

Life-cycle costs for flooring in commercial buildings

A comparison of eighteen common flooring types: ceramic tile, porcelain tile, quarry tile, laminate, granite, limestone, marble, travertine, engineered wood, solid wood, sheet vinyl, vinyl composition tile, flexible luxury vinyl flooring, rigid core flooring, epoxy terrazzo, poured epoxy, carpet tiles, and nylon broadloom carpet.

Calculations are based on publicly-available cost databases.

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April 15, 2023

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Introduction

There are several methods available to evaluate and compare the economic performance of products or systems. For this study, life-cycle cost analysis (LCCA) is used to compare 18 flooring types installed in a typical office building. For the purpose of this study, a typical office building is defined according to the commercial building characteristics included in the 2018 Commercial Building Energy Consumption Survey (CBECS) (US EIA 2020) (see Key Assumptions section for more information). The LCCA was conducted according to ASTM E917-17, Standard Practice for Measuring Life-Cycle Costs of Buildings and Building Systems.

An LCCA is a powerful tool to aid decision makers in evaluating all relevant costs for a given building system. Costs are summed in terms of either present values or annual values over a specified period of time; for this study, present values are used. This allows for comparison of the construction and maintenance costs of alternative building systems that meet the same functional requirements. In this study, the functional requirements of all flooring types are that they are fit for use and provide adequate durability and cleanliness for light to medium commercial use in office space.

This is not to say that all flooring types naturally receive the same soil load, wear pattern, or abrasive conditions, nor is their appearance similar. As such, soil conditions and appearance affect the maintenance cycle and expectations for each product category. For example, marble and other stone flooring are often used in areas where foot traffic and abrasive conditions are frequent (for example, commercial building lobbies), yet are generally expected to have a highly polished finish. Because of this, maintenance for stone flooring is more involved than materials such as carpet, for example, which has a different expected appearance and soil load.

Although this study was based on flooring use in light to medium commercial applications, many of the results would be applicable to residential applications as well. Differences in wear and cleaning routines between residential and light to medium commercial applications are similar for the eighteen flooring types studied, with the primary difference being an increased loading for commercial applications attributed to more frequent rolling of carts and higher pedestrian traffic.

A note about conservative assumptions: This study was primarily funded by the Tile Council of North America (TCNA) although with financial and technical support from several industry associations representing other flooring types. While the selection of engineering parameters was made by the author without influence from TCNA or others, as a condition of undertaking this report and to avoid any suggestion of bias favoring the source of primary financial support, in the evaluation of any data ambiguities, any reasonable choices that could potentially favor the selection of flooring types other than ceramic, porcelain, and quarry tile were preferred. These choices are identified and referred to as conservative assumptions within this report.

Objectives, Constraints, and Alternatives

Objective

The objective is to determine the life-cycle cost of 18 different flooring types for use in an office building with a period of analysis of 75 years (see pages 27-28). An analysis based on forty years was also made and is provided in the appendix.

Constraints

There are unlimited choices for each of the flooring types when it comes to aesthetics, so typical performance and costs for each flooring type must be selected. Certain flooring types may be designed specifically for commercial (higher traffic) versus residential (lower traffic) areas.

Product maintenance and replacement schedules are based on typical product life cycles, warranty periods, or other factors, as described in the Key Assumptions and Cost Data section. User preferences and design trends cannot be anticipated, thus, product replacements due to these factors are not considered.

Because different flooring types do not all receive the same soil load, wear pattern, or abrasive conditions as noted previously, this study is not an “apples to apples” comparison of different flooring types, as soil loads naturally differ and appearance expectations differ.

Descriptions of the product types in the RS Means database are generally succinct and include generic installation method descriptions.

Cost data were used from RS Means online database for average 2020 values. Annual 2020 costs were chosen because they represented the most-current values that were not influenced by COVID-19 pandemic-related fluctuations. When cost data were not available in the RS Means database, online searches of cost data from big-box retailers were used or industry sources were consulted to approximate cost data in relation to available RS Means data.

Alternatives

The 18 types of flooring considered in this LCCA are listed in Table 1.

Table 1. Flooring Types

CSI Designation	Flooring Types
09 30 13	Ceramic Tile
09 30 13	Porcelain Tile
09 30 13	Quarry Tile
09 62 19	Laminate
09 63 40	Granite
09 63 40	Limestone
09 63 40	Marble
09 63 40	Travertine
09 64 19	Engineered Wood
09 64 29	Solid Wood
09 65 16.23	Sheet Vinyl
09 65 19.19	Vinyl Composition Tile (VCT)
09 65 19.23	Flexible Luxury Vinyl Flooring (LVF/LVP)
09 65 19.43	Rigid Core Flooring (RCB, SPC, WPC, etc.) ¹
09 66 13	Epoxy Terrazzo
09 67 23	Poured Epoxy
09 68 13	Carpet Tiles/Carpet Squares
09 68 16	Nylon Broadloom Carpet

Ceramic Tile

Ceramic tile is a ceramic surfacing unit, usually relatively thin in relation to facial area, having either a glazed or unglazed face, and fired above red heat in the course of manufacture to a temperature sufficiently high to produce specific physical properties and characteristics. Ceramic tile is the term used for all types of ceramic surfacing units produced, whether they be quarry, porcelain, mosaic, or pressed floor. For the purpose of this study, ceramic tiles are only those ceramic surfacing units that are used in flooring applications that are not quarry nor porcelain tiles.

The CSI Masterformat designation for ceramic tile is 09 30 13 with performance criteria standardized in ANSI A137.1, *American National Standard Specifications for Ceramic Tile*. Ceramic tiles are primarily made up of clays, sand, feldspar, and other additives. They are pressed into shape and then fired in a kiln.

Grout and mortar are required to install ceramic tiles and their costs were included in this analysis. Mortar coverage was assumed to be evenly distributed with average contact areas of at least 80% and 95% for dry and wet areas, respectively (TCNA 2021a). Grout joints are assumed to at least meet minimum width requirements per the *TCNA Handbook*.

For this study, contractor feedback was sought (TCNA 2021b) to determine commonly used *TCNA Handbook* installation details for ceramic tile over concrete substrates and wood substrates. The following were the most commonly cited:

¹ RCB refers to Rigid Core Board, SPC refers to Stone Polymer Composite, and WPC refers to Wood Polymer Composite.

- Installation over concrete substrate:
 - F113-21: Ceramic tile, cementitious bond coat, cementitious grout, optional membrane
 - F115-21: Ceramic tile, cementitious bond coat, epoxy or furan grout, optional membrane
- Installation over wood substrate:
 - F144-21 (in both 1/2" & 1/4" thicknesses): Ceramic tile, epoxy or cementitious bond coat, cementitious or epoxy grout, optional membrane, cement backer board or fiber-cement backer board, dry-set mortar, plywood T&G subfloor
 - F145-21: Ceramic tile, epoxy or cementitious bond coat, cementitious or epoxy grout, optional membrane, mortar bed, metal lath, cleavage membrane, plywood T&G subfloor

TCNA guidance related to tile maintenance includes daily or periodic removal of soil with a broom, dust mop, or vacuum, and use of a damp mop as necessary.

Porcelain Tile

Porcelain tile is a ceramic tile that has a water absorption of 0.5% or less per ASTM C373-18 that is generally made by the pressed or extruded method. It does not include materials with very little or no crystallinity, such as glass tile (Class P1, E1, or O1).

The CSI Masterformat designation for Porcelain tile is 09 30 13 with performance criteria standardized in either ANSI A137.1, *American National Standard Specifications for Ceramic Tile*, or ANSI A137.3, *American National Standard Specifications for Gauged Porcelain Tiles and Gauged Porcelain Tile Panels/Slabs*.

Grout and mortar are required to install porcelain tiles with mortar coverage assumed to be evenly distributed and average contact areas of at least 80% and 95% for dry and wet areas, respectively (TCNA 2021a). Grout joints are assumed to at least meet minimum width requirements per the *TCNA Handbook*.

TCNA guidance related to tile maintenance includes daily or periodic removal of soil with a broom, dust mop, or vacuum, and use of a damp mop as necessary.

Quarry Tile

Glazed or unglazed quarry tile is made by the extrusion process from natural clay or shale. It is typically manufactured in reds and other natural colors.

The CSI Masterformat designation for quarry tile is 09 30 13 with performance criteria standardized in ANSI A137.1, *American National Standard Specifications for Ceramic Tile*. Quarry tiles in compliance with ANSI A137.1 may be impervious, vitreous, or semivitreous with a water absorption value up to 5.0% per the ASTM C373-18 test method.

Grout and mortar are required to install quarry tiles with mortar coverage assumed to be evenly distributed and average contact areas of at least 80% and 95% for dry and wet areas, respectively (TCNA 2021a). Grout joints are assumed to meet typical width requirements of 1/4 to 3/8 in. per the *TCNA Handbook*.

TCNA guidance related to tile maintenance includes daily or periodic removal of soil with a broom, dust mop, or vacuum, and use of a damp mop as necessary.

Laminate

According to the North American Laminate Flooring Association (NALFA), laminate flooring is

defined as “A rigid floor covering, typically in a plank or tile format, having a multiple layer product structure, e.g., backer, substrate, overlay, and decor. The planks/tiles have worked edges that allow the product to be joined together to form a larger integral unit. The product may vary in surface texture and gloss. Laminate flooring does not include products having a resilient, stone, textile, wood, leather, or metal top surfacing material(s).” (NALFA 2019)

The CSI Masterformat for laminate flooring is 09 62 19 with performance criteria standardized in ANSI/NALFA LF 01, *Laminate Flooring Specification and Test Methods*.

NALFA (2019) refers to individual product manufacturer literature for proper installation techniques. No specific maintenance recommendations could be found in the NALFA literature. However, the following maintenance recommendations were found on a home-improvement store’s website (The Home Depot 2021a): sweep regularly, vacuum weekly, wet mop every 2 to 3 months, and deep clean occasionally. Additionally, other online sources indicate that laminate flooring needs to be occasionally “deglossed” and recoated with a new finish (Deziel 2022). This process is similar to the recoating process for solid and engineered wood, except laminate products are not sanded in the same way as wood flooring. For this study, it is assumed that laminate needs to be deglossed and recoated every 10 years, the same frequency as solid and engineered wood flooring recoating.

