FINAL EXAM ANSWER SHEET

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***** See instructions on the inside cover page to submit your exams and pay for your course.***

MASONRY CONSTRUCTION

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Wisconsin Contractors Institute

Masonry Construction

Course Number 22606 – 3 C.E. Hours

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INTRODUCTION

This course explores masonry construction; included in the course is an overview of the history of masonry, a review of masonry terms, an introduction to the types of masonry materials, their manufacturing methods, and applications in residential as well as the several types of masonry construction. The course allows contractors to explore the most widely used masonry materials in today's residential construction, and it includes the methods of installation of those materials.

THE HISTORY OF MASONRY

What is Masonry?

This section starts with a brief overview of masonry history, starting with some of the earliest uses of masonry throughout the years. Then offers some of the earliest examples of masonry construction and gradually moves through the development of masonry materials, concluding with a look at how masonry materials are used in the modern world.

Masonry is the art and craft of building or fabricating with stone, clay, brick, or concrete block, is one of the oldest of the skilled trades. It dates back to the use of sunbaked clay brick more than 6,000 years ago. Masonry construction helped build some of the world's most notable structures, including the Egyptian Pyramids, the Roman Colosseum, the Taj Mahal, and the Great Wall of China.

Located just east of the Roman Forum, the massive stone amphitheater known as the Colosseum was commissioned around A.D. 70-72. The Coliseum was officially opened in 80 A.D. The Coliseum, which is an amphitheater, had proximally 100 days of games in the opening year, including gladiatorial combat and wild animal fights after four centuries of active use the arena felon to neglect and up until the 18th century when it fell into neglect up until the 18th century it was used as a source of building materials, and approximately two-thirds of the original Coliseum had been destroyed over time. Today the amphitheater remains a popular tourist destination as well as an iconic symbol of Rome and its long, tumultuous history. The Coliseum, which measures some 620 x 513', was the largest amphitheater in the Roman world. The Coliseum was a freestanding structure that was built of travertine limestone, volcanic rock, and brick-faced concrete. The exterior had three stories of arched entrances and a total of around 80 supported or semicircular columns.

The Great Wall of China is another example of early masonry construction. The Great Wall is a series of fortifications that were built across the historical northern borders of the ancient Chinese states and Imperial China as protection against various nomadic groups. Several walls were built from as early as the seventh century B.C., with other stretches being constructed as late as the Ming Dynasty, which ran between 1366 and 1644. Not only was the Great Wall built for the defense against nomadic troops, but it also provided border control which allowed for the imposition of duties on goods arriving at the area. The Great Wall was one of the first efforts to regulate trade and to control immigration and emigration. Before the use of bricks, the Great Wall was mainly built from rammed earth stones; however, during the Ming Dynasty, bricks were used as well as earth and stone. While portions of the wall toward the north of Beijing and near tourist centers have been preserved and extensively renovated, many other areas of the wall are in disrepair. The wall sometimes provided a source of stones to build houses and roads. Some sections of the wall were prone to graffiti and vandalism, and a number of the brick were pilfered and sold on the open market.

The Taj Mahal represents the finest and most sophisticated example of Indo Islamic architecture. The Taj Mahal was built as a memorial to one of the deceased wives of an Emperor. Today the Taj Mahal is one of the most famous and recognizable buildings in the world, and its domed marble mausoleum is the most familiar part of the Taj Mahal. The Taj Ma included tombs, a waterworks infrastructure and encompasses the small town of Taj Ganji to the south and a moonlight garden to the north. Construction of the Taj Mahal began in 1632 A. D. The building is constructed with walls of brick and rubble on the inner core and faced with either marble or sandstone locked together with iron dowels and clamps. Over 1000 elephants were used to transport the building materials during construction. The bricks were fired locally, and the sandstone was quarried 28 miles away. The white

marble was brought 250 miles from quarries in the region. There were also a number of minerals used in the construction, including turquoise, Jasper, and Sapphire. In all, 28 types of precious and semi-precious stones were inlaid into the white marble. It is reported that the scaffolding and the centering for the arches were constructed entirely of brick. Legend says that the emperor offered the scaffolding brick to anyone who would remove them, and at the end of construction, they were all removed within a week. Wikipedia reports that many scholars dispute this last fact and consider that a great deal of the scaffold was constructed using bamboo and timber ramps. The construction project employed some 20,000 artisans.

The Egyptian Pyramids are thought to have been constructed in approximately 400 B.C. The Pyramid of Khufu is the largest Egyptian pyramid. It is the only one of the Seven Wonders of the World still in existence. The Colossus of Rhodes, the Lighthouse of Alexandria, the Mausoleum at Halicarnassus, the Temple of Artemis, and the Statue of Zeus were all destroyed. The location and ultimate fate of the Hanging Gardens are unknown, and there is speculation that they may not have existed at all. The limestone was likely transported on canal boats on the Nile River and then transferred to sleds that were dragged across the sand, which was moistened in order to help reduce friction as the sleds were being moved.

The Early Days of Masonry Construction

Through civilization, architects and builders have chosen masonry for its beauty, versatility, and durability. Masonry is resistant to fire, earthquakes, and sound. Masonry is artistic and durable, and masonry structures can withstand the normal wear and tear of centuries.

The level of complexity involved in masonry work varies from laying a simple masonry wall to installing an ornate exterior or high-rise building. Whether contractors are working with brick, block, tile, terra-cotta, or stone, and regardless of the level of craftsmanship involved, the skill and precision of the mason can never be replaced by machines. This concept will be discussed later in the course.

The art of masonry began spontaneously in the creation of walls from stone or pieces of caked mud. The first mortar was just mud smeared in between pieces of stone to add stability. Over time, brick and later limestone were introduced in masonry construction.

The most frequently used products are clay brick and concrete blocks by masons. Brick is man's oldest manufactured product. Sun-baked clay bricks were used in the construction of buildings more than 6,000 years ago. In order to prevent distortion and cracking of the clay shapes, chopped straw and grass were added to the clay mixture. The next big step in enhancing brick production occurred about 4,000 B.C. At that time, manufacturers began producing brick in uniform shapes. Along with the shaping of brick, the move from sunbaking to firing was another important change. This improved the durability of the brick.

Through the centuries, the methods for producing brick have continued to evolve. Today, the United States standard brick size is 2½ x 3¾ x 8 inches. Brick is composed of shale and clay and is fired in kilns of approximately 2,000 degrees Fahrenheit. The firing process causes the clay particles to bond chemically.

As brick construction became more elaborate, the use of brick became more sophisticated. The evolution of brick construction design led, in part, to the development of the concrete block.

The first hollow concrete block was designed in 1890 by Harmon S. Palmer in the United States. After ten years of experimenting, Palmer patented the design in 1900. Palmer's blocks were 8 in (20.3 cm) by 10 in (25.4 cm) by 30 in (76.2 cm), and they were so heavy they had to be lifted into place with a small crane. By 1905, an estimated 1,500 companies were manufacturing concrete blocks in the United States.

These early blocks were usually cast by hand, and the average output was about ten blocks per person per hour. Today, concrete block manufacturing is a highly automated process that can produce up to 2,000 blocks per hour.

The manufacturing and uses of concrete block evolved over a long period of time. This evolution was prompted by the development of cavity walls. When originally developed, cavity walls consisted of two separate brick or stone walls with about a 2-inch air space between them.

Cavity walls were developed to reduce the problems associated with water penetration. Water that would seep inside the outer wall would then run down that wall, while the inside wall would remain dry. Cavity walls soon became recognized as the best way to build, not only because they helped reduce problems with water penetration but because they could support a heavy load such as a roof or floor. In 1850 a special block with air cells was developed. Over the years, modifications to this product were introduced until the industry arrived at the standardized product that is used today.

Below is an approximate timeline regarding the development of masonry materials and techniques.

10,000 – 6,000 BC	The first sun-dried clay bricks were made.
3500 BC	The first kiln fired clay brick units were made.
2500 BC	Masons began using mortar made with sand and gypsum.
500 BC	Some mortar was made with sand and lime.
50 A.D.	Concrete brick units were made by Romans.
1824	Portland cement is invented-used in concrete and later in mortar.
1830	Imitation stone is made using Portland cement-based materials.
1890	Harmon S. Palmer invents concrete block in the U.S.
1940	Paddlewheel type mortar mixer is invented.

After more than 6,000 years, masonry is still used today. Today when looking around at office buildings, schools, houses, patios, and fireplaces, it is possible to notice that there are many aspects of society where some form of masonry can be seen.

There has been some recent advancement with technology regarding the role of masons. In the past, there was little doubt that the role of masons would be in jeopardy. For example, there is a company called FBR (Fast Brick Robotics) from Western Australia, which has developed a machine called the Hadrian X, which is the world's first mobile robotic block laying machine and system in the world. This is touted as being able to build block structures from a 3D CAD model, which produces far less waste than traditional construction methods and dramatically improves site safety and efficiency. The manufacturer claims that their machine is capable of building the walls of the house in as little as a day. The company has also developed a machine known as the Hadrian 105, which is an automated bricklaying machine. Even with advances in technology, it is believed that the skill and precision of the mason can't be fully replaced with machines.

FINAL EXAM QUESTIONS:

1. **All of the following statements about the art of masonry are true, EXCEPT for:**
   a. Masonry is the art and craft of building or fabricating with stone, clay, brick or concrete block.
   b. Masonry has only been a craft that has been practiced since 18th century.
   c. The art of masonry is one of the oldest of the skilled trades dating back more than 6,000 years.
   d. Some of the world's most notable structures including the Roman Coliseum, Egyptian Pyramids, the Taj Mahal, and the Great Wall of China are early examples of masonry.

2. **Masonry was developed through the years because:**
   a. It is less expensive than other forms of construction.
   b. Easy to find materials.
   c. Was chosen for its beauty, versatility and durability; it is also resistant to fire earthquakes and sound.
   d. Artisans skilled in masonry work were plentiful and therefore easy to build.

3. **All of the following statements about masonry construction are true except for:**
   a. Sunbaked clay products were used in the construction of building more than 6,000 years ago.
   b. Brick is man's oldest manufactured product.
   c. The brick we use today is basically the same as the brick we used six thousand years ago.
   d. The most significant development in manufacturing brick was producing brick and uniform shapes and firing the brick in order to improve durability.

4. **The first hollow concrete block was designed in 1890 by Harmon S Palmer, the design was patented in 1900. Which of the following statement(s) about that invention are true.**
   a. The block was so heavy they had to be lifted in place by crane.
   b. The block that Harmon invented is virtually the same size and weight as the block we have today.
   c. Both a and b
   d. Neither a or b

5. **A major problem with masonry construction was:**
   a. The material eroded very easily.
   b. The walls would leak allowing water and moisture to seep into the interior of the building, thus cavity walls were developed.
   c. The material did not prove to be as fireproof as originally thought.
   d. Artisans skilled in masonry construction were plentiful and it was difficult to determine which craftsmen to use.

6. **A masonry unit is a generic default term to reference which of the following?**
   a. Brick
   b. Concrete block
   c. Stone
   d. All of the above

MASONRY TERMS AND MATERIALS

It is important for contractors to be familiar with masonry terms. This section will define key masonry terms.

One of the most important masonry terms is a **masonry unit**. A masonry unit is a generic default term to reference any individual piece of masonry, whether it be glass, brick, block, stone, or any other material used in masonry construction. Masonry units can vary in the type of material that makes up the unit, as well as the shape, size, and color of the unit.

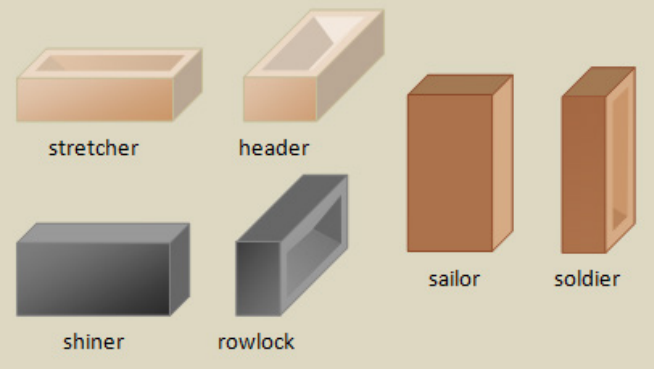
The most common types of masonry units include clay units, concrete units, and natural stone. Masonry units can be made up of both natural and manufactured materials. For example, natural stone is a masonry unit, although it is not a manufactured masonry unit.

Common Brick Terms

A brick is a cube with three dimensions. It has a length, a width, and a height. In the U.S. today, the standard brick size is 2½ x 3¾ x 8 inches. Bricks have six sides, with each side having a distinct name. The long side of the brick is called the **face**. The backside of the brick is called the **side**. The two edges are called the **cull** and the **end**. The top and bottom sides are called the **bed**.

It is often rather confusing to properly understand and to identify what brick may be called based on their orientation and installation. Below is a list of names that are often referred to in the masonry industry when referring to brick and their installation. The table contains the name and provides contractors with the exposed face of the brick, which is visible.

Brick Name	Exposed Faces of Brick
Stretcher	Length and Height
Header	Width and Height
Soldier	Height and Length
Sailor	Width and Length
Rowlock (Bull Header)	Height and Width
Rowlock Stretcher (Shiner)	Length and Width



This illustration gives some idea of how the brick is placed in reference to the preceding slide, and the terms are used. These names can often be referenced by remembering that a soldier stands at attention, a sailor more so at ease or at parade rest; a stretcher lying flat, a header and row lot showing just the end of the brick, and a row lock stretcher showing a face of the brick laid lengthwise.

The photo shows a representation of a row lock or what is sometimes called a bull header used beneath a window as an exterior windowsill. It also shows

a stretcher beneath the sill as the brick is laid in courses up the wall.

This photo shows a number of orientations of brick as they have been used in residential construction. At the sides of the windows and in the architectural detail at the second-floor level, the photo shows that headers have been used. Above the windows, the photo has a rowlock has been used as the brick have been installed in an arch above the fixed sash portion of the windows. In the architectural detail between floor levels, the photo shows brick standing on their ends with the vertical face exposed. This is a soldier. The courses of brick that make up the remainder of the wall are stretchers because the brick is laid lengthwise with one face visible.

Some additional brick terms to be familiar with include course, wythe, as well as terms that describe dimensions. A **course** of brick is a continuous horizontal bond. Courses are measured or counted vertically. **Wythe** is a term given to one thickness of masonry in a wall. A **specific dimension** is the anticipated dimension of the unit after manufacture. The **actual dimension** is the precise measurement after manufacture. The **nominal dimension** is the sum of the specified dimension plus the anticipated width of the mortar joint (usually 3/8"). In most instances, three courses of brick plus the mortar joints equals 8."

Here are some additional interesting facts about brick. The size of bricks has not changed significantly through the years. Brick is designed to fit comfortably in the hand of a mason and be laid in mortar. Brick has a dimensional relationship between length width and height for instance:

- Two brick plus one mortar joint equals one brick length.
- Three brick heights plus two mortar joints equal to brick length.
- The height of three courses of brick equals the height of one concrete block.

Another term important term to become familiar with is **concrete masonry unit** or what is often referred to as CMU's. A concrete masonry unit is any masonry unit that is made of concrete, that could be a standard concrete block, a split face concrete block, or cultured stone, which is also manufactured using concrete. Concrete masonry units will be covered in more detail later on in the course.

FINAL EXAM QUESTIONS:

7. A brick is a masonry unit which is composed of six sides; each side having a unique name depending on the face of the brick that is exposed. All of the following are common brick names with the exception of:

a. Sailor
b. Soldier
c. Trooper
d. Rowlock

8. When considering common brick terms, the word "course" means:

a. A continuous horizontal bond which is measured or counted vertically
b. The texture of the brick on the exposed face.
c. The size of the brick prior to firing.
d. The thickness of a masonry wall.

9. The specified dimension of a brick is:

a. The precise measurement after manufacture.

b. The sum of the specified dimension plus the anticipated width of the mortar joint which is usually three eights of an inch.

c. Not a significant number because all brick varies in size.

d. The anticipated dimension of the unit after manufacture.

10. The following statements about brick are all true except:

a. The height of three courses of brick equals the height of six one concrete block.

b. There is no relationship between the height of a concrete block and the number of courses of brick because all brick are different sizes.

c. Two brick plus one mortar joint equals one brick length.

d. Three brick Heights plus two mortar joints equals one brick length.

MANUFACTURING METHODS AND APPLICATIONS

This section dives a little deeper and discusses the manufacturing method for brick and other products as well as their application in the construction industry. The section also discusses the two most common brick products that are encountered as well as many others.

Clay Brick – Manufacturing and Applications

The fundamentals of brick manufacturing have not changed over time. However, technological advancements have made contemporary brick plants substantially more efficient and have improved the overall quality of the products. Complete knowledge of raw materials and their properties, better control of firing, improved kiln designs, and more advanced mechanization have all contributed to advancing the brick industry.

The most significant part of brick is the raw material that being clay. Clay is one of the most abundant materials on earth; however, Fort to be usable, it must possess plasticity strength both wet and dry in order to maintain its shape, and it must be able to fuse together when it is subject to the appropriate firing temperature. Clay can be found in nearly every state in the United States. For your interest, below is a list of the top 10 brick producers in the country. This list includes the name of the company, its location, the number of employees, and its gross revenues.

COMPANY	LOCATION	NUMBER OF EMPLOYEES	REVENUE
Acme Brick	Fort Worth, TX	2633	$750.8 M
General Shale, Inc.	Johnson City, TN	1500	$300 M
Brampton Brick, Inc.	Farmersburg, IN	319	$124.5 M
Glen-Gery Corp.	Wyomissing, PA	900	$124.3 M
Carolina Ceramics Brick Company	Columbia, SC	569	$113.8 M
Hebron Brick Supply Company	Fargo, ND	514	$102.8 M
Endicott Clay Products Co.	Fairbury, NE	447	$89.4 M
Triangle Brick Company	Durham, NC	388	$57.5 M

Morin Brick Company	Auburn, ME	300	$40 M
Palmetto Brick Co.	Wallace, SC	200	$33.2 M

Although the fact that the raw material used in manufacturing brick is clay, and it appears that there would not be multiple types of clay, there are, in fact, some different types that are used in manufacturing various types of brick. In manufacturing, common brick frequently surfaces clay and shale are used. Clay consists of upthrusts of older or recent sedimentary formations found near the surface of the earth. Shales are deeper and are clays that have been subject to extremely high pressure and have nearly hardened into slate. Fire clays our mind at the deepest levels, and they have refractory characteristics, which makes them very suitable for our typical firebrick that is used inside of masonry fireplaces.

There are several phases required in the process of manufacturing brick. They are listed below.

The phases of manufacturing brick include:

- Mining and storage of raw materials
- Preparing the raw materials
- Forming the brick
- Drying and hacking
- Firing and cooling
- De-hacking and storage

Mining and Storage

Surface clays, shales, and some fire clays are mined in open pits with power equipment. Then the clay or shale mixtures are transported to plant storage areas. Continuous brick production regardless of weather conditions is ensured by storing enough raw materials required for many days of plant operation. Normally, several storage areas (one for each source) are used to facilitate the blending of the clays. Blending produces more uniform raw materials, helps control color, and allows raw material control for manufacturing a certain brick.

Preparation

The first step in preparation is to break up clay lumps and stones. To do this, the materials are processed through size-reduction machines before mixing the raw material. Usually, the materials are processed through inclined vibrating screens to control particle size. During the process of preparing the raw materials often sand is added as well as additional water if it is needed to assist with the bonding of the clay particles.

Forming the Brick

Tempering, the first step in the forming process, produces a homogeneous, plastic clay mass. Usually, this is achieved by adding water to the clay in a pug mill, a mixing chamber with one or more revolving shafts with blade extensions. After pugging, the plastic clay mass is ready to form. There are three principal processes for forming brick: stiff-mud, soft-mud, and dry-press.

Stiff-Mud Process – In the stiff-mud or extrusion process, water in the range of 10 to 15 percent is mixed into the clay to produce plasticity. After pugging, the tempered clay goes through a deairing chamber that maintains a vacuum of 15 to 29 in. (375 to 725 mm) of mercury. De-airing removes air holes and bubbles, giving the clay increased workability and plasticity, resulting in greater strength. Next, the clay is extruded through a die to produce a column of clay. As the clay column leaves the die, textures or surface coatings may be applied (Textures, Coatings, and Glazes). An automatic cutter then slices through the clay column to create the individual brick. Cutter spacings and die sizes must be calculated to compensate for normal shrinkage that occurs during drying and firing. About 90 percent of bricks in the United States are produced by the extrusion process.

Soft-Mud Process – The soft-mud or molded process is particularly suitable for clays containing too much water to be extruded by the stiff-mud process. Clays are mixed to contain 20 to 30 percent water and then formed into a brick in molds. To prevent the clay from sticking, the molds are lubricated with either sand or water to produce "sand-struck" or "water-struck" brick. Brick may be produced in this manner by machine or by hand.

Dry-Press Process – This process is particularly

suited to clays of very low plasticity. Clay is mixed with a minimal amount of water (up to 10 percent), then pressed into steel molds under pressures from 500 to 1500 psi by hydraulic or compressed air rams.

Drying and Hacking

Wet brick from molding or cutting machines contains 7 to 30 percent moisture, depending upon the forming method. Before the firing process begins, most of this water is evaporated in dryer chambers at temperatures ranging from about 100 ºF to 400 ºF (38 ºC to 204 ºC). The extent of drying time, which varies with different clays, usually is between 24 to 48 hours. Although heat may be generated specifically for dryer chambers, it usually is supplied from the exhaust heat of kilns to maximize thermal efficiency. In all cases, heat and humidity must be carefully regulated to avoid cracking in the brick.

Hacking is the process of loading a kiln car or kiln with brick. The number of the brick on the kiln car is determined by kiln size. The bricks are typically placed by robots or mechanical means. The setting pattern has some influence on appearance. Bricks placed face-to-face will have a more uniform color than the brick that is cross-set or placed face-to-back.

Firing and Cooling

Bricks are fired between 10 and 40 hours, depending upon kiln type and other variables. There are several types of kilns used by manufacturers. The most common type is a tunnel kiln, followed by periodic kilns. Fuel may be natural gas, coal, sawdust, methane gas from landfills, or a combination of these fuels. In a tunnel kiln, bricks are loaded onto kiln cars, which pass through various temperature zones as they travel through the tunnel. The heat conditions in each zone are carefully controlled, and the kiln is continuously operated. A periodic kiln is one that is loaded, fired, allowed to cool, and unloaded, after which the same steps are repeated. Dried brick are set in periodic kilns according to a prescribed pattern that permits the circulation of hot kiln gases.

Firing may be divided into five general stages:

1. final drying (evaporating free water);
2. dehydration;
3. oxidation;
4. vitrification; and
5. flashing or reduction firing.

All except flashing are associated with rising temperatures in the kiln. Although the actual temperatures will differ with clay or shale, final drying takes place at temperatures up to about 400 ºF (204 ºC), dehydration from about 300 ºF to 1800 ºF (149 ºC to 982 ºC), oxidation from 1000 ºF to 1800 ºF (538 ºC to 982 ºC) and vitrification from 1600 ºF to 2400 ºF (871 ºC to 1316 ºC). Clay, unlike metal, softens slowly and melts or vitrifies gradually when subjected to rising temperatures. Vitrification allows the clay to become a hard, solid mass with relatively low absorption.

Melting takes place in three stages:

1. incipient fusion, when the clay particles become sufficiently soft to stick together in a mass when cooled;
2. vitrification, when extensive fluxing occurs and the mass becomes tight, solid, and nonabsorbent; and
3. viscous fusion, when the clay mass breaks down and becomes molten, leading to a deformed shape.

The key to the firing process is to control the temperature in the kiln so that incipient fusion and partial vitrification occur, but viscous fusion is avoided. The rate of temperature change must be carefully controlled and is dependent on the raw materials, as well as the size and coring of the brick being produced. Kilns are normally equipped with temperature sensors to control firing temperatures in the various stages. Near the end, the brick may be "flashed" to produce color variations

Cooling

After the temperature has peaked and is maintained for a prescribed time, the cooling process begins. Cooling time rarely exceeds 10 hours for tunnel kilns and from 5 to 24 hours in periodic kilns. Cooling is an important stage in brick manufacturing because the rate of cooling has a direct effect on color.

The next and final step in the manufacturing process is referred to as de-hacking.

De-hacking and Storage

De-hacking is the process of unloading a kiln or kiln car after the brick has cooled, a job often performed by robots. Brick are sorted, graded, and packaged. Then they are placed in a storage yard or loaded onto rail cars or trucks for delivery. Most of the brick today is packaged in self-contained, strapped cubes, which can be broken down into individual strapped packages for ease of handling on the job site. The packages and cubes are configured to provide openings for handling by forklifts.

Brick Applications

In residential and commercial construction, bricks are used primarily in:

- Foundations
- Veneers
- Structural Walls
- Fireplaces
- Architectural Design Enhancements

Below are some examples showing common uses of construction bricks.

Quoin Corners

The photo below illustrates brick being used as a veneer on a frame residential home. The brick, however, is laid at the corners in a manner that makes them stand out from the veneer itself. This type of architectural detail is referred to as a quoin corner. According to one 19th century encyclopedia, these imply strength, permanence, and expense, all reinforcing the onlooker's sense of a structure's presence.

https://www.geograph.org.uk/photo/2132065 by Unknown Author is licensed under CC BY-SA

Herringbone Design

The following photo shows brick being used and laid in a herringbone design which creates additional architectural detail and variety to normal brick courses.

In some residential communities' brick veneer may only be used on the front exterior surface of the home, while other services will be covered in other less expensive materials. Contractors may also encounter homes that may be a combination of lap siding, brick veneer, and cultured stone. It is important to remember that when various materials are used on the exterior surfaces of the home, it is important to thoroughly evaluate the transition between materials because they require special attention in order to prevent water penetration which can cause damage to building components.

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FINAL EXAM QUESTIONS:

11. Clay which is the main ingredient in brick manufacturing is:

a. Difficult to find in the United States

b. A minor ingredient in the manufacturing of brick.

c. Is one of the most abundant minerals on earth.

d. Must not fuse together when exposed to appropriate temperatures.

12. Which of the following is NOT a phase or step in brick manufacturing?

a. Mining and storage of raw materials
b. Forming the brick.
c. Firing and cooling
d. Using the clay particles without controlling particle size.

13. In the brick manufacturing process de-hacking refers to the process of:

a. Taking the brick out of the mold.
b. Removing the straps around the brick at the job site.
c. Unloading and unpacking the kiln after drying.
d. Taking the brick out of the factory and placing them on the truck for delivery.

14. In residential construction brick are:

a. Not used because they are expensive.
b. Are not used because they lack durability.
c. Are used primarily for foundations, veneers, structural walls, and fireplaces.
d. Subject to damage and deterioration.

Concrete Block – Manufacturing and Applications

Definition

Concrete masonry units are an important concept, which was introduced in the definition section. Recall that concrete masonry units or (CMU) are any masonry unit that is made of concrete, that could be a standard concrete block, a split face concrete block, or cultured stone, which is also manufactured using concrete. This section focuses specifically on the concrete block. A concrete block is primarily used as a building material in the construction of walls. It is sometimes called a concrete masonry unit. A concrete block is one of several precast concrete products used in construction. The term precast refers to the fact that the blocks are formed and hardened before they are brought to the job site. Most concrete blocks have one or more hollow cavities, and their sides may be cast smooth or with a design. In use, concrete blocks are stacked one at a time and held together with fresh concrete mortar to form the desired length and height of the wall.

How Concrete Blocks Are Made

This section highlights the process for making concrete blocks. The concrete commonly used to make concrete blocks is a mixture of powdered Portland cement, water, sand, and gravel. This produces a light gray block with a fine surface texture and a high compressive strength. A typical concrete block weighs 38-43 lb. In general, the concrete mixture used for blocks has a higher percentage of sand and a lower percentage of gravel and water than the concrete mixtures used for general construction purposes. This produces a very dry, stiff mixture that holds its shape when it is removed from the block mold.

The production of concrete blocks consists of four basic processes: mixing, molding, curing and cubing. Some manufacturing plants produce only concrete blocks, while others may produce a wide variety of precast concrete products, including blocks, flat paver stones, and decorative landscaping pieces such as lawn edging. Some plants are capable of producing 2,000 or more blocks per hour.

Mixing

The sand and gravel are stored outside in piles and are transferred into storage bins in the plant by a conveyor belt as they are needed. The Portland cement is stored outside in large vertical silos to protect it from moisture. As a production run starts, the required amounts of sand, gravel, and cement are transferred by gravity or by mechanical means to a weigh batcher which measures the proper amounts of each material. The dry materials then flow into a stationary mixer, where they are blended together for several minutes.

There are two types of mixers commonly used. One type, called a planetary or pan mixer, resembles a shallow pan with a lid. Mixing blades are attached to a vertical rotating shaft inside the mixer. The

other type is called a horizontal drum mixer. After the dry materials are blended, a small amount of water is added to the mixer. If the plant is located in a climate subject to temperature extremes, the water may first pass through a heater or chiller to regulate its temperature. Admixture chemicals and coloring pigments may also be added at this time. The concrete is then mixed for six to eight minutes.

Molding

From the hopper, the concrete is conveyed to another hopper on top of the block machine at a measured flow rate. In the block machine, the concrete is forced downward into molds. The molds consist of an outer mold box containing several mold liners. The liners determine the outer shape of the block and the inner shape of the block cavities. As many as 15 blocks may be molded at one time. When the molds are full, the concrete is compacted by the weight of the upper mold head coming down on the mold cavities. This compaction may be supplemented by air or hydraulic pressure cylinders acting on the mold head. Most block machines also use a short burst of mechanical vibration to further aid compaction. The compacted blocks are pushed down and out of the molds onto a flat steel pallet. The pallet and blocks are pushed out of the machine and onto a chain conveyor. In some operations, the blocks then pass under a rotating brush which removes loose material from the top of the blocks.

Curing

The pallets of blocks are conveyed to an automated stacker or loader, which places them in a curing rack. Each rack holds several hundred blocks. When a rack is full, it is rolled onto a set of rails and moved into a curing kiln. The kiln is an enclosed room with the capacity to hold several racks of blocks at a time. There are two basic types of curing kilns. The most common type is a low-pressure steam kiln. In this type, the blocks are held in the kiln for one to three hours at room temperature to allow them to harden slightly. Steam is then gradually introduced to raise the temperature at a controlled rate of not more than 60°F per hour. Standard weight blocks are usually cured at a temperature of 150-165°F, while lightweight blocks are cured at 170-185°F. When the curing temperature has been reached, the steam is shut off, and the blocks are allowed to soak in the hot, moist air for 12-18 hours. After soaking, the blocks are dried by exhausting the moist air and further raising the temperature in the kiln. The whole curing cycle takes about 24 hours.

Another type of kiln is the high-pressure steam kiln, sometimes called an autoclave. In this type, the temperature is raised to 300-375°F, and the pressure is raised to 80-185 psi. The blocks are allowed to soak for five to 10 hours. The pressure is then rapidly vented, which causes the blocks to quickly release their trapped moisture. The autoclave curing process requires more energy and a more expensive kiln, but it can produce blocks in less time.

Cubing

The racks of cured blocks are rolled out of the kiln, and the pallets of blocks are unstacked and placed on a chain conveyor. The blocks are pushed off the steel pallets, and the empty pallets are fed back into the block machine to receive a new set of molded blocks. If the blocks are to be made into split-face blocks, they are first molded as two blocks joined together. Once these double blocks are cured, they pass through a splitter, which strikes them with a heavy blade along the section between the two halves. This causes the double block to fracture and form a rough, stone-like texture on one face of each piece. The blocks pass through a cuber which aligns each block and then stacks them into a cube three blocks across by six blocks deep by three or four blocks high. These cubes are carried outside with a forklift and placed in storage. Normally there is a 72–8” block on in a pallet or cube.

Lightweight Concrete vs. Cinder Block

Although contractors often refer to concrete block rather generically, it is important to differentiate between a standard concrete block, lightweight concrete block, and cinderblock.

Lightweight Concrete Block

Lightweight concrete blocks are made by replacing the sand and gravel with expanded clay, shale, or slate. Expanded clay, shale, and slate are produced by crushing the raw materials and heating them to about 2000°F (1093°C). At this temperature, the material bloats or puffs up because of the rapid generation of gases caused by the combustion of small quantities of organic material trapped inside. A typical lightweight block weighs 22-28 lb. and is used to build non-load-bearing walls and partitions. Expanded blast furnace slag, as well as natural

volcanic materials such as pumice and scoria, are also used to make lightweight blocks.

Cinder Block

If granulated coal or volcanic cinders are used instead of sand and gravel, the resulting block is commonly called a cinder block. This produces a dark gray block with a medium-to-coarse surface texture, good strength, good sound-deadening properties, and a higher thermal insulating value than a concrete block. A typical cinder block weighs 26-33 lb.

Applications

Some of the most common applications for the use of concrete block and the ones which contractors are most likely to encounter are where the concrete blocks are used for:

- Foundations with or without a brick
- Block Piers
- Dry stacked of modular or manufactured homes
- Load Bearing Walls
- Partition Walls
- Structural Walls reinforced with steel and concrete

When discussing concrete blocks, it is important to realize that blocks come in a number of shapes or designs, all of which have a different purpose in mind. It is important for contractors to highlight the stretcher unit, which is the common block that is used on the majority of a foundation wall; however single corner units are often used when making 90° turns so that the irregular end of the stretcher unit is not exposed. Another shape is double corner units that are often used for masonry piers. A third example of a different shape is Lintel units which are often filled with concrete and rebar, as well as bond beam units that are used when incorporating rebar into the wall, filling the voids with concrete in order to provide structural and loadbearing strength.

FINAL EXAM QUESTIONS:

15. Which statement about concrete block is most correct.

a. A concrete block is the only pre-cast product used in the construction industry.

b. The term pre-cast means that the block are always the same design and shape.

c. Concrete block is not considered a CMU.

d. The term pre-cast refers to the fact that the blocks are formed and hardened before they are brought to the job site.

16. Which of the following statements about kilns is NOT true?

a. There are two basic types of kilns

b. Kilns are used during the cubing process

c. The most common type of kiln is a low-pressure steam kiln

d. Kilns are used during the curing process

17. Concrete blocks are manufactured using what step(s)?

a. Firing in a kiln at the same temperatures as brick.

b. Mixing, molding, curing, and cubing.

c. Placing them in cubes containing exactly 100 block per cube.

d. Adding at least 50% water.

18. Which statement about concrete block is NOT true.

a. Concrete block and cinder block refer to the same product with the same ingredients.

b. Concrete block can be standard block weighing between 38-43 lbs. each, or lightweight block weighing between 22-28 lbs. each.

c. Concrete blocks are made from Portland cement, water, sand, and gravel.

d. Cinder block are made using coal or volcanic cinders instead of sand and gravel; they also have higher thermal insulating values than concrete block.

Concrete – Manufacturing and Applications

This section covers the manufacturing of concrete and the many applications that contractors will encounter in residential construction. Often times contractors will hear concrete known as ready-mix, wherein the concrete is manufactured in a batch plant and trucked to the job site for use. When ordering concrete, it is ordered in a set engineered mix design that is based on the strength of the concrete and its psi rating. Concrete is normally delivered in one of two ways it either arrives on site ready to use in a transit mixer, often referred to as a barrel truck, or in a volumetric concrete mixer. The major difference between the two is that the in-transit mixer comes stocked with a specified number of cubic yards of concrete, while the volumetric concrete mixer will mix the amount of concrete needed for the job while on site.

The major components of concrete simply put their water, sand, some sort of aggregate, and Portland cement. The exact proportion of these ingredients used will, in fact, determine the strength of the concrete mix.

This photo is of a barrel truck. With barrel trucks or in-transit mixers, there are several components involved in the successful operation and delivery of concrete on the job site. The barrel itself is driven by a hydraulic transmission system that constantly turns the barrel in order to successfully mix the concrete components while in transit and to prevent the mix from setting up in the barrel prematurely. There is a water supply located on each of the barrel trucks in order to keep the concrete moist and workable and also to clean the shoot or discharge system after the concrete is delivered. In most instances, the control of the discharge of the concrete is handled by a control system at the exterior of the truck or from inside the cab. Contractors may occasionally encounter a barrel truck where the discharge is actually located toward the front of the vehicle instead of at the rear. Functionally, however, the front and rear discharge types of in-transit mixers operate in the same fashion.

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This photo is of a volumetric concrete mixing truck. In volumetric concrete mixing trucks, there

are hoppers on the truck which hold the aggregate or rock, the sand, the cement, and water. They're also additional reservoirs for additives and bitumen emulsion. Bitumen emulsion, however, is primarily used for pavement preservation techniques. Once on-site, the ingredients are mixed in the proper proportions to provide the desired concrete strength, and they are delivered through the concrete mixing shoot and deposited where needed.

As mentioned previously, the strength of the **concrete** is inversely proportional to the water/**cement** ratio. In other words, the **more** water you use to mix the **concrete**, the weaker the **concrete** mix. The less water you use to mix the **concrete**, the **stronger** the **concrete** mix. To **make** the **concrete stronger**, **add more cement** or less sand.

Some customary concrete design requirements or required strength in psi are listed below:

- Minimum 2,500 – 3,000 psi
- Footings and Slabs 3,500 – 4,000 psi
- Suspended Slabs, Beams, and Girders 3,500 – 5,000 psi

Remember:

- Compressive strength is usually tested at 7 and 28 days.
- 28 Day psi test is the American Concrete Institute (ACI) standard.

Now to briefly address the tensile strength of concrete. It is important for contractors to realize the difference between compressive strength and tensile strength. Compressive strength is the amount of pressure per square inch which can be placed directly on the concrete without the concrete itself deteriorating. Tensile strength, however, is regarded as the ability of concrete to resist breaking or cracking under tension. Concrete has very low tensile strength. Cracks in concrete occur when the tensile force exceeds the tensile strength of the concrete. Concrete structures undergoing tensile stress must be reinforced with materials that have high tensile strength, such as steel. Concrete is often reinforced with 6-10 gauge wire mesh which comes in roles consisting of 6x6 inch squares. Often times concrete will be reinforced with rebar or reinforced steel bars which are connected together and placed in the concrete.

Later the course will discuss some of the inherent problems which can occur when steel or wire is introduced into concrete.

Applications

Some of the most common applications for the use of concrete:

- Footings
- Poured and Formed Concrete Foundations
- Slabs
- Driveways
- Walkways
- Patios
- Pools

When addressing footings and foundations, it is important to highlight how concrete is normally used in residential foundations. The most common uses today would be for a poured reinforced concrete basement foundation with a concrete basement floor, a slab on grade, or a raised foundation that simply has a home built over a crawlspace. It is important to note in all of these instances, and a poured concrete footing is normally required.

Masonry Mortar – Manufacturing and Applications

This section covers masonry mortar, how it is manufactured and how it is used in the construction industry. Mortar can be made in one of two ways.

The older method is to take Portland cement, add hydrated lime and mix with fine sand. Masonry cement is simply a material made by most cement companies where they inter-grind the Portland with lime or other ingredients designed to produce high air content in a kiln.

All traditional **mortars** are essentially a blend of sand, Portland cement, and hydrated lime. These three ingredients are mixed at different proportions depending on the intended use. The **four** main types

of mortar most commonly **used** are; Type N, M, S, and O. Now to take a look at each one of these types of mortar and what they are mainly used for.

Type N mortar is the most common type and is usually recommended on the exterior, above-grade walls. This general-purpose mortar has good bonding capabilities. And since the cement is not overburdened by Portland, it cures more slowly and allows for better workability. Type N mortar has a compressive strength of about 750 PSI, which is ideal for use with semi-soft stone or masonry applications. It is more elastic than a high-strength mortar, which helps to prevent cracking and spalling of adjacent masonry units. Although commonly used in setting bricks, Type N can also be used for repointing newer brickwork.

Type M mortar is the strongest of the four and has a compressive strength of 2500 PSI. Type M mortar should be used when the structure has to withstand high gravity and/or lateral loads. Type M mortar is also a good choice for hard stone projects where the compressive strength of the stone is greater than 2500 PSI. The characteristics of Type M mortar make it ideal for below-grade applications, such as at foundations and retaining walls.

Type S mortar is a medium-strength mortar achieving a compressive strength of approximately 1800 PSI. Type S mortar can be used on at/or below-grade exterior walls and hard coat traditional stucco systems. The strength and bonding properties of Type S mortar are greater than that of Type N, and the increased amount of lime in Type S allows the mortar to withstand excessive moisture and increases its bonding and elastic capabilities.

Type O mortar has the weakest compressive strength, approximately 350 PSI. Type O is easy to work with, and the consistency of the blend makes it a good choice for repointing performed at a structurally stable wall. Its low compressive strength makes it a good option for soft stone applications such as setting sandstone or brownstone. Type O mortar also allows for more flexing, which can help prevent cracks and spalls in masonry units.

The standard mortar mixing ratio normally includes one part mortar mix, whether it is premade or a combination of cement and lime, three to four parts sand, and water in an amount that makes the mortar workable.

It is often asked what the perfect consistency of mortar is. The answer is quite simple: "the perfect mortar is whatever the mason says it is!"

Applications

Common uses for masonry mortar include

- Brick Laying
- CMU – Block Laying
- Cultured Stone
- Real Stone
- Stucco

Cement – Manufacturing and Application

It is important to understand the difference between cement and concrete. Although the terms cement and concrete often are used interchangeably, cement is actually an ingredient of concrete. Concrete is a mixture of aggregates and paste. Cement comprises from 10 to 15 percent of the concrete mix by volume.

Cement is not stronger than concrete. On its own, in fact, cement is prone to cracking. When combined with aggregate materials and water and allowed to harden, however, cement—now concrete—is extraordinarily strong.

Cement is a product that should never be used alone. Occasionally contractors encounter it being used in an attempt to repair spalling concrete driveways are walks; however, in most cases, it quickly cracks and therefore is unacceptable as a standalone product. Concrete is, however, an important component in concrete, mortar, stucco, tile grout, and in many thin-set adhesives.

FINAL EXAM QUESTIONS:

19. Which statement about concrete is true?

a. Concrete is always delivered to the job site in the same type of truck.

b. Concrete can be delivered in an in-transit mixer (barrel truck) or in a volumetric concrete mixer.

c. Concrete is always mixed in the same way using the exact same proportion of ingredients.

d. Concrete has tremendous tensile strength.

20. The ingredients of concrete are:

a. Water, sand, aggregate, and cement.

b. Clay, sand, water, and gravel.

c. Always cement, aggregate, fiber, and acrylic additives.

d. None of the above

21. Which statement is NOT correct:

a. Concrete is measured in compressive strength based on psi.

b. Concrete achieves its full compressive strength in 28 days.

c. Concrete and cement are correctly used as interchangeable words for the same product.

d. Reinforcement is often added to concrete to compensate for its lack of tensile strength.

22. Mortar can be mixed using:

a. Portland cement, lime, sand, and water.

b. Only pre-made mortar mix.

c. Using mortar mix, sand and lime.

d. Using the mix, but omitting the sand.

Gabion – Manufacturing and Applications

https://alleideen.com/garten-und-landschaftsbau/02/diepersonalisierte- gartengestaltung-gabione.html by Unknown Author is licensed under CC BY-ND

A gabion (from Italian gabbione meaning "big cage"; from Italian gabbia and Latin cavea meaning "cage") is a cage, cylinder, or box filled with rocks, concrete, or sometimes sand and soil for use in civil engineering, road building, military applications, and landscaping. "GAY bion"

You may see gabion used for flood control, the containment of rock slides, in the building of retaining walls, and used as architectural and landscaping accents.

Granite – Manufacturing and Applications

Granite is the most widespread of igneous rocks, underlying much of the continental crust. Granite is intrusive igneous rock. Intrusive rocks form from molten material (magma) that flows and solidifies underground, where magma cools slowly. Eventually, the overlying rocks are removed, exposing the granite. Granites usually have a coarse texture (individual minerals are visible without magnification) because the magma cools slowly underground, allowing larger crystal growth.

Granites are most easily characterized as light-colored and coarse-grained as a result of cooling slowly below the surface. Color variation is a response to the percent of each mineral found in the

sample. The crystals in granite provide a variety of mixed colors — feldspar (pink or red), mica (dark brown or black), quartz (clear pink, white, or black), and amphibole (black).

Granite is high in quartz (about 25%), feldspar, and mica. It is widely used for architectural facades, construction materials, ornamental stone, and monuments. Over 40% of the dimension stone quarried is granite. Crushed granite is used as a durable construction material in asphalt and concrete used in highway and infrastructure projects.

Mount Airy granite is more widely recognized for its dimensional uses — including such high-profile projects as the World War II Memorial in Washington, D.C.; the Arlington Memorial Bridge; and, in North Carolina, the Wright Brothers Memorial — but it is also popular for curbing, especially in Northern states.

Some of the most common applications for granite in addition to buildings, bridges, paving, monuments, curbing, countertops, floors, and stair treads would include the use of crushed granite or stone used for drainage, as a substrate beneath driveways or roadways, and as the bed for laying railroad tracks. Now when considering granite in most instances, it is the aggregate that is used in most concrete mixes.

Adobe – Manufacturing and Applications

Adobe is Spanish for 'mudbrick,' but in some English-speaking regions of Spanish heritage, the term is used to refer to any kind of earthen construction. Most adobe buildings are similar in appearance to cob (made of subsoil, water, and straw), and sometimes lime) and rammed (compacts damp soil with clay, sand, and gravel) earth buildings. Adobe is among the earliest building materials and is used throughout the world. In many parts of the United States, you may be unlikely to encounter an Adobe structure unless, of course, you are in the south or southwest.

Adobe was one of the first materials ancient humans used to create buildings, dating as far back as the 8th century B.C. The word "**adobe**" is Spanish, but etymologists trace its **origins** to an old Arabic word, al-tob or al-tub, meaning "brick."

The **adobe**, or sun-dried brick, is one of the oldest and most common building **materials** known to man. Traditionally, **adobe** bricks were never kiln fired. Unbaked **adobe** bricks consisted of sand, sometimes gravel, clay, water, and often straw or grass mixed together by hand, formed in wooden molds, and dried by the sun.

Due to the fact that adobe is a product that is made from using dried mud, it makes sense that it is subject to erosion and surface deterioration because these surface coatings were almost always applied to the exterior of adobe structures.

Next, the course will take a look at some of the products that were used in order to preserve the adobe buildings.

Mud Plaster

Mud plaster has long been used as a surface coating. Like adobe, mud plaster is composed of clay, sand, water, straw, or grass and therefore exhibits sympathetic properties to those of the original adobe. The mud plaster bonds to the adobe because the two are made of the same materials. Although applying mud plaster requires little skill, it is a time-consuming and laborious process. Once in place, the mud plaster must be smoothed. This is done by hand; sometimes deerskins, sheepskins, and small, slightly rounded stones are used to smooth the plaster to create a "polished" surface. In some areas, pink or ochre pigments are mixed into the final layer and "polished."

Whitewash

Whitewash has been used on earthen buildings since before recorded history. Consisting of ground gypsum rock, water, and clay, whitewash acts as a sealer, which can be either brushed on the adobe wall or applied with large pieces of coarse fabric such as burlap.

Initially, whitewash was considered inexpensive and easy to apply. But its impermanence and the cost of annually renewing it has made it less popular as a surface coating in recent years.

Lime Plaster

Lime plaster, widely used in the 19th century as both an exterior and interior coating, is much

harder than mud plaster. It is, however, less flexible and cracks easily. It consists of lime, sand, and water and is applied in heavy coats with trowels or brushes. To make the lime plaster adhere to adobe, walls are often scored diagonally with hatchets, making grooves about 1½ inches deep. The grooves are filled with a mixture of lime mortar and small chips of stone or broken roof tiles. The wall is then covered heavily with lime plaster.

Cement Stucco

In the United States, cement stucco came into use as an adobe surface coating in the early 20th century for the revival styles of Southwest adobe architecture. Cement stucco consists of cement, sand, and water, and it is applied with a trowel in from 1 to 3 coats over a wire mesh nailed to the adobe surface. This material has been very popular because it requires little maintenance when applied over-fired or stabilized adobe brick and because it can be easily painted.

It should be noted, however, that the cement stucco does not create a bond with unfired or un-stabilized adobe; it relies on the wire mesh and nails to hold it in place. Since nails cannot bond with the adobe, a firm surface cannot be guaranteed. Even when very long nails are used, moisture within the adobe may cause the nails and the wire to rust, thus, losing contact with the adobe.

FINAL EXAM QUESTIONS:

23. All of the following are true about Gabion, EXCEPT:

a. It is a term derived from Italian meaning "big cage"

b. It is constructed by placing stone, rock, concrete etc., in a wire cage.

c. It is used primarily for erosion control, flood control, retaining walls, sea walls, or architectural and landscaping accents.

d. It is a very good and suitable product for constructing foundations.

24. Granite is:

a. Only used for countertops.

b. Never used for drainage, substrates, driveways, roadways, or railroads.

c. Is only used for carving monuments and for exterior of large office buildings.

d. Is the most widespread indigenous rock which underlies most of the continental crust in the US.

25. Adobe structures are often coated in all of the following EXCEPT:

a. Mud plaster

b. Whitewash

c. Bituminous Waterproofing

d. Stucco

Cast Stone, Natural Stone, and Cultured Stone

This section shifts to discuss stone that is used in masonry construction. In order to grasp a full understanding of this subject, it is important for contractors to delineate between the types of stone that contractors will encounter. These include natural stone, cast stone, and cultured stone.

Natural stone is millions of years old. It is quarried from the earth and has gone through many natural changes over time. Granite, marble, and limestone

Cast stone is a type of precast concrete designed to simulate diverse types of natural cut stone.

Cultured stone (faux Stone, manufactured stone) is concrete poured into a mold then colored to look like real stone.

Among the types of natural stone, contractors frequently encounter marble. Marble is simply metamorphosed limestone. It is commonly known that limestone is used for exterior veneers, fireplaces, columns, stairs, countertops, and floors.

An example of natural stone includes the statue of Abraham Lincoln at the Lincoln Memorial in Washington DC, which was carved out of Georgia white marble in 1920

There are several benefits of using natural stone; natural stone is:

- A product of the earth – the original green building material
- Stone is extremely durable and ages gracefully over time
- Offers ease of care and maintenance
- Stone is recyclable, and therefore environmentally friendly
- Quarried and manufactured sustainably-minimizing waste and conserving other resources.

Cast stone is the reconstructed stