07147	0.00770	0.00192	0.03923	1.01385
	Winnipeg	6.26142	0.00903	0.07147	0.00770	0.00192	0.03923	1.01385
Central	Toronto	6.25106	0.00902	0.07135	0.00768	0.00192	0.03917	1.01385
East	Montreal	6.20204	0.00895	0.07079	0.00762	0.00190	0.03886	1.01385
	Halifax	6.20204	0.00895	0.07079	0.00762	0.00190	0.03886	1.01385

TABLE 5.28 CEMENT RAW MATERIALS TRANSPORTATION EMISSIONS [g/m^2 OF 3-COAT STUCCO OVER UNIT MASONRY SOLID BASE]

Region	City	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
West Ct	Vancouver	13.15537	0.07471	0.04616	0.05983	0.00683	0.00791	0.00000
Prairie	Calgary	31.58083	0.04556	0.58272	0.03248	0.00448	0.05322	0.00000
	Winnipeg	31.58083	0.04556	0.58272	0.03248	0.00448	0.05322	0.00000
Central	Toronto	9.30968	0.03267	0.07720	0.02632	0.00366	0.02815	0.00000
East	Montreal	3.25043	0.00975	0.02760	0.00796	0.00125	0.01364	0.00000
	Halifax	3.25043	0.00975	0.02760	0.00796	0.00125	0.01364	0.00000

TABLE 5.29 CEMENT PROCESSING – FUEL EMISSIONS [g/m^2 OF 3-COAT STUCCO OVER UNIT MASONRY SOLID BASE]

Region	City	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
West Ct	Vancouver	561.22047	1.99758	1.14547	0.01136	0.00803	0.37978	0.00000
Prairie	Calgary	362.23784	0.00146	0.43002	0.00875	0.00948	0.10933	0.00000
	Winnipeg	362.23784	0.00146	0.43002	0.00875	0.00948	0.10933	0.00000
Central	Toronto	574.87563	5.16869	1.49932	0.01051	0.00502	0.52443	0.00000
East	Montreal	705.94924	9.56298	1.77684	0.01474	0.00687	0.55823	0.00000
	Halifax	705.94924	9.56298	1.77684	0.01474	0.00687	0.55823	0.00000

TABLE 5.30 CEMENT PROCESSING – PROCESS EMISSIONS [g/m^2 OF 3-COAT STUCCO OVER UNIT MASONRY SOLID BASE]

Region	City	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
West Ct	Vancouver	990.66473	-1.92003	7.83555	0.00000	0.00000	0.00000	0.96030
Prairie	Calgary	990.66473	-0.00135	9.52431	0.00000	0.00000	0.00000	1.86470
	Winnipeg	990.66473	-0.00135	9.52431	0.00000	0.00000	0.00000	1.86470
Central	Toronto	990.66473	-4.96810	2.60700	0.00000	0.00000	0.00000	0.67654
East	Montreal	990.66473	-9.19188	4.12632	0.00000	0.00000	0.00000	1.71606
	Halifax	990.66473	-9.19188	4.12632	0.00000	0.00000	0.00000	1.19873

TABLE 5.31 CEMENT PROCESSING – TOTAL EMISSIONS (FUEL + PROCESS) [g/m^2 OF 3-COAT STUCCO OVER UNIT MASONRY SOLID BASE]

Region	City	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
West Ct	Vancouver	1551.88520	0.07750	8.98103	0.01136	0.00803	0.37978	0.96030
Prairie	Calgary	1352.90257	0.00005	9.95433	0.00875	0.00948	0.10933	1.86470
	Winnipeg	1352.90257	0.00005	9.95433	0.00875	0.00948	0.10933	1.86470
Central	Toronto	1565.54035	0.20054	4.10631	0.01051	0.00502	0.52443	0.67654
East	Montreal	1696.61397	0.37104	5.90316	0.01474	0.00687	0.55823	1.71606
	Halifax	1696.61397	0.37104	5.90316	0.01474	0.00687	0.55823	1.19873

TABLE 5.32 FINISHED CEMENT TRANSPORTATION EMISSIONS [g/m^2 OF 3-COAT STUCCO OVER UNIT MASONRY SOLID BASE]

Region	City	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
West Ct	Vancouver	19.19134	0.02769	0.21906	0.02359	0.00589	0.12025	0.00000
Prairie	Calgary	52.48784	0.07573	0.59912	0.06451	0.01611	0.32888	0.00000
	Winnipeg	180.43563	0.26032	3.57298	0.17865	0.01991	0.14547	0.00000
Central	Toronto	19.60553	0.04033	0.20116	0.03354	0.00662	0.10683	0.00000
East	Montreal	24.47054	0.03530	0.30427	0.02937	0.00693	0.13709	0.00000
	Halifax	36.10200	0.07633	0.36655	0.06338	0.01230	0.19399	0.00000

TABLE 5.33 TOTAL EMISSIONS DUE TO PRODUCTION OF CEMENT [g/m^2 OF 3-COAT STUCCO OVER UNIT MASONRY SOLID BASE]

Region	City	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
West Ct	Vancouver	1590.50601	0.18901	9.31786	0.10249	0.02268	0.54725	1.97415
Prairie	Calgary	1443.23265	0.13043	11.20764	0.11344	0.03199	0.53066	2.87855
	Winnipeg	1571.18045	0.31502	14.18150	0.22757	0.03579	0.34725	2.87855
Central	Toronto	1600.70663	0.28262	4.45603	0.07806	0.01722	0.69858	1.69039
East	Montreal	1730.53699	0.42510	6.30582	0.05969	0.01695	0.74782	2.72991
	Halifax	1742.16845	0.46612	6.36810	0.09370	0.02233	0.80472	2.21259

TABLE 5.34 BREAKDOWN OF CEMENT CO_2, SO_2 AND NO_x FUEL AND PROCESS EMISSIONS [g/m^2 OF 3-COAT STUCCO OVER UNIT MASONRY SOLID BASE]

Region	City	Fuel CO_2	Process CO_2	Total CO_2	Fuel SO_2	Process SO_2	Total SO_2	Fuel NO_x	Process NO_x	Total NO_x
West Ct	Vancouver	599.84128	990.66473	1590.50601	2.10903	-1.92003	0.18901	1.48230	7.83555	9.31786
Prairie	Calgary	452.56792	990.66473	1443.23265	0.13178	-0.00135	0.13043	1.68333	9.52431	11.20764
	Winnipeg	580.51572	990.66473	1571.18045	0.31637	-0.00135	0.31502	4.65720	9.52431	14.18150
Central	Toronto	610.04190	990.66473	1600.70663	5.25072	-4.96810	0.28262	1.84903	2.60700	4.45603
East	Montreal	739.87226	990.66473	1730.53699	9.61698	-9.19188	0.42510	2.17950	4.12632	6.30582
	Halifax	751.50372	990.66473	1742.16845	9.65800	-9.19188	0.46612	2.24178	4.12632	6.36810

5.2.2 Air emissions from production of lime

TABLE 5.35 LIME RAW MATERIALS EXTRACTION EMISSIONS [g/m^2 OF 3-COAT STUCCO OVER UNIT MASONRY SOLID BASE]

Region	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
Canada	2.97699	0.00429	0.03398	0.00366	0.00091	0.01865	0.44558

TABLE 5.36 LIME PROCESSING – FUEL EMISSIONS [g/m^2 OF 3-COAT STUCCO OVER UNIT MASONRY SOLID BASE]

Region	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
Canada	280.94244	0.00113	0.33351	0.00678	0.00735	0.08479	0.00000

TABLE 5.37 LIME PROCESSING – PROCESS EMISSIONS [g/m^2 OF 3-COAT STUCCO OVER UNIT MASONRY SOLID BASE]

Region	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
Canada	685.84665	0.00000	0.72073	0.00000	0.00000	0.00000	1.04345

TABLE 5.38 LIME PROCESSING – TOTAL EMISSIONS (FUEL + PROCESS) [g/m^2 OF 3-COAT STUCCO OVER UNIT MASONRY SOLID BASE]

Region	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
Canada	966.78909	0.00113	1.05425	0.00678	0.00735	0.08479	1.04345

TABLE 5.39 FINISHED LIME TRANSPORTATION EMISSIONS [g/m^2 OF 3-COAT STUCCO OVER UNIT MASONRY SOLID BASE]

Region	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
Canada	9.47549	0.01367	0.10816	0.01165	0.00291	0.05937	0.00000

TABLE 5.40 TOTAL EMISSIONS DUE TO PRODUCTION OF LIME [g/m^2 OF 3-COAT STUCCO OVER UNIT MASONRY SOLID BASE]

Region	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
Canada	979.24157	0.01910	1.19638	0.02209	0.01117	0.16282	1.48903

TABLE 5.41 BREAKDOWN OF LIME CO_2, SO_2 AND NO_x FUEL AND PROCESS EMISSIONS [g/m^2 OF 3-COAT STUCCO OVER UNIT MASONRY SOLID BASE]

Region	Fuel CO_2	Process CO_2	Total CO_2	Fuel SO_2	Process SO_2	Total SO_2	Fuel NO_x	Process NO_x	Total NO_x
Canada	293.39492	685.84665	979.24157	0.01910	0.00000	0.01910	0.47565	0.72073	1.19638

5.2.3 Air emissions from production of sand

TABLE 5.42 SAND EXTRACTION EMISSIONS [g/m² OF 3-COAT STUCCO OVER UNIT MASONRY SOLID BASE]

Region	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
Canada	25.20973	0.03637	0.28775	0.03099	0.00774	0.15796	0.66032

TABLE 5.43 FINISHED SAND TRANSPORTATION EMISSIONS [g/m² OF 3-COAT STUCCO OVER UNIT MASONRY SOLID BASE]

Region	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
Canada	33.05276	0.04769	0.37728	0.04063	0.01014	0.20711	0.00000

TABLE 5.44 TOTAL EMISSIONS DUE TO PRODUCTION OF SAND [g/m² OF 3-COAT STUCCO OVER UNIT MASONRY SOLID BASE]

Region	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
Canada	58.26248	0.08406	0.66503	0.07161	0.01788	0.36507	0.66032

5.2.4 Air emissions from stucco processing

EMISSIONS DUE TO STUCCO MIXING:

Air emissions due to the mixing of stucco are calculated to be 1.80000 g/m² of 3-coat stucco over unit masonry solid base.

5.2.5 Total air emissions – 3-coat PC stucco over unit masonry base

TABLE 5.45 ALL COMPONENTS RAW MATERIALS EXTRACTION EMISSIONS [g/m² OF 3-COAT STUCCO OVER UNIT MASONRY SOLID BASE]

Region	City	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
West Ct	Vancouver	34.46082	0.04972	0.39335	0.04236	0.01058	0.21593	2.11976
Prairie	Calgary	34.44814	0.04970	0.39321	0.04234	0.01057	0.21585	2.11976
	Winnipeg	34.44814	0.04970	0.39321	0.04234	0.01057	0.21585	2.11976
Central	Toronto	34.43779	0.04968	0.39309	0.04233	0.01057	0.21578	2.11976
East	Montreal	34.38877	0.04961	0.39253	0.04227	0.01055	0.21548	2.11976
	Halifax	34.38877	0.04961	0.39253	0.04227	0.01055	0.21548	2.11976

TABLE 5.46 ALL COMPONENTS RAW MATERIALS TRANSPORTATION EMISSIONS [g/m^2 OF 3-COAT STUCCO OVER UNIT MASONRY SOLID BASE]

Region	City	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
West Ct	Vancouver	13.15537	0.07471	0.04616	0.05983	0.00683	0.00791	0.00000
Prairie	Calgary	31.58083	0.04556	0.58272	0.03248	0.00448	0.05322	0.00000
	Winnipeg	31.58083	0.04556	0.58272	0.03248	0.00448	0.05322	0.00000
Central	Toronto	9.30968	0.03267	0.07720	0.02632	0.00366	0.02815	0.00000
East	Montreal	3.25043	0.00975	0.02760	0.00796	0.00125	0.01364	0.00000
	Halifax	3.25043	0.00975	0.02760	0.00796	0.00125	0.01364	0.00000

TABLE 5.47 ALL COMPONENTS PROCESSING – FUEL EMISSIONS [g/m^2 OF 3-COAT STUCCO OVER UNIT MASONRY SOLID BASE]

Region	City	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
West Ct	Vancouver	842.16292	1.99871	1.47899	0.01814	0.01538	0.46457	0.00000
Prairie	Calgary	643.18029	0.00259	0.76353	0.01553	0.01682	0.19412	0.00000
	Winnipeg	643.18029	0.00259	0.76353	0.01553	0.01682	0.19412	0.00000
Central	Toronto	855.81807	5.16983	1.83283	0.01729	0.01236	0.60922	0.00000
East	Montreal	986.89168	9.56411	2.11035	0.02152	0.01422	0.64302	0.00000
	Halifax	986.89168	9.56411	2.11035	0.02152	0.01422	0.64302	0.00000

TABLE 5.48 ALL COMPONENTS PROCESSING – PROCESS EMISSIONS [g/m^2 OF 3-COAT STUCCO OVER UNIT MASONRY SOLID BASE]

Region	City	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
West Ct	Vancouver	1676.51138	0.00000	8.55629	0.00000	0.00000	0.00000	2.00375
Prairie	Calgary	1676.51138	0.00000	10.24504	0.00000	0.00000	0.00000	2.90815
	Winnipeg	1676.51138	0.00000	10.24504	0.00000	0.00000	0.00000	2.90815
Central	Toronto	1676.51138	0.00000	3.32773	0.00000	0.00000	0.00000	1.71999
East	Montreal	1676.51138	0.00000	4.84705	0.00000	0.00000	0.00000	2.75951
	Halifax	1676.51138	0.00000	4.84705	0.00000	0.00000	0.00000	2.24218

TABLE 5.49 ALL COMPONENTS PROCESSING – TOTAL EMISSIONS (FUEL + PROCESS) [g/m^2 OF 3-COAT STUCCO OVER UNIT MASONRY SOLID BASE]

Region	City	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
West Ct	Vancouver	2518.67429	1.99871	10.03527	0.01814	0.01538	0.46457	2.00375
Prairie	Calgary	2319.69166	0.00259	11.00858	0.01553	0.01682	0.19412	2.90815
	Winnipeg	2319.69166	0.00259	11.00858	0.01553	0.01682	0.19412	2.90815
Central	Toronto	2532.32944	5.16983	5.16056	0.01729	0.01236	0.60922	1.71999
East	Montreal	2663.40306	9.56411	6.95740	0.02152	0.01422	0.64302	2.75951
	Halifax	2663.40306	9.56411	6.95740	0.02152	0.01422	0.64302	2.24218

TABLE 5.50 ALL FINISHED COMPONENTS TRANSPORTATION EMISSIONS [g/m^2 OF 3-COAT STUCCO OVER UNIT MASONRY SOLID BASE]

Region	City	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
West Ct	Vancouver	61.71958	0.08904	0.70449	0.07586	0.01894	0.38673	0.00000
Prairie	Calgary	95.01608	0.13708	1.08455	0.11679	0.02916	0.59536	0.00000
	Winnipeg	222.96387	0.32167	4.05842	0.23092	0.03296	0.41195	0.00000
Central	Toronto	62.13377	0.10169	0.68659	0.08581	0.01968	0.37331	0.00000
East	Montreal	66.99878	0.09666	0.78971	0.08164	0.01998	0.40356	0.00000
	Halifax	78.63024	0.13768	0.85199	0.11565	0.02536	0.46046	0.00000

EMISSIONS DUE TO STUCCO MIXING:

Emissions due to the mixing of stucco are calculated to be 1.80000 g/m2 of 3-coat stucco over unit masonry solid base.

TABLE 5.51 TOTAL EMISSIONS DUE TO PRODUCTION OF STUCCO [g/m^2 OF 3-COAT STUCCO OVER UNIT MASONRY SOLID BASE]

Region	City	CO_2	SO_2	NO_x	VOC	CH_4	CO	TPM
West Ct	Vancouver	2628.01006	0.29216	11.17927	0.19619	0.05173	1.07514	5.92350
Prairie	Calgary	2480.73670	0.23358	13.06906	0.20714	0.06104	1.05855	6.82790
	Winnipeg	2608.68450	0.41817	16.04292	0.32128	0.06484	0.87514	6.82790
Central	Toronto	2638.21068	0.38577	6.31745	0.17176	0.04627	1.22647	5.63974
East	Montreal	2768.04104	0.52825	8.16724	0.15339	0.04601	1.27570	6.67926
	Halifax	2779.67250	0.56927	8.22952	0.18740	0.05138	1.33260	6.16194

TABLE 5.52 BREAKDOWN OF TOTAL CO_2, SO_2 AND NO_x FUEL AND PROCESS EMISSIONS [g/m^2 OF 3-COAT STUCCO OVER UNIT MASONRY SOLID BASE]

Region	City	Fuel CO_2	Process CO_2	Total CO_2	Fuel SO_2	Process SO_2	Total SO_2	Fuel NO_x	Process NO_x	Total NO_x
West Ct	Vancouver	951.49869	1676.51138	2628.01006	2.21218	-1.92003	0.29216	2.62299	8.55629	11.17927
Prairie	Calgary	804.22533	1676.51138	2480.73670	0.23493	-0.00135	0.23358	2.82401	10.24504	13.06906
	Winnipeg	932.17313	1676.51138	2608.68450	0.41952	-0.00135	0.41817	5.79788	10.24504	16.04292
Central	Toronto	961.69931	1676.51138	2638.21068	5.35387	-4.96810	0.38577	2.98971	3.32773	6.31745
East	Montreal	1091.52967	1676.51138	2768.04104	9.72013	-9.19188	0.52825	3.32019	4.84705	8.16724
	Halifax	1103.16113	1676.51138	2779.67250	9.76116	-9.19188	0.56927	3.38246	4.84705	8.22952

6.0 Emissions to Water

This section addresses emissions to water from the production of exterior stucco finishes. As discussed in the Institute's Cement and Brick reports, little water is used in cement, lime or sand production. It is only in the extraction of limestone for cement and lime production that some liquid effluent is generated (quarry and storm water), apart from water used for occasional plant equipment or yard clean up. Only clean, quality sand should be used for exterior stucco finishes, and sand would therefore generally be washed during its processing. Water use and resulting effluent from the production of cement, lime and aggregate was discussed in detail, and appropriate estimates developed in the earlier Institute studies (Table 6.2 of the Cement update for cement, and Table 6.2.1 of the Brick and Mortar study for lime and sand).

Water also plays a direct role in the production of exterior stucco finishes on the job sites, being added to and mixed with the three dry ingredients. Water then is used for equipment (mixer) washout and washoff. Mixing of exterior stucco finishes on the job site is very similar to preparation of cement mortar, using the same type of equipment, and the same techniques. Therefore, we can safely use the same volumes and contamination levels for effluent characteristics of stucco processing as those developed for cement mortar in Section 14.2 (Table 14.3) of the 1993 Cement and Concrete report. In Table 6.1, water flows and levels of various contaminants in mg/l of effluent from all the relevant flows are summarized. The water effluent flows from various sources are converted, taking the stucco raw materials composition into consideration, to flow per m^2 of stucco wall surface in Table 6.2.

TABLE 6.1 EFFLUENT FROM INDIVIDUAL STUCCO COMPONENTS AND PROCESSING [mg/l OF EFFLUENT]

	Cement			Lime			Sand	Stucco
	Plant	**Quarry water**	**Storm water**	**Plant**	**Quarry water**	**Storm water**	**Wash water**	**Mixer washout**
Flow	2003.17 [l/tonne]	1017.42 [l/tonne]	1.81 [l/tonne]	3295.43 [l/tonne]	1827.46 [l/tonne]	3.55 [l/tonne]	234.88 [l/tonne]	25.00 [l/m^3 of stucco]
pH	8.26	8.15	8.84	8.30	8.21	8.84	7.85	8.00
	[mg/l of effluent]							
Suspended Solids	62.47	86.41	137.61	59.04	103.70	137.62	8.68	87.50
Aluminum	0.16	0.67		0.16	0.76			
Phenolics	0.00	0.01	0.00	0.00	0.01	0.00		
Oil & Grease	1.42	1.53	0.67	1.41	1.77	0.67	0.97	7.50
Nitrate, Nitrite	0.41	2.74	1.96	0.42	2.90	1.96		
DOC	2.65	2.29		2.60	2.49			
Chlorides	44.45	1109.15	162.55	44.92	1290.03	162.55		
Sulphates	105.85	200.66	163.60	104.57	217.71	163.59		
Sulphides	0.00	0.03		0.00	0.04			
Ammonia, -um		1.21			1.41			
Phosphorus		0.01			0.01			
Zinc	0.00	0.00		0.00	0.00			

TABLE 6.2 RAW MATERIALS USE AND ASSIGNED EFFLUENT FLOW IN LITERS PER m² OF STUCCO WALL SURFACE

	Stucco #1	Stucco #2
kg of cement/m² of stucco	3.55589	1.98795
kg of aggregates/m² of stucco	18.36090	13.20642
kg of lime/m² of stucco	1.21905	0.87369
liters of cement plant water /m² of stucco	7.12305	3.98220
liters of quarry water /m² of stucco	3.61785	2.02259
liters of stormwater /m² of stucco	0.00643	0.00360
liters of lime plant water /m² of stucco	4.01729	2.87918
liters of lime quarry water /m² of stucco	2.22776	1.59663
liters of lime quarry stormwater /m² of stucco	0.00433	0.00310
liters of aggregate quarry water /m² of stucco	4.31261	3.10192
liters of stucco mixer wash water /m² of stucco	0.55000	0.37500
total liters/m² of stucco	21.85903	13.96422

Note: Stucco #1 – 3-coat PC stucco over metal lath
Stucco #2 – 3-coat PC stucco over unit masonry solid base

In Tables 6.3 and 6.4, weighted average effluent contamination from various streams of cement, lime and sand production, and from the stucco mixer washout are given in grams per square meter of stucco wall surface. These were derived by combining the assigned effluent flow in liters per m² of stucco wall surface from Table 6.2 with the levels of contamination from various water effluents as tabulated in Table 6.1. The totals from all effluent streams for the twelve relevant contaminants are shown.

TABLE 6.3 3-COAT PC EXTERIOR STUCCO OVER METAL LATH WEIGHTED AVERAGE EFFLUENT [g/m² of stucco surface]

	Cement			Lime			Sand	Stucco	Total
	plant	quarry water	storm water	plant	quarry water	storm water	wash water	mixer washout	
Suspended Solids	0.44499	0.31263	0.00089	0.23719	0.23102	0.00060	0.03743	0.04813	**1.31286**
Aluminum	0.00115	0.00241	0.00000	0.00063	0.00169	0.00000	0.00000	0.00000	**0.00588**
Phenolics	0.00001	0.00004	0.00000	0.00001	0.00003	0.00000	0.00000	0.00000	**0.00009**
Oil & Grease	0.01010	0.00554	0.00000	0.00566	0.00395	0.00000	0.00418	0.00413	**0.03356**
Nitrate, Nitrite	0.00289	0.00990	0.00001	0.00170	0.00646	0.00001	0.00000	0.00000	**0.02098**
DOC	0.01888	0.00830	0.00000	0.01044	0.00554	0.00000	0.00000	0.00000	**0.04316**
Chlorides	0.31661	4.01275	0.00105	0.18044	2.87388	0.00070	0.00000	0.00000	**7.38543**
Sulphates	0.75398	0.72595	0.00105	0.42010	0.48500	0.00071	0.00000	0.00000	**2.38679**
Sulphides	0.00002	0.00011	0.00000	0.00001	0.00008	0.00000	0.00000	0.00000	**0.00023**
Ammonia, -um	0.00000	0.00438	0.00000	0.00000	0.00314	0.00000	0.00000	0.00000	**0.00752**
Phosphorus	0.00000	0.00003	0.00000	0.00000	0.00002	0.00000	0.00000	0.00000	**0.00005**
Zinc	0.00002	0.00001	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	**0.00003**

TABLE 6.4 3-COAT PC EXTERIOR STUCCO OVER SOLID UNIT MASONRY WEIGHTED AVERAGE EFFLUENT [g/m^2 of stucco surface]

	Cement			Lime			Sand	Stucco	Total
	Plant	quarry water	storm water	Plant	quarry water	storm water	wash water	mixer washout	
Suspended Solids	0.24877	0.17478	0.00049	0.16999	0.16557	0.00043	0.02692	0.03281	**0.81977**
Aluminum	0.00064	0.00135	0.00000	0.00045	0.00121	0.00000	0.00000	0.00000	**0.00365**
Phenolics	0.00001	0.00002	0.00000	0.00001	0.00002	0.00000	0.00000	0.00000	**0.00006**
Oil & Grease	0.00565	0.00310	0.00000	0.00405	0.00283	0.00000	0.00301	0.00281	**0.02145**
Nitrate, Nitrite	0.00162	0.00554	0.00001	0.00122	0.00463	0.00001	0.00000	0.00000	**0.01302**
DOC	0.01056	0.00464	0.00000	0.00748	0.00397	0.00000	0.00000	0.00000	**0.02665**
Chlorides	0.17700	2.24336	0.00058	0.12932	2.05970	0.00050	0.00000	0.00000	**4.61047**
Sulphates	0.42152	0.40585	0.00059	0.30108	0.34760	0.00051	0.00000	0.00000	**1.47715**
Sulphides	0.00001	0.00006	0.00000	0.00001	0.00006	0.00000	0.00000	0.00000	**0.00014**
Ammonia, -um	0.00000	0.00245	0.00000	0.00000	0.00225	0.00000	0.00000	0.00000	**0.00470**
Phosphorus	0.00000	0.00002	0.00000	0.00000	0.00001	0.00000	0.00000	0.00000	**0.00003**
Zinc	0.00001	0.00001	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	**0.00002**

Table 6.5 presents the estimates of weighted average effluent characteristics per liter of effluent flow for the two stucco finishes. These estimates were derived by combining the total contamination for the twelve relevant contaminants from Tables 6.3 and 6.4 with the total volumes of water effluent for the two stuccos from table 6.2.

TABLE 6.5 WEIGHTED AVERAGE EFFLUENT OF STUCCO PRODUCTS [mg/l OF EFFLUENT]

	Stucco #1	Stucco #2
pH	8.16	8.15
Suspended Solids	60.05938	58.70501
Aluminum	0.26899	0.26158
Phenolics	0.00414	0.00404
Oil & Grease	1.53523	1.53625
Nitrate, Nitrite	0.95964	0.93203
DOC	1.97449	1.90835
Chlorides	337.86155	330.16329
Sulphates	109.18870	105.78077
Sulphides	0.01043	0.01017
Ammonia, -um	0.34392	0.33640
Phosphorus	0.00209	0.00202
Zinc	0.00136	0.00119

Note: Stucco #1 – 3-coat PC stucco over metal lath
Stucco #2 – 3-coat PC stucco over unit masonry solid base

7.0 Solid Waste

This section addresses the two contributions to solid waste generated due to the production of exterior stucco finishes components and their processing

During cement production, as discussed in the 1993 Institute report on Cement and the Cement update published in 1999, cement kiln dust (CKD) is generated. While some major portion is recycled into the cement kiln raw meal, a smaller portion is discarded, and has to be considered as solid waste. Table 7.3 from the Cement and Concrete update gives the amounts of discarded CKD in the different regions in g/kg of cement. These numbers were multiplied by mass of cement in kg/m^2 of stucco surface from Tables 3.3 and 3.6 for the two stucco finishes under consideration. Resulting amounts of CKD waste assignable to exterior stucco finishes are tabulated below.

TABLE 7.1 WASTE DUE TO DISCARDED CEMENT KILN DUST (CKD) [g/m^2 OF STUCCO SURFACE]

	stucco coat	kg of cement /m^2 of stucco	Vancouver	Calgary	Winnipeg	Toronto	Montreal	Halifax
			waste CKD[2] [g/kg of cement]					
			15.78866	7.45892	7.45892	8.21859	15.64011	16.39480
Stucco #1	scratch	1.61599	25.51437	12.05357	12.05357	13.28119	25.27432	26.49389
	brown	1.40723	22.21834	10.49645	10.49645	11.56549	22.00931	23.07133
	finish	0.53266	8.41006	3.97311	3.97311	4.37776	8.33094	8.73293
	total	**3.55589**	**56.14277**	**26.52313**	**26.52313**	**29.22444**	**55.61456**	**58.29816**
Stucco #2	scratch	0.78590	12.40832	5.86197	5.86197	6.45900	12.29158	12.88469
	brown	0.66938	10.56869	4.99289	4.99289	5.50140	10.46925	10.97443
	finish	0.53266	8.41006	3.97311	3.97311	4.37776	8.33094	8.73293
	total	**1.98795**	**31.38707**	**14.82797**	**14.82797**	**16.33816**	**31.09177**	**32.59206**

Note: Stucco #1 – 3-coat PC stucco over metal lath
Stucco #2 – 3-coat PC stucco over unit masonry solid base

There is no solid waste associated with lime production. While some fines are produced during the limestone processing, these are fully used.

The second source of solid waste, as in any other concrete or mortar mixing operation, is the stucco mixer washout. As the same type of mixer and the same procedures are used to process exterior stucco finishes as cement mortar, we will assume the same solid waste due to mixer washout for mixing exterior stucco finishes. Table 15.2 of both the Cement and Concrete reports gives that amount of waste as 2.59 kg/m^3 of mix. Multiplying this by the volume of stucco per square meter of the stucco surface gives the mass of solid waste due to stucco mixed washout in g/m^2, as shown in Table 7.2.

TABLE 7.2 WASTE DUE TO STUCCO PROCESSING [g/m^2 OF STUCCO SURFACE]

Stucco #1 – 3-coat PC stucco over metal lath	56.98
Stucco #2 – 3-coat PC stucco over unit masonry solid base	38.85

Table 7.3 provides the total mass of solid waste associated with production of the two stucco finishes, a sum of assignable CKD waste and stucco mixer washout waste, on the regional basis:

TABLE 7.3 TOTAL SOLID WASTE DUE TO STUCCO PRODUCTION [g/m^2 OF STUCCO SURFACE]

	Vancouver	Calgary	Winnipeg	Toronto	Montreal	Halifax
Stucco #1	113.12277	83.50313	83.50313	86.20444	112.59456	115.27816
Stucco #2	70.23707	53.67797	53.67797	55.18816	69.94177	71.44206

Note: Stucco #1 – 3-coat PC stucco over metal lath
Stucco #2 – 3-coat PC stucco over unit masonry solid base