Granite

The most-commonly used igneous rock type for flooring in commercial construction is granite (NSI 2016). Granite is comprised of siliceous minerals.

The CSI Masterformat designation for stone flooring is 09 63 40 and the relevant specification for granite is ASTM C615, *Standard Specification for Granite Dimension Stone*.

The most common thin-set installation method for stone flooring in a commercial application is a thin-bed mortar system over concrete floors. This installation method is explained in section 3.2.6 in Chapter 13 of the *Dimension Stone Design Manual* (NSI 2022a). For thick-bed installations of stone flooring in commercial applications, a common installation method is defined in section 3.2.2 in Chapter 13 of the *Dimension Stone Design Manual* (NSI 2022a). Mortar coverage is assumed to be evenly distributed; average contact area should be at least 80% or 95% depending on the application and there should be no voids exceeding 2 sq. in. or 4 sq. in. (depending on material thickness) and no voids within 2 in. of tile corners (NSI 2022a). Grout joints are assumed to at least meet minimum width requirements per Chapter 13 of the *Dimension Stone Design Manual* (NSI 2022a).

Care and maintenance requirements for stone flooring are included in the *Natural Stone Flooring and Paving Industry-wide Type III EPD* (NSI 2022b) and the *Life Cycle Assessment (LCA) of Stone Flooring by National Stone Institute (NSI)* (Ecoform 2022). NSI recommends that granite should be cleaned daily using a vacuum or dust mop to remove debris. Floors should be wet-mopped monthly with a pH-neutral cleaner. According to NSI (NSI 2022b and Ecoform 2022), floors do not need to be repolished within a 75-year service interval nor do they need to be resealed.

Limestone

Limestone is a sedimentary rock comprised of calcium carbonate components that is formed by compression of layers of sediment over time on a geologic scale (NSI 2022a). It is typically a

consistent color throughout.

The CSI Masterformat designation for stone flooring is 09 63 40 and the relevant specification for limestone is ASTM C568, *Standard Specification for Limestone Dimension Stone*.

The most common installation method for stone flooring in a commercial application is a thin-bed mortar system over concrete floors. This installation method is explained in section 3.2.6 in Chapter 13 of the *Dimension Stone Design Manual* (NSI 2022a). For thick-bed installations of stone flooring in commercial applications, a common installation method is defined in section 3.2.2 in Chapter 13 of the *Dimension Stone Design Manual* (NSI 2022a). Mortar coverage is assumed to be evenly distributed; average contact area should be at least 80% or 95% depending on the application and there should be no voids exceeding 2 sq. in. or 4 sq. in. (depending on material thickness) and no voids within 2 in. of tile corners (NSI 2022a). In addition, limestone, which is susceptible to shrinkage of cement mortar, is assumed to be installed on mortar that is applied in a uniform thickness and within the minimum and maximum thickness allowed by the manufacturer (TCNA 2021a). Grout joints are assumed to at least meet minimum width requirements per Chapter 13 of the *Dimension Stone Design Manual* (NSI 2022a).

Care and maintenance requirements for stone flooring are included in the *Natural Stone Flooring and Paving Industry-wide Type III EPD* (NSI 2022b) and the *Life Cycle Assessment (LCA) of Stone Flooring by National Stone Institute (NSI)* (Ecoform 2022). NSI recommends that limestone should be cleaned daily using a vacuum or dust mop to remove debris. Floors should be wet-mopped monthly with a pH-neutral cleaner. Resealing every 5 years and no repolishing over the 75-year service interval were also assumed (NSI 2022b and Ecoform 2022).

Marble

Marble is a metamorphic rock comprised of calcium carbonate components with mild to moderate veining. Its structure has been transformed with heat and pressure from sedimentary limestone to a recrystallized rock (NSI 2022a).

The CSI Masterformat designation for stone flooring is 09 63 40 and the relevant specification for marble is ASTM C503, *Standard Specification for Marble Dimension Stone*.

The most common thin-set installation method for stone flooring in a commercial application is a thin-bed mortar system over concrete floors. This installation method is explained in section 3.2.6 in Chapter 13 of the *Dimension Stone Design Manual* (NSI 2022a). For thick-bed installations of stone flooring in commercial applications, a common installation method is defined in section 3.2.2 in Chapter 13 of the *Dimension Stone Design Manual* (NSI 2022a). Mortar coverage is assumed to be evenly distributed; average contact area should be at least 80% or 95% depending on the application and there should be no voids exceeding 2 sq. in. or 4 sq. in. (depending on material thickness) and no voids within 2 in. of tile corners (NSI 2022a). In addition, softer marbles that are susceptible to shrinkage of cement mortar are assumed to be installed on mortar that is applied in a uniform thickness and within the minimum and maximum thickness allowed by the manufacturer (TCNA 2021a). Grout joints are assumed to at least meet minimum width requirements per Chapter 13 of the *Dimension Stone Design Manual* (NSI 2022a).

Care and maintenance requirements for stone flooring are included in the *Natural Stone Flooring and Paving Industry-wide Type III EPD* (NSI 2022b) and the *Life Cycle Assessment (LCA) of Stone*

Flooring by National Stone Institute (NSI) (Ecoform 2022). NSI recommends that marble should be cleaned daily using a vacuum or dust mop to remove debris. Floors should be wet-mopped monthly with a pH-neutral cleaner. Resealing every 5 years and no repolishing over the 75-year service interval were also assumed (NSI 2022b and Ecoform 2022).

Travertine

Travertine is largely comprised of calcium carbonate components and is classified as a sedimentary rock (NSI 2022a). Similar to limestone and marble, it has a consistent color throughout and light to moderate veining.

The CSI Masterformat designation for stone flooring is 09 63 40 and the relevant specification for travertine is ASTM C1527, *Standard Specification for Travertine Dimension Stone*.

The most common thin-set installation method for stone flooring in a commercial application is a thin-bed mortar system over concrete floors. This installation method is explained in section 3.2.6 in Chapter 13 of the *Dimension Stone Design Manual* (NSI 2022a). For thick-bed installations of stone flooring in commercial applications, a common method is defined in section 3.2.2 in Chapter 13 of the *Dimension Stone Design Manual* (NSI 2022a). Mortar coverage is assumed to be evenly distributed; average contact area should be at least 80% or 95% depending on the application and there should be no voids exceeding 2 sq. in. or 4 sq. in. (depending on material thickness) and no voids within 2 in. of tile corners (NSI 2022a). In addition, travertine, which is susceptible to shrinkage of cement mortar, is assumed to be installed on mortar that is applied in a uniform thickness and within the minimum and maximum thickness allowed by the manufacturer (TCNA 2021a). Grout joints are assumed to at least meet minimum width requirements per Chapter 13 of the *Dimension Stone Design Manual* (NSI 2022a).

Care and maintenance requirements for stone flooring are included in the *Natural Stone Flooring and Paving Industry-wide Type III EPD* (NSI 2022b) and the *Life Cycle Assessment (LCA) of Stone Flooring by National Stone Institute (NSI) (Ecoform 2022)*. NSI recommends that travertine should be cleaned daily using a vacuum or dust mop to remove debris. Floors should be wet-mopped monthly with a pH-neutral cleaner. Resealing every 5 years and no repolishing over the 75-year service interval were also assumed (NSI 2022b and Ecoform 2022).

Engineered Wood

Engineered wood flooring is comprised of real wood from top to bottom, and ranges in thickness from 3/8 to 3/4 in. (NWFA 2019). It is normally made using multiple wood veneers or slats of wood glued together in opposing directions. The top-most layer of wood (also called lamina or lamella) is considered the wear layer (NWFA 2019). The species of the wear layer determines how the engineered wood floor is specified, while the thickness of the wear layer determines if an engineered wood floor can be refinished, and if so, how frequently.

The CSI Masterformat designation for engineered wood (composition) flooring is 09 64 19 with performance criteria standardized in ANSI/HPVA EF, *American National Standard for Engineered Wood Flooring* (DHA 2020). This standard includes guidance on tolerances and various requirements such as moisture content, labeling, and construction.

Engineered-wood floors are typically installed by one of two methods. Approximately 55% of wood floors are installed by attaching to the subfloor with either nails, adhesive, or both. The other

45% are installed using the floating method, with the installation secured in place using a locking mechanism or edge glued (NWFA 2019).

Maintenance recommendations for engineered wood floors consist of daily sweeping or dust mopping, weekly vacuuming, and monthly cleaning using a wood-floor cleaner. Engineered-wood floors should be recoated every 10 years (NWFA 2022b). Recoating includes the following steps: vacuuming the floor, cleaning with a pH neutral cleaner, lightly abrading with a fine grit, vacuuming and dry tacking, then applying a new coat of finish (NWFA 2022a). Whether an engineered wood floor can be refinished varies significantly from product to product based on the thickness of the wear layer and is not considered in this study.

Solid Wood

Solid wood flooring is made of a solid piece of wood from top to bottom (NWFA 2019). Solid wood strip, plank, and wide plank varieties are designated by linear width, with strip widths less than 3 in., plank widths from 3 to 5 in., and wide-plank widths greater than 5 in. (NWFA 2019). It can be made of various species of hardwood or softwood, however, the most-popular varieties according to a 2020 National Wood Flooring Association species report (NWFA 2022a²) are white oak 34%, red oak 32%, maple 10%, hickory/pecan 9%, birch 3%, bamboo 2%, American cherry 1%, imported exotic species 5%, and other domestic species 4%. Solid wood flooring can be sanded and refinished numerous times during its service life (NWFA 2019).

The CSI Masterformat designation for wood strip and plank flooring is 09 64 29 with performance criteria standardized in NWFA/NOFMA *International Standards for Unfinished & Factory Finished Solid Wood Flooring Products*, which include grading rules, and various guidelines including configuration, moisture content, packaging, and factory finishing (NWFA 2018).

According to NWFA (2019), most solid wood floors are installed by attaching the strips or planks to the subfloor with either mechanical fasteners, adhesive, or both.

Maintenance recommendations from NWFA include daily sweeping or dust mopping, weekly vacuuming, and monthly cleaning using a wood-floor cleaner. In addition, wood floors should be recoated every 10 years, and completely sanded and refinished every few decades (NWFA 2022b). Recoating (also known as a “maintenance coat”) includes the following steps: vacuuming the floor, cleaning with a pH neutral cleaner, lightly abrading with a fine grit, vacuuming and dry tacking, then applying a new coat of finish (NWFA 2022a).

Sheet Vinyl

The CSI Masterformat for vinyl sheet flooring is 09 65 16.23. The relevant specifications related to sheet vinyl floor coverings with and without backing are ASTM F1303, *Specification for Sheet Vinyl Floor Covering with Backing*, and ASTM F1913, *Specification for Vinyl Sheet Floor Covering Without Backing*.

Sheet vinyl flooring is manufactured in various thicknesses and colors. Sheet vinyl with backing is considered “heterogeneous vinyl flooring,” and that without backing is considered “homogeneous vinyl flooring” (RFCI 2019a and RFCI 2019b).

² Results of the 2020 NWFA species report were communicated through personal communication in 2022.

Sheet vinyl with backing is classified by type, grade, and backing class (ASTM F1303). The type is classified based on the binder content of the PVC wear layer; Type I has a minimum PVC binder content of 90% and Type II has a minimum PVC binder content of 34%. Grades are dependent on the thickness of the total wear layer and backing class is based on material composition and the category of use.

Sheet vinyl without backing is classified based on the binder content of the PVC-pattern portion of its wear layer, the total thickness of the PVC wear layer, and the thickness of any clear specialty top layer(s) (ASTM F1913). A 50% minimum binder content of the PVC-pattern portion of the wear layer is required. The total average thickness of the PVC wear layer and any clear specialty top layer(s) must equal or exceed 0.075 in. with any clear specialty top layers less than 0.0004 in. not included in the total.

Both heterogenous and homogenous sheet vinyl are installed by unrolling the material and cutting it to size. Adhesives are applied to the subfloor with hand trowels, commonly in a 300 g/m² application (RFCI 2019a and RFCI 2019b).

For this study, maintenance requirements are assumed to be the same as those recommended in the Resilient Floor Covering Institute's (RFCI's) environmental product declaration (EPD) for heterogenous vinyl flooring (RFCI 2019a) and homogenous vinyl flooring (RFCI 2019b). It is assumed that the vinyl sheet flooring is dusted daily, damp mopped weekly, and buffed (or the finish is restored) monthly. In addition, various online sources indicated that sheet vinyl flooring finish should be stripped regularly, and two coats of finish reapplied (Build Direct n.d.). For this study, annual stripping and refinishing is assumed, the same frequency as VCT.

Vinyl Composition Tile (VCT)

Vinyl composition tile (VCT) used as flooring is designated as either solid tile, through-pattern tile, or surface-pattern tile (RFCI 2019c). Materials used in VCT include binder, fillers, and pigments. Performance criteria are standardized in ASTM F1066, *Specification for Vinyl Composition Tile*, which stipulates that the binder shall “consist of one or more resins of poly(vinyl chloride) or vinyl chloride copolymers, or both, compounded with suitable plasticizers and stabilizers.” VCT is most commonly available in a 1/8 in. thickness (RFCI 2019c). The CSI Masterformat for VCT flooring is 09 65 19.19.

Adhesives are applied to the subfloor with hand trowels (RFCI 2019c), commonly in a 300 g/m² application, with the VCT installed onto the adhesive and cut to size at the perimeter.

Maintenance requirements for VCT include daily dusting, weekly damp mopping, and monthly buffing. In addition, their finish should be stripped on an annual basis and two coats of finish reapplied (RFCI 2019c).

Flexible Luxury Vinyl Flooring (LVF)

Flexible, luxury vinyl flooring (LVF, also referred to as luxury vinyl tile or LVT) performance criteria are standardized in ASTM F1700, *Specification for Solid Vinyl Floor Tile* (RFCI 2019d), These flooring surfaces are “monolithic, surface decorated or printed, and protected by a clear wear layer (ASTM F1700).” LVF is classified by type and class. Classes I, II, and III correspond to monolithic, surface-decorated, and printed-film vinyl tiles, respectively. Types A and B indicate a smooth or embossed surface, respectively. LVF materials consist of binder, filler, pigments,

lubricants, and processing aids (ASTM F1700). Product thicknesses typically range from 2 to 5 mm (RFCI 2019d). The CSI Masterformat designation for flexible, vinyl tile flooring is 09 65 19.23.

Adhesives are applied to the subfloor with hand trowels (RFCI 2019d), commonly in a 300 g/m² application with the LVF installed onto the adhesive and cut to size at the perimeter.

Maintenance requirements for LVF include daily dusting, weekly damp mopping, and monthly buffing (RFCI 2019d).

Rigid Core Flooring

The CSI Masterformat for rigid core flooring is 09 65 19.43. Performance criteria are standardized in ASTM F3261, *Standard Specification for Resilient Flooring in Modular Format with Rigid Polymeric Core*.

The common element to rigid core flooring is a polymeric rigid core, which is distinct from other types of plastic-based flooring products. ASTM F3261 defines a polymeric rigid core as “the material layer which provides thickness, stiffness, dimensional stability and other properties needed for the finished resilient flooring.” Flooring is produced in tile or plank format, can have a decorated or printed surface, and may include a clear wear layer (ASTM F3261).

Rigid core flooring is installed using one of two methods. Either adhesive is applied to the subfloor with hand trowels, or “flooring is installed as a floating floor,” in which case no adhesive is necessary (RFCI 2019d). In this study, installation with adhesive was assumed.

Recommended maintenance for rigid core flooring includes daily dusting, weekly damp mopping, and quarterly buffing (according to RFCI 2019e), however, monthly buffing was assumed for this study to be consistent with maintenance requirements for other vinyl flooring types (RFCI 2019a – RFCI 2019d).

Epoxy Terrazzo

The CSI Masterformat designation for epoxy terrazzo is 09 66 23. Performance specifications and installation instructions are not standardized but are provided by the product manufacturer. Epoxy terrazzo is typically 1/4 to 3/8 in. thick.

Epoxy terrazzo is a composite flooring system that mixes epoxy with various aggregates—such as marble, quartz, granite, glass, porcelain, mother of pearl, or mirror chips—for application over a concrete slab.

NTMA recommends dust or wet mopping for routine maintenance. The Terrazzo Maintenance Guide (2021) also recommends that floors are scrubbed weekly with clean water and a white scrubbing pad.

Poured Epoxy

The CSI Masterformat designation for poured epoxy flooring is 09 67 23. ASTM C722, *Standard Specification for Chemical-Resistant Monolithic Floor Surfacing*, is applicable for chemical-resistant poured epoxy floors.

Poured epoxy is a composite flooring system that mixes epoxy with various aggregates—such as marble, quartz, granite, glass, porcelain, mother of pearl, or mirror chips—that forms a monolithic surface over concrete subflooring (RFA 2018).

Maintenance recommendations for epoxy floor coatings are largely manufacturer specific. General recommendations include sweeping and mopping floors regularly and using an electric polishing machine as needed (RFA 2020).

Carpet Tiles and Nylon Broadloom Carpet

According to the Carpet and Rug Institute Inc. (CRI), 95% of commercial carpet is tufted (CRI 2021). Per CRI, there are “five primary pile fibers: nylon, polyester, polypropylene (olefin), triexta, and wool,” with the majority of fiber types used in the US being synthetic. For the purpose of this study, only nylon-fiber broadloom carpet and carpet tiles are considered because of their popularity (Floors USA 2022).

The CSI Masterformat for sheet carpeting is 09 68 16 and 09 68 13 for tile carpeting. Several specifications exist related to the properties of carpet, but a standard specification for manufacturing does not exist. CRI publishes standards for installation (CRI 2019b) and maintenance (CRI 2019a) of commercial carpet.

Broadloom carpet is typically installed by one of two methods: glued down or stretched in. The glued-down installation method adheres the carpet to the substrate using adhesive. In the stretched-in method, tack strips along walls and other vertical elements hold the carpet in place under tension. CRI does not give installation recommendations related to carpet tile, other than to refer to the manufacturer’s instructions.

In terms of maintenance, CRI recommends routine vacuuming and spill, spot, and stain removal in addition to periodic preventative cleaning (sometimes referred to as “deep cleaning”). Routine cleaning should occur as needed, usually daily, including timely spot cleaning. CRI does not give a recommendation on frequency of cleaning other than to say that it depends on location, use, and exposure, among other factors. To establish frequencies for periodic preventative cleaning, several online sources were consulted (Peters 2016, Bissell 2023, and Banchy 2019). For carpet tiles, which are commonly installed in higher traffic areas in comparison to nylon broadloom carpet, preventative cleaning is assumed to occur 6 times per year; for nylon broadloom carpet, it is assumed to occur 4 times per year.

Key assumptions and cost data

Cost data were directly obtained or estimated from RS Means online database. Material costs in RS Means are developed by RS Means staff in consultation with material manufacturers, dealers, distributors, and contractors in the US and Canada. Costs for some flooring products used in this study were not available in the RS Means database. In these cases, various online retailers were consulted to estimate a relative cost between a flooring product not contained in RS Means and a similar product that is contained in RS Means. That relative cost was then used to adjust the RS Means cost for the included product to estimate an RS Means cost for the product not included in the database—these estimated costs are identified as “proxy” costs. Additional explanation of the estimation method and relative costs are included in the relevant flooring category cost data sections. If a line item for a similar product was not contained in RS Means and an estimated cost could not be calculated, industry sources were consulted to provide justification for use of similar

costs for different line items in RS Means—these instances are indicated in the relevant flooring category cost data sections.

Due to significant recent cost variation in some categories of flooring products, average annual data from calendar year 2020 were used, which is still recent yet less affected by global supply chain issues caused by the COVID-19 pandemic.

Average labor cost data in RS Means is compiled from wage rates in the largest 30 US cities. In this study, national average labor rates were also used.

All costs presented assume overhead and profit for the installing contractor of 10% for both materials and installation; this is the default value contained in RS Means. Individual or corporate tax rates for the individual or group purchasing the flooring or making the decision on what flooring to choose are not included in the analysis since this is a relative assessment and it can be assumed that the tax rate would be the same regardless of the flooring type chosen for a particular commercial building.

For the purposes of this report, all flooring is considered to be installed initially as new construction. It is assumed that all flooring is installed using the appropriate method for the application, and therefore the flooring will not need to be prematurely replaced due to improper installation. All floor systems, structural subfloors, and substrates, whether wood or concrete, are assumed to be constructed in conformance with applicable building codes. Serviceability requirements for substrates, such as those related to deflection, spacing, flatness, moisture content, and other factors for the successful installation of a given flooring type, are also assumed to be met.

“Estimated service life,” also known as “useful service life” or “estimated useful life,” refers to the amount of time a specified flooring product will generally maintain its expected appearance and the functional requirements noted in the introduction of this report. At the end of a product’s estimated service life, it was assumed the product must be replaced.

Commercial building characteristics were taken from the 2018 Commercial Building Energy Consumption Survey (CBECS). The U.S. Energy Information Administration (US EIA 2020) is required to collect commercial building data periodically for CBECS, and data presented in 2018 is the eleventh and most-recent iteration. CBECS provides independent, statistically representative data on the characteristics of commercial buildings. In the 2018 CBECS, the average square footage of a commercial building in the U.S. was 16,400 ft² and the median building size was 5400 ft².

More than 71% of the U.S. building stock is 10,000 ft² or smaller. For some flooring types, RS Means lists costs based on an assumed area of installation. If costs in the database were dependent on a square footage of installation, the CBECS square footages were referenced to choose a cost.

The service requirements of the office building are assumed to be light to medium commercial use, such as in office spaces, reception areas, kitchens, and bathrooms (per TCNA Handbook, passes ASTM C627 cycles 1 through 6 for ceramic floor tile installation). It is assumed that the substrate does not include radiant heat.

Typical installation details, such as those described in each flooring type, are assumed. The

installation details chosen do not include a waterproofing membrane or other membranes that are necessary for the proper watertightness of certain flooring types. Because not all flooring types evaluated in this study are appropriate for high-moisture applications, typical details appropriate for high-moisture applications were not chosen.

Costs associated with daily cleaning practices common to all flooring types, whether regular dusting, mopping, or vacuuming, were assumed to be the same for this comparative analysis. The RS Means database cost for weekly “Hard floor, cleaning, sweep and wet mop” was used as a weekly proxy for this analysis. That cost is \$0.04 per square foot, with one-quarter of that being materials cost and three-quarters being labor cost. At a frequency of once per week over a 75-year study period and at a 3% discount rate, the total net present value for this cleaning is \$61.78 per square foot; this cost was applied equally to the life cycle costs of all 18 flooring types in the “Summary and Results” section table. This cost is not listed in each individual flooring cost table but is included in the LCCA totals. Maintenance costs that were unique to a flooring category, such as sealing of stone flooring or refinishing of solid wood flooring, are also included in this study.

Ceramic Tile

Total ceramic tile costs (materials and installation, including overhead and profit) in the RS Means database ranged between \$9.53 and \$11.51 depending on the various descriptors such as color and ceramic tile size. The cost from “RS Means Color Group 2” of \$11.03 was chosen because it is near the median in the range of available costs. It is also slightly greater than average for the range of costs in this category and hence it is a conservative assumption.

The estimated service life of ceramic tiles is 75 years or longer, thus replacement is not needed during the study period and replacement costs are not applicable. A service life of 75 years was assumed because it corresponds to the estimated service life of mosaic, quarry, pressed floor, glazed wall, and porcelain tiles in the North American industry-average environmental product declaration (EPD) for ceramic tiles (ULE 2020). There is no maintenance required of ceramic tile flooring other than daily cleaning, the cost of which is not shown in this section but is incorporated in the life-cycle costs results table.

Table. Ceramic tile flooring costs per square foot (Source: RS Means database)

RS Means database descriptor	Materials	Labor
First costs		
Ceramic tile, floors, natural clay, random or uniform, thin set, color group 2	\$ 6.50	\$ 4.53
Maintenance costs		
N/A	—	—
Replacement costs		
N/A	—	—

Note: costs include overhead and profit. N/A = not applicable.

Porcelain Tile

Two material costs (including overhead and profit) were included in the RS Means database for porcelain tile. The minimum material cost was \$6.85, and the maximum was \$9.15, depending on the type of grout installed. The material cost of \$6.85 was chosen because the higher cost material assumes epoxy grout, which is not typical.

The estimated service life of porcelain tiles is 75 years or longer, thus replacement is not needed during the study period and replacement costs are not applicable. A service life of 75 years was assumed because it corresponds to the estimated service life of mosaic, quarry, pressed floor, glazed wall, and porcelain tiles in the North American industry-average environmental product declaration (EPD) for ceramic tiles (ULE 2020). There is no maintenance required of porcelain tile flooring other than daily cleaning, the cost of which is not shown in this section but is incorporated in the life-cycle costs results table.

Table. Porcelain tile flooring costs per square foot (Source: RS Means database)

RS Means database descriptor	Materials	Labor
First costs		
Tile, porcelain type, minimum	\$ 6.85	\$ 4.53
Maintenance costs		
N/A	—	—
Replacement costs		
N/A	—	—

Note: costs include overhead and profit. N/A = not applicable.

Quarry Tile

As noted in the previous section, total ceramic tile costs (materials and installation, including overhead and profit) in the RS Means database ranged between \$9.53 and \$11.51 depending on the ceramic tile size. The cost chosen for quarry tile was \$9.53 because it is known to be an economical tile type according to TCNA (2021c).

The estimated service life of quarry tiles is 75 years or longer, thus replacement is not needed during the study period and replacement costs are not applicable. A service life of 75 years was assumed because it corresponds to the estimated service life of mosaic, quarry, pressed floor, glazed wall, and porcelain tiles in the North American industry-average environmental product declaration (EPD) for ceramic tiles (ULE 2020). There is no maintenance required of quarry tile flooring other than daily cleaning, the cost of which is not shown in this section but is incorporated in the life-cycle costs results table.

Table. Quarry tile flooring costs per square foot (Source: RS Means database)

RS Means database descriptor	Materials	Labor
First costs		
Ceramic tile, floors, natural clay, random or uniform, thin set, color group 1	\$ 5.00	\$ 4.53
Maintenance costs		
N/A	—	—
Replacement costs		
N/A	—	—

Note: costs include overhead and profit. N/A = not applicable.

Laminate

There was only one listing for laminate flooring in the RS Means database for a laminate floor that included both material and installation costs. The values are shown in the table that follows.

In addition to daily cleaning, laminate flooring requires periodic deep cleaning. Deep cleaning was not included in the RS Means database, so the cost of weekly cleaning, sweeping, and wet-mopping was used as a proxy for deep cleaning. It was assumed that this deep cleaning occurs monthly and that the cost of four weekly cleanings is equal to that of one monthly deep clean. Laminate flooring also requires deglossing and recoating of the finish. This cost was not included in the RS Means database, so the RS Means cost to recoat wood strip flooring was used as a proxy. For this analysis, it was assumed that deglossing and recoating occurs every 10 years.

Laminate flooring has an expected service life of 20 years according to various industry EPDs (Tarkett 2018, EPLF 2021). This estimate is conservative because the service life is likely less in a commercial application versus a residential application. Because the laminate flooring will need to be replaced over the duration of the study period, costs to remove the flooring and replace it are included in the following table. There were no demolition costs for laminate flooring in the RS Means database, so demolition costs for VCT flooring were used as a proxy.

Table. Laminate flooring costs per square foot (Source: RS Means database)

RS Means database descriptor	Materials	Labor
First costs		
Floating floor, laminate, wood pattern strip, complete	\$ 5.45	\$ 3.04
Maintenance costs		
(Monthly deep cleaning proxy) Hard floor, cleaning, sweep and wet mop (weekly) x 4	\$ 0.04	\$ 0.12
(Deglossing and recoating proxy) Wood strip flooring, sanding & finishing, 2 coats polyurethane	\$ 0.23	\$ 0.83
Replacement costs		
Floating floor, laminate, wood pattern strip, complete	\$ 5.45	\$ 3.04
(Flooring demolition proxy) Flooring demolition, vinyl composition tile, 12" x12"	—	\$ 1.01

Note: costs include overhead and profit.

Granite

Granite did not have cost data in the RS Means database. However, NSI members (2022c) report that the costs of granite and marble flooring are similar. Thus, the marble material cost in the RS Means database is used as a proxy for the cost of granite flooring.

The estimated service life of granite is 75 years or longer, thus replacement is not needed during the study period and replacement costs are not applicable. This service life is justified based on a NAHB study (2007) and the Life Cycle Assessment of Stone Flooring by National Stone Institute (NSI) (Ecoform 2022). In addition to daily cleaning, granite flooring requires wet-mopping monthly with a pH neutral cleaner, so that maintenance cost is included in this study. The cost of one weekly cleaning is used as a proxy for one monthly wet mopping.

Table. Granite flooring costs per square foot (Source: RS Means database)

RS Means database descriptor	Materials	Labor
First costs		
(Granite materials and labor proxy) Marble flooring, white Carara [sic], thin set, 12" x 12" x 3/8"	\$ 12.80	\$ 13.85

Maintenance costs		
(Wet-mopping monthly with a pH neutral cleaner proxy) Hard floor, cleaning, sweep and wet mop (weekly)	\$ 0.01	\$ 0.03
Replacement costs		
N/A	—	—

Note: costs include overhead and profit. N/A = not applicable.

Limestone

Limestone did not have cost data in the RS Means database. Cost values were estimated based on an adjustment of travertine flooring values from the RS Means database. The range of costs were surveyed online from one national retailer: Floor and Decor; neither The Home Depot nor Lumber Liquidators carry limestone flooring. The range of costs for limestone (Floor and Decor 2022a) and travertine (Floor and Decor 2022b) was \$2.29 to \$5.49 and \$1.99 to \$5.29 per square foot, respectively. Thus, it was estimated that the cost of limestone flooring was approximately the same as that of the travertine material in the RS Means database.

The estimated service life of limestone is 75 years or longer, thus replacement is not needed during the study period and replacement costs are not applicable. This service life is justified based on a NAHB study (2007) and the Life Cycle Assessment of Stone Flooring by National Stone Institute (NSI) (Ecoform 2022). In addition to daily cleaning, limestone flooring requires wet-mopping monthly with a pH neutral cleaner, and resealing every 5 years, thus these maintenance costs are included in this study. The cost of one weekly cleaning is used as a proxy for one monthly wet mopping. The cost for resealing limestone flooring was not included in the RS Means database, so a primer/sealer coat cost was used as a proxy.

Table. Limestone flooring costs per square foot (Source: RS Means database.)

RS Means database descriptor	Materials	Labor
First costs		
(Limestone materials and labor proxy) Marble flooring, thin gauge tile, Travertine	\$ 10.45	\$ 13.85
Maintenance costs		
(Resealing proxy) Paints & coatings, miscellaneous interior, floors, concrete/wood, oil base, primer/sealer coat, spray	\$ 0.10	\$ 0.14
(Wet-mopping monthly with a pH neutral cleaner proxy) Hard floor, cleaning, sweep and wet mop (weekly)	\$ 0.01	\$ 0.03
Replacement costs		
N/A	—	—

Note: costs include overhead and profit. N/A = not applicable.

Marble

Two options for marble flooring costs installed by the thin-set method were available in the RS Means database: a 12-in. square tile and a 6 in. by 12 in. shaped tile. The 12-in.-square tile was chosen because it is more commonly used.

The estimated service life of marble is 75 years or longer, thus replacement is not needed during the study period and replacement costs are not applicable. This service life is justified based on a NAHB study (2007) and the Life Cycle Assessment of Stone Flooring by National Stone Institute (NSI) (Ecoform 2022). In addition to daily cleaning, marble flooring requires wet-mopping

monthly with a pH neutral cleaner, and resealing every 5 years, thus these maintenance costs are included in this study. The cost of one weekly cleaning is used as a proxy for one monthly wet mopping. The cost for resealing marble flooring was not included in the RS Means database, so a primer/sealer coat cost was used as a proxy.

Table. Marble flooring costs per square foot (Source: RS Means database)

RS Means database descriptor	Materials	Labor
First costs		
Marble flooring, white Carara [sic], thin set, 12" x 12" x 3/8"	\$ 12.80	\$ 13.85
Maintenance costs		
(Resealing proxy) Paints & coatings, miscellaneous interior, floors, concrete/wood, oil base, primer/sealer coat, spray	\$ 0.10	\$ 0.14
(Wet-mopping monthly with a pH neutral cleaner proxy) Hard floor, cleaning, sweep and wet mop (weekly)	\$ 0.01	\$ 0.03
Replacement costs		
N/A	—	—

Note: costs include overhead and profit. N/A = not applicable.

Travertine

There is only one entry for travertine in the RS Means database, which is listed in the following table.

The estimated service life of travertine is 75 years or longer, thus replacement is not needed during the study period and replacement costs are not applicable. This service life is justified based on a NAHB study (2007) and the Life Cycle Assessment of Stone Flooring by National Stone Institute (NSI) (Ecoform 2022). In addition to daily cleaning, travertine flooring requires wet-mopping monthly with a pH neutral cleaner, and resealing every 5 years, thus these maintenance costs are included in this study. The cost of one weekly cleaning is used as a proxy for one monthly wet mopping. The cost for resealing marble flooring was not included in the RS Means database, so a primer/sealer coat cost was used as a proxy.

Table. Travertine flooring costs per square foot (Source: RS Means database)

RS Means database descriptor	Materials	Labor
First costs		
Marble flooring, thin gauge tile, Travertine	\$ 10.45	\$ 13.85
Maintenance costs		
(Resealing proxy) Paints & coatings, miscellaneous interior, floors, concrete/wood, oil base, primer/sealer coat, spray	\$ 0.10	\$ 0.14
(Wet-mopping monthly with a pH neutral cleaner proxy) Hard floor, cleaning, sweep and wet mop (weekly)	\$ 0.01	\$ 0.03
Replacement costs		
N/A	—	—

Note: costs include overhead and profit. N/A = not applicable.

Engineered Wood

Engineered wood did not have cost data in the RS Means database. Cost values were estimated based on an adjustment of solid wood flooring values. The range of costs were surveyed online

from two national retailers: Lumber Liquidators and The Home Depot. The range of costs for engineered wood (2021a) and solid hardwood (2021b) at Lumber Liquidators was \$2.99 to \$7.99 and \$3.78 to \$8.99 per square foot, respectively. At The Home Depot, for engineered wood (2021b) and solid hardwood (2021c), costs were \$2.50 to \$10.99 and \$3.49 to \$11.51 per square foot, respectively. Thus, it was estimated that the cost of engineered wood flooring was approximately \$1 per square foot less than that used for solid hardwood in this study. Thus, solid wood costs from the RS Means database were used and \$1 was subtracted from the materials cost. Installation costs used were the same as those used for solid wood.

Engineered wood has an estimated service life of 25 years (Heidari 2022) and will need to be replaced over the life of the building. Costs to remove the engineered wood flooring and replace it with new product are included in the table that follows. In addition to daily cleaning, engineered-wood flooring has unique maintenance requirements in that floors need to be recoated every 10 years. The cost for recoating engineered wood was not included in the RS Means database, so a cost for wood strip flooring sanding and finishing was used as a proxy. NWFA (2022b) estimated the cost to recoat engineered wood flooring at approximately \$1.50 per square foot (combined materials and labor), therefore the RS Means proxy cost used for this study is considered a conservative estimate. Additionally, while some engineered wood products can be sanded and refinished, guidance from NWFA (2022a) states that refinishing of engineered wood flooring does not regularly occur (as opposed to recoating that is performed), so that cost is not included in this analysis. There were no demolition costs for engineered wood flooring in the RS Means database, so a cost for wood strip flooring demolition was used as a proxy.

Table. Engineered-wood flooring costs per square foot (Source: RS Means database.)

RS Means database descriptor	Materials	Labor
First costs		
(Engineered wood materials and labor proxy) Weighted average of oak and maple	\$ 3.51	\$ 4.41
Maintenance costs		
(Recoating proxy) Wood strip flooring, sanding & finishing, 2 coats polyurethane	\$ 0.23	\$ 0.83
Replacement costs		
(Engineered wood materials and labor proxy) Weighted average of oak and maple	\$ 3.51	\$ 4.41
(Demolition proxy) Flooring demolition, wood strip flooring, interior, 2- 1/4" x 25/32" thick	—	\$ 1.59

Note: costs include overhead and profit; material costs are \$1 less than that for the solid hardwood category.

Solid Wood

Red oak and white oak make up 66% of the market share, by species, of solid wood flooring installed in the United States (NWFA 2021a). The next largest market share is maple at 10% (NWFA 2021a). Other species represent significantly smaller portions of the market share and were not considered in determining material cost. Rather, a weighted average of maple and the two oak species was used to represent the flooring category of solid wood.

Solid wood flooring is assumed to have an estimated service life of 75 years or greater, thus replacement is not needed during the study period and replacement costs are not applicable. This service life is based on a National Association of Home Builders (NAHB) study (2007). As the

service life of a wood floor in a commercial application is likely less than that of a residential application due to increased wear and traffic, the use of 75 years is considered a conservative assumption in this comparative assessment. In addition to daily cleaning, solid-wood flooring has unique maintenance requirements in that floors need to be sanded, refinished, and recoated during the service life. It is assumed that this refinishing occurs every 25 years and recoating every 10 years. The cost for recoating solid wood was not included in the RS Means database, so a cost for wood strip flooring sanding and finishing was used as a proxy. NWFA (2022b) estimated the cost to recoat solid wood flooring at approximately \$1.50 per square foot (combined materials and labor), therefore the RS Means proxy cost used for this study is considered a conservative estimate.

Table. Solid wood flooring costs per square foot (Source: RS Means database)

RS Means database descriptor	Materials	Labor
First costs		
wood strip flooring, maple, #2 & better, 25/32 in. x 2 1/4 in. + sanding and finishing, 2 coats polyurethane	\$ 5.90	\$ 4.41
wood strip flooring, oak, white or red, #1 common, 25/32 in. x 2 1/4 in. + sanding and finishing, 2 coats polyurethane	\$ 4.23	\$ 4.41
Weighted average of oak and maple:	\$ 4.51	\$ 4.41
Maintenance costs		
Wood strip flooring, refinish, sand, 2 coats poly, wax, hardwood	\$ 0.25	\$ 3.11
(Recoating proxy) Wood strip flooring, sanding & finishing, 2 coats polyurethane	\$ 0.23	\$ 0.83
Replacement costs		
N/A	—	—

Note: costs include overhead and profit. N/A = not applicable.

Sheet Vinyl

For sheet vinyl goods, only backed flooring types are included in the RS Means database. Six different entries were available; they were differentiated by three different thicknesses (0.065, 0.080, and 0.125 in. thick) and two patterns (plain or intricate). Costs for a plain patterned sheet vinyl and the middle thickness were chosen for this study.

The reference service life of resilient tile/sheet flooring was taken to be 15 years (Fannie Mae 2019). Thus, replacement costs are included in the following table. Flooring removal costs were only available for VCT, so these costs are used as a proxy for sheet vinyl flooring. RS Means does not include costs for preparation of the subfloor after flooring demolition and prior to replacement—it was assumed that subfloor preparation is incorporated in the demolition costs, which is considered a conservative assumption. In addition to daily cleaning, a unique maintenance requirement for sheet vinyl floors is monthly buffing, which is included in the following table and incorporated into this analysis. Buffing was not included in the RS Means database, so the cost of weekly cleaning, sweeping, and wet-mopping for four weeks was used as a proxy for monthly buffing. Sheet vinyl flooring finish also needs to be stripped on an annual basis and two coats of finish reapplied. This stripping and refinishing cost was not included in the RS Means database, so the RS Means cost for sanding and finishing wood flooring was used as a proxy. This was verified against an online source for stripping and refinishing that showed a median, average cost of \$1.04 per square foot for materials and labor (Homewyse 2022), which is similar to the proxy used in the table below.

Table. Sheet vinyl flooring costs per square foot (Source: RS Means database)

RS Means database descriptor	Materials	Labor
First costs		
Resilient flooring, vinyl sheet goods, backed, plain pattern/colors, 0.080" thick	\$ 4.57	\$ 2.53
Maintenance costs		
(Monthly buffing proxy) Hard floor, cleaning, sweep and wet mop (weekly) x4	\$ 0.04	\$ 0.12
(Stripping/refinishing proxy) Wood strip flooring, sanding & finishing, 2 coats polyurethane	\$ 0.23	\$ 0.83
Replacement costs		
(Flooring demolition proxy) Flooring demolition, vinyl composition tile, 12" x 12"	—	\$ 1.01
Resilient flooring, vinyl sheet goods, backed, plain pattern/colors, 0.080" thick	\$ 4.57	\$ 2.53

Note: costs include overhead and profit.

Vinyl Composite Tile (VCT)

Similar to sheet vinyl, VCT costs were available for nine types: three different thicknesses in combination with three different patterns. Thicknesses were either 1/16, 3/32, or 1/8 in. Patterns were either embossed, marbled, or solid. Costs for a 1/8 in. thick solid VCT were chosen for this analysis.

The Fannie Mae Estimated Useful Life Tables state that the reference service life of resilient tile/sheet flooring is 15 years. Thus, replacement costs are included in the following table. RS Means does not include costs for preparation of the subfloor after flooring demolition and prior to replacement—it was assumed that subfloor preparation is incorporated in the demolition costs, which is considered a conservative assumption. In addition to daily cleaning, VCT floors also require monthly buffing and annual stripping and refinishing, the costs of which are also included in the following table and incorporated into this analysis. Buffing was not included in the RS Means database, so the cost of weekly cleaning, sweeping, and wet-mopping for four weeks was used as a proxy for monthly buffing. Proxy costs were verified by industry sources (NTCA 2022). For annual stripping and refinishing, there was no cost data included in RS Means, so the RS Means cost for sanding and finishing wood flooring is used as a proxy. This was verified against an online source for stripping and refinishing which showed a median, average cost of \$1.04 per square foot for materials and labor (Homewyse 2022), which is similar to the proxy used in the table below.

Table. Vinyl composite tile flooring costs per square foot (Source: RS Means database)

RS Means database descriptor	Materials	Labor
First costs		
Flooring, vinyl composition tile, solid, 12" x 12" x 1/8"	\$ 1.93	\$ 1.16
Maintenance costs		
(Monthly buffing proxy) Hard floor, cleaning, sweep and wet mop (weekly) x 4	\$ 0.04	\$ 0.12
(Stripping/refinishing proxy) Wood strip flooring, sanding & finishing, 2 coats polyurethane	\$ 0.23	\$ 0.83
Replacement costs		
Flooring demolition, vinyl composition tile, 12" x 12"	—	\$ 1.01

Flooring, vinyl composition tile, solid, 12" x 12" x 1/8"	\$ 1.93	\$ 1.16
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Note: costs include overhead and profit.

Flexible Luxury Vinyl Flooring (LVF)

Six vinyl tile costs are included in the RS Means database and differ based on pattern; all sizes are a consistent 12 x 12 x 1/8 in. For consistency with other patterns chosen for other vinyl floorings, the “solid” color was chosen for this study.

Resilient tile/sheet flooring has a reference service life of 15 years according to Fannie Mae’s Estimated Useful Life Tables. Thus, replacement costs are included in the following table. Flooring removal costs were only available for VCT, so these costs are used as a proxy for LVF. RS Means does not include costs for preparation of the subfloor after flooring demolition and prior to replacement—it was assumed that the subfloor preparation is incorporated in the demolition costs, which is considered a conservative assumption. In addition to daily cleaning, LVF also requires monthly buffing, the cost of which is also included in the following table and incorporated into this analysis. Buffing was not included in the RS Means database, so the cost of weekly cleaning, sweeping, and wet-mopping for four weeks was used as a proxy for monthly buffing.

Table. Flexible luxury vinyl flooring costs per square foot (Source: RS Means database)

RS Means database descriptor	Materials	Labor
First costs		
Flooring, vinyl tile, solid colors, 12" x 12" x 1/8"	\$ 3.40	\$ 1.16
Maintenance costs		
(Monthly buffing proxy) Hard floor, cleaning, sweep and wet mop (weekly) x 4	\$ 0.04	\$ 0.12
Replacement costs		
(Flooring demolition proxy) Flooring demolition, vinyl composition tile, 12" x 12"	—	\$ 1.01
Flooring, vinyl tile, solid colors, 12" x 12" x 1/8"	\$ 3.40	\$ 1.16

Note: costs include overhead and profit.

Rigid Core Flooring

Rigid core flooring did not have cost data in the RS Means database. Cost values were estimated based on an adjustment of LVF flooring values. The range of costs were surveyed online from two national retailers: Lumber Liquidators and The Home Depot. The range of costs for rigid vinyl plank (2021c) and luxury vinyl plank (2021d) (i.e., rigid core flooring and LVF) at Lumber Liquidators was \$1.28 to \$4.19 and \$0.88 to \$3.49 per square foot, respectively. At The Home Depot, for rigid vinyl plank (2023a) and luxury vinyl plank (2023b) costs were \$ 1.97 to \$7.79 and \$ 0.89 to \$ 4.69 per square foot, respectively. Averaging the mean values, it was estimated that the cost of rigid core flooring was greater than that of LVF by 53%. This 53% increase was applied to the LVF material costs used in this study for use with the rigid core flooring. The cost of installation was assumed to be the same as that of VCT, which is a conservative assumption according to industry sources.

Resilient tile/sheet flooring has a reference service life of 15 years according to Fannie Mae’s Estimated Useful Life Tables. Thus, replacement costs are included in the following table. Since installation with adhesive is assumed, demolition costs for VCT were used as a proxy. RS Means does not include costs for preparation of the subfloor after flooring demolition and prior to

replacement—it was assumed that the subfloor preparation is incorporated in the demolition costs, which is considered a conservative assumption. In addition to daily cleaning, similar to flexible LVF and other vinyl floorings, monthly buffing was assumed, the cost of which is also included in the following table and incorporated into this analysis. Buffing was not included in the RS Means database, so the cost of weekly cleaning, sweeping, and wet-mopping for four weeks was used as a proxy for monthly buffing.

Table. Rigid core flooring costs per square foot (Source: RS Means database)

RS Means database descriptor	Materials	Labor
First costs		
(Rigid core materials and labor proxy) Flooring, vinyl tile, solid colors, 12" x 12" x 1/8" with 53% increase in material cost	\$ 5.20	\$ 1.16
Maintenance costs		
(Monthly buffing proxy) Hard floor, cleaning, sweep and wet mop (weekly) x 4	\$ 0.04	\$ 0.12
Replacement costs		
(Flooring demolition proxy) Flooring demolition, vinyl composition tile, 12" x 12"	—	\$ 1.01
(Rigid core materials and labor proxy) Flooring, vinyl tile, solid colors, 12" x 12" x 1/8" (with 53% increase in material cost)	\$ 5.20	\$ 1.16

Note: costs include overhead and profit.

Epoxy Terrazzo

Costs for epoxy terrazzo in the RS Means database varied from \$8.14 to \$19.15 per square foot, depending on flooring thickness and aggregate chip type. Because market data was unavailable to determine the most-common epoxy terrazzo type, a median cost was selected for this analysis and is shown in the following table.

The estimated service life of terrazzo is 75 years based on a NAHB study (2007). In addition, Section 5.14.7 of NIST’s *Building for Environmental and Economic Sustainability (BEES) Online 2.1 Technical Manual* (NIST 2021) states that terrazzo “is expected to last at least as long as the building itself,” so a 75-year service life is justified. Thus, replacement is not needed during the study period. The *Terrazzo Maintenance Guide* (2021) recommends that floors are scrubbed weekly with clean water and a white pad, which is unique to this flooring type. This scrubbing was not included in the RS Means database, so the cost of weekly cleaning, sweeping, and wet-mopping was used as a proxy for this weekly scrubbing and is included in the following table. The only other maintenance requirement for epoxy terrazzo is daily cleaning, the cost of which is not shown in this section but is incorporated in the life-cycle costs results table.

Table. Epoxy terrazzo flooring costs per square foot (Source: RS Means database)

RS Means database descriptor	Materials	Labor
First costs		
Epoxy resin terrazzo, floor, epoxy terrazzo, glass or mother of pearl, 3/8" thick, average	\$ 7.90	\$ 5.76
Maintenance costs		
(Weekly scrubbing proxy) Hard floor, cleaning, sweep and wet mop (weekly)	\$ 0.01	\$ 0.03
Replacement costs		

N/A	—	—
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Note: costs include overhead and profit. N/A = not applicable.

Poured Epoxy

Various costs are available for poured epoxy flooring depending on the use, thickness, and square footage installed. Of the available costs, a median cost for a ½ in. thick epoxy flooring was chosen since market data is unavailable to better-inform the most-common thickness.

Poured epoxy flooring is typically manufactured as a proprietary system and no industry or trade association was found for this flooring type. Thus, when researching typical service lives of epoxy flooring, only manufacturer-specific information could be found. Two websites listed the average service life of poured-epoxy flooring as between 10 and 20 years (SSI 2021 and Stonehard 2019). A service life of 15 years was used for this study. Thus, replacement is needed during the study period with the cost of acrylic or epoxy flooring demolition available from the RS Means database. While the database does not specify whether this cost includes subsequent subfloor preparation for replacement flooring, this was assumed and can be considered a conservative assumption.

Maintenance recommendations for epoxy floor coatings are also manufacturer specific. General recommendations include daily cleaning, weekly scrubbing, and using an electric polishing machine as needed. The cost of daily cleaning is not shown in this section but is incorporated in the life-cycle costs results table while the cost of weekly scrubbing and electric polishing as needed is included in the following table using the cost of weekly cleaning, sweeping, and wet-mopping as a proxy .

Table. Poured-epoxy flooring costs per square foot (Source: RS Means database)

RS Means database descriptor	Materials	Labor
First costs		
Composition flooring, epoxy, with colored quartz chips, broadcast, 1/2" thick	\$ 4.97	\$ 6.52
Maintenance costs		
(Weekly scrubbing and polishing as needed proxy) Hard floor, cleaning, sweep and wet mop (weekly)	\$ 0.01	\$ 0.03
Replacement costs		
Composition flooring, epoxy, with colored quartz chips, broadcast, 1/2" thick	\$ 4.97	\$ 6.52
Flooring demolition, composition, acrylic or epoxy	—	\$ 2.53

Note: costs include overhead and profit.

Carpet Tile

Costs for carpet tiles were available for a range of weights in the RS Means database, ranging from 24 oz to 42 oz. Market data on consumer preferences for carpet tile weights were not available, so a product in the middle of that range was chosen for use in this study.

Carpet tile has an estimated service life of 5 years according to Fannie Mae's Estimated Useful Life Tables, thus replacement is needed during the study period. In addition to daily cleaning, carpet tiles require periodic preventive cleaning, the cost of which is included in this study. Preventive cleaning costs were not included in the RS Means database, but a range of prices from \$0.15 to \$0.25 per square foot were found online (Shiny Carpet 2022). A cost of \$0.20 per square

foot per cleaning was assumed for this study, and a frequency of 6 times per year was used.

Table. Carpet tile costs per square foot (Source: RS Means database)

RS Means database descriptor	Materials	Labor
First costs		
Carpet tile, tufted nylon, 35 oz., 18" x 18" or 24" x 24"	\$ 4.44	\$ 0.81
Maintenance costs		
Preventative cleaning (6 times per year)	—	\$ 0.20
Replacement costs		
Carpet tile, releasable adhesive, removal	—	\$ 0.20
Carpet tile, tufted nylon, 35 oz., 18" x 18" or 24" x 24"	\$ 4.44	\$ 0.81

Note: costs include overhead and profit.

Nylon Broadloom Carpet

Sheet nylon broadloom carpet was listed under four different weights in the RS Means database, ranging from 26 oz to 40 oz. Market data on consumer preferences for nylon broadloom carpet weights were not available, so a middle weight was chosen for this category.

Broadloom carpet has an estimated service life of 5 years according to Fannie Mae’s Estimated Useful Life Tables, thus replacement is needed during the study period. In addition to daily cleaning, nylon broadloom carpet requires periodic preventative cleaning, the cost of which is included in this study. Preventative cleaning costs were not included in the RS Means database, but a range of prices from \$0.15 to \$0.25 per square foot were found online. A cost of \$0.20 per square foot per cleaning was assumed for this study (Shiny Carpet 2022), and a frequency of 4 times per year was used.

Table. Nylon broadloom carpet costs per square foot (Source: RS Means database)

RS Means database descriptor	Materials	Labor
First costs		
Carpet, commercial grades, direct cement, nylon, level loop, 32 oz., medium traffic	\$ 5.00	\$ 0.86
Maintenance costs		
Preventative cleaning (4 times per year)	—	\$ 0.20
Replacement costs		
Flooring demolition, carpet, bonded, scrim applied, includes surface scraping	—	\$ 0.34
Carpet, commercial grades, direct cement, nylon, level loop, 32 oz., medium traffic	\$ 5.00	\$ 0.86

Note: costs include overhead and profit.

Basic LCCA assumptions

This LCCA was conducted according to ASTM E917-17, *Standard Practice for Measuring Life-Cycle Costs of Buildings and Building Systems*, using the present-value calculation method. The base study period was calendar year 2020 and the designated study period was 75 years. This period was chosen because the LCCA is being performed for general information (not for a specific project, which would have more well-defined performance requirements) and it is “limited to the typical life of the type of building.” (ASTM E917).

As consumers look toward more sustainable and durable products, it is common to consider the impacts and costs over the full life cycle of a building. When evaluating the environmental impact of a material, both the *International Green Construction Code (IgCC)* and *ASHRAE 189.1, Standard for the Design of High-Performance Green Buildings*, use a 75-year period of analysis. To check the sensitivity of the analysis to this study period, additional analyses were run with a study period of 40 years and results are shown in the appendix.

A real discount rate of 3% was assumed, which is expressed in terms net of general price inflation. Thus, a general inflation rate is not considered in this study. According to ASTM E917, “The discount rate selected should reflect the investor’s time value of money. That is, the discount rate should reflect the rate of interest that makes the investor indifferent between paying or receiving a dollar now or at some future point in time. The discount rate is used to convert costs occurring at different times to equivalent costs at a common point in time.”

The 3% real discount rate was chosen based on Lavappa and Kneifel (2018), which set the real discount rate based on “long-term Treasury Bond rates averaged over 12 months and the general inflation rate.” In its Technical Note 2032 rev 2, the National Institute of Standards and Technology notes that average discount rates range from -0.5% to 7% (NIST 2021). To check the sensitivity of the analysis to this discount rate, additional analyses were run at discount rates of 0%, 5%, and 7% and results are shown in the appendix.

The operational profile of each building applies only in that some cost data in the RS Means database is broken out by square footage. Thus, when a choice was made based on assumed square footage installed, the information in the building description section was used.

A marginal income tax rate was not included because it would be the same for each individual flooring type, thus would not influence the results.

For those flooring types that did not have an estimated service life that was a multiple of the study period, a residual value was calculated at the end of the study period and subtracted from the net present value. The residual value is calculated as a percentage of the initial cost discounted back to the net present value from 75 years.

Costs related to landfill disposal or recycling fees, manufacturer take back programs, and associated transportation are not included in this analysis. Requirements vary widely by flooring type, jurisdictional requirements, and availability. In addition, technologies and strategies available 75 years in the future are speculative. Thus, omitting end-of-life disposal costs is considered a conservative assumption.

After compiling the cost data, an LCCA was performed using an excel spreadsheet. The results are shown in the following section.

A note about conservative assumptions: This study was primarily funded by the Tile Council of North America (TCNA) although with financial and technical support from several industry associations representing other flooring types. While the selection of engineering parameters was made by the author without influence from TCNA or others, as a condition of undertaking this report and to avoid any suggestion of bias favoring the source of primary financial support, in the

evaluation of any data ambiguities, any reasonable choices that could potentially favor the selection of flooring types other than ceramic, porcelain, and quarry tile were preferred. These choices are identified and referred to as conservative assumptions within this report.

Summary and Results

For this study, LCCA is used to compare 18 flooring types installed in a typical, light to medium commercial office building. For the purpose of this study, a typical office building is defined according to the commercial building characteristics included in the 2018 Commercial Building Energy Consumption Survey (CBECS) (see Key Assumptions section for more information). The LCCA was conducted according to ASTM E917-17, Standard Practice for Measuring Life-Cycle Costs of Buildings and Building Systems. Costs are summed in terms of present values over a service life of 75 years. LCCA allows the comparison of the construction and maintenance costs of alternative flooring systems that meet the same functional requirements to compare flooring alternatives for use in an office building. In this study, the functional requirements of all flooring types are that they are fit for use and provide adequate durability and cleanliness for light to medium commercial use in office space.

Results of the LCCA are shown in the following table; each flooring type incorporates a common cleaning cost of \$61.78/sq. ft. (refer to p. 16 for explanation). For a 3% discount rate and 75-year study period, quarry tile floors had the lowest net present value (i.e., lowest cost). Ceramic tile, porcelain tile, solid wood, and engineered wood flooring were the next grouping with similar net present values. Poured epoxy, VCT, and sheet vinyl flooring types had the greatest net present values. Additional analyses were run at discount rates of 0, 5%, and 7% and for a 40-year study period with results shown in the appendix.

Table. Life-cycle cost analysis results for 18 flooring types using a 3% real discount rate and 75-year study period.

Flooring Type	Estimated Service Life	Net Present Value, USD
Quarry tile	75 years	\$71.31
Ceramic tile	75 years	\$72.81
Porcelain tile	75 years	\$73.16
Solid wood	75 years	\$75.78
Engineered wood	25 years	\$78.76
Limestone	75 years	\$101.68
Travertine	75 years	\$101.68
Granite	75 years	\$102.69
Marble	75 years	\$104.03
Nylon broadloom carpet	5 years	\$125.41
LVF	15 years	\$131.66
Carpet tile	5 years	\$132.57
Rigid core	15 years	\$136.13
Epoxy terrazzo	75 years	\$137.22
Laminate	20 years	\$138.45
Poured epoxy	15 years	\$155.91
VCT	15 years	\$159.48
Sheet vinyl	15 years	\$169.46

Constraints of the study included:

- Unlimited choices for each of the flooring types when it comes to aesthetics, so typical performance and costs for each flooring type were selected.

- Certain flooring types may be designed specifically for heavy commercial (higher traffic) versus residential (lower traffic) areas, yet all flooring types were evaluated based on light to medium commercial use.
- Product maintenance and replacements due to user preferences or design trends were not included.
- Not all flooring types receive the same soil load, wear pattern, or abrasive conditions, nor are there similar expectations for their polish and appearance. While these assumptions are reasonable, they affect the maintenance cycle and expectations for each product category.
- Cost data available in the RS Means online database are only for generally succinct descriptions of product types and generic installation methods.
- Cost data that weren't available in the RS Means online database were obtained from various online sources in 2021–2023, thus cost fluctuations between years are not included.

Similar to the above table, as shown in the appendix, for all discount rates evaluated and both study periods, quarry tile had the lowest net present value. Engineered wood, solid wood, ceramic tile, and porcelain tile flooring all had similar net present values. Poured epoxy, VCT, and sheet vinyl flooring types had the greatest net present values.

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Appendix—Discount rate and study period sensitivity analyses

Results of the LCCA at three different discount rates and an additional study period are shown in the following tables. For each table, depending on the length of the study period and the discount rate, the following common cleaning costs were applied equally to the net present value of each flooring type:

- 75-year study period, 7% discount rate: \$29.53 per square foot.
- 75-year study period, 5% discount rate: \$40.53 per square foot.
- 75-year study period, 0% discount rate: \$156.00 per square foot.
- 40-year study period, 7% discount rate: \$27.73 per square foot.
- 40-year study period, 5% discount rate: \$35.69 per square foot.
- 40-year study period, 3% discount rate: \$48.08 per square foot.
- 40-year study period, 0% discount rate: \$83.20 per square foot.

7% discount rate and 75-year study period

For a 7% discount rate and 75-year study period, quarry tile had the lowest net present value. Solid wood, engineered wood, ceramic tile, and porcelain tile flooring were the next grouping with similar net present values. VCT, poured epoxy, and sheet vinyl flooring types had the greatest net present values.

Table. Life-cycle cost analysis results for 18 flooring types using a 7% real discount rate and 75-year study period.

Flooring Type	Estimated Service Life	Net Present Value, USD
Quarry tile	75 years	\$39.06
Solid wood	75 years	\$40.19
Engineered Wood	25 years	\$40.51
Ceramic tile	75 years	\$40.56
Porcelain tile	75 years	\$40.91
Limestone	75 years	\$61.24
Travertine	75 years	\$61.24
Nylon broadloom carpet	5 years	\$62.01
Granite	75 years	\$62.99
Marble	75 years	\$63.59
LVF	15 years	\$64.46
Carpet tile	5 years	\$65.23
Rigid core	15 years	\$67.26
Laminate	20 years	\$69.02
Epoxy terrazzo	75 years	\$72.72
VCT	15 years	\$77.21
Poured epoxy	15 years	\$78.38
Sheet vinyl	15 years	\$83.46

5% discount rate and 75-year study period

For a 5% discount rate and 75-year study period, quarry tile floors had the lowest net present value. Ceramic tile, porcelain tile, solid wood, and engineered wood flooring were the next grouping with similar net present values. Poured epoxy, VCT, and sheet vinyl flooring types had the greatest net present values.

Table. Life-cycle cost analysis results for 18 flooring types using a 5% real discount rate and 75-year study period.

Flooring Type	Estimated Service Life	Net Present Value, USD
Quarry tile	75 years	\$50.06
Ceramic tile	75 years	\$51.56
Porcelain tile	75 years	\$51.91
Solid wood	75 years	\$52.27
Engineered wood	25 years	\$53.54
Limestone	75 years	\$75.03
Travertine	75 years	\$75.03
Granite	75 years	\$76.53
Marble	75 years	\$77.38
Nylon broadloom carpet	5 years	\$83.68
LVF	15 years	\$87.39
Carpet tile	5 years	\$88.24
Rigid core	15 years	\$90.77
Laminate	20 years	\$92.66
Epoxy terrazzo	75 years	\$94.72
Poured epoxy	15 years	\$104.85
VCT	15 years	\$105.28
Sheet vinyl	15 years	\$112.81

0% discount rate and 75-year study period

For a 0% discount rate and 75-year study period, quarry tile floors had the lowest net present value. Ceramic tile, porcelain tile, solid wood, and engineered wood flooring were the next grouping with similar net present values. Poured epoxy, VCT, and sheet vinyl flooring types had the greatest net present values.

Table. Life-cycle cost analysis results for 18 flooring types using a 0% real discount rate and 75-year study period.

Flooring Type	Estimated Service Life	Net Present Value, USD
Quarry tile	75 years	\$165.53
Ceramic tile	75 years	\$167.03
Porcelain tile	75 years	\$167.38
Solid wood	75 years	\$181.36
Engineered wood	25 years	\$189.30
Granite	75 years	\$218.65
Limestone	75 years	\$219.90
Travertine	75 years	\$219.90
Marble	75 years	\$222.25
Nylon broadloom carpet	5 years	\$308.66
Epoxy terrazzo	75 years	\$325.66
LVF	15 years	\$326.84
Carpet tile	5 years	\$327.55
Rigid core	15 years	\$335.84
Laminate	20 years	\$341.00
Poured epoxy	15 years	\$379.57
VCT	15 years	\$398.99
Sheet vinyl	15 years	\$419.04

7% discount rate and 40-year study period

For a 7% discount rate and 40-year study period, quarry tile had the lowest net present value. Solid wood, engineered wood, ceramic tile, and porcelain tile flooring were the next grouping with similar net present values. VCT, poured epoxy, and sheet vinyl flooring types had the greatest net present values.

Table. Life-cycle cost analysis results for 18 flooring types using a 7% real discount rate and 40-year study period.

Flooring Type	Estimated Service Life	Net Present Value, USD
Quarry tile	75 years	\$36.96
Solid Wood	75 years	\$37.94
Engineered Wood	25 years	\$38.10
Ceramic Tile	75 years	\$38.42
Porcelain tile	75 years	\$38.76
Nylon Broadloom Carpet	5 years	\$58.21
Limestone	75 years	\$58.23
Travertine	75 years	\$58.23
Granite	75 years	\$59.95
Marble	75 years	\$60.51
LVF	15 years	\$60.54
Carpet tile	5 years	\$61.25
Rigid Core	15 years	\$63.18
Laminate	20 years	\$64.95
Epoxy terrazzo	75 years	\$68.69
VCT	15 years	\$72.50
Poured epoxy	15 years	\$73.62
Sheet vinyl	15 years	\$78.41

5% discount rate and 40-year study period

For a 5% discount rate and 40-year study period, quarry tile floors had the lowest net present value. Ceramic tile, solid wood, porcelain tile, and engineered wood flooring were the next grouping with similar net present values. Poured epoxy, VCT, and sheet vinyl flooring types had the greatest net present values.

Table. Life-cycle cost analysis results for 18 flooring types using a 5% real discount rate and 40-year study period.

Flooring Type	Estimated Service Life	Net Present Value, USD
Quarry tile	75 years	\$44.59
Ceramic tile	75 years	\$45.99
Solid Wood	75 years	\$46.25
Porcelain Tile	75 years	\$46.32
Engineered wood	25 years	\$47.21
Limestone	75 years	\$67.36
Travertine	75 years	\$67.36
Granite	75 years	\$68.81
Marble	75 years	\$69.56
Nylon broadloom carpet	5 years	\$73.65
LVF	15 years	\$76.95
Carpet tile	5 years	\$77.68
Rigid core	15 years	\$79.94
Laminate	20 years	\$81.60
Epoxy terrazzo	75 years	\$84.14
Poured epoxy	15 years	\$92.31
VCT	15 years	\$92.69
Sheet vinyl	15 years	\$99.37

3% discount rate and 40-year study period

For a 3% discount rate and 40-year study period, quarry tile floors had the lowest net present value. Ceramic tile, porcelain tile, solid wood, and engineered wood flooring were the next grouping with similar net present values. Poured epoxy, VCT, and sheet vinyl flooring types had the greatest net present values.

Table. Life-cycle cost analysis results for 18 flooring types using a 3% real discount rate and 40-year study period.

Flooring Type	Estimated Service Life	Net Present Value, USD
Quarry tile	75 years	\$56.25
Ceramic tile	75 years	\$57.53
Porcelain tile	75 years	\$57.83
Solid wood	75 years	\$59.08
Engineered wood	25 years	\$61.32
Limestone	75 years	\$81.04
Travertine	75 years	\$81.04
Granite	75 years	\$82.01
Marble	75 years	\$83.06
Nylon broadloom carpet	5 years	\$97.52
LVF	15 years	\$102.42
Carpet tile	5 years	\$103.12
Rigid core	15 years	\$105.94
Epoxy terrazzo	75 years	\$107.43
Laminate	20 years	\$107.86
Poured epoxy	15 years	\$121.25
VCT	15 years	\$124.06
Sheet vinyl	15 years	\$131.88

0% discount rate and 40-year study period

For a 0% discount rate and 40-year study period, quarry tile floors had the lowest net present value. Ceramic tile, porcelain tile, solid wood, and engineered wood flooring were the next grouping with similar net present values. Poured epoxy, VCT, and sheet vinyl flooring types had the greatest net present values.

Table. Life-cycle cost analysis results for 18 flooring types using a 0% real discount rate and 40-year study period.

Flooring Type	Estimated Service Life	Net Present Value, USD
Quarry tile	75 years	\$88.28
Ceramic tile	75 years	\$89.08
Porcelain tile	75 years	\$89.27
Solid wood	75 years	\$94.50
Engineered wood	25 years	\$100.64
Granite	75 years	\$116.61
Limestone	75 years	\$117.28
Travertine	75 years	\$117.28
Marble	75 years	\$118.53
Nylon broadloom carpet	5 years	\$164.46
Epoxy terrazzo	75 years	\$173.69
LVF	15 years	\$174.18
Carpet tile	5 years	\$174.60
Rigid core	15 years	\$178.98
Laminate	20 years	\$180.11
Poured epoxy	15 years	\$202.10
VCT	15 years	\$212.66
Sheet vinyl	15 years	\$223.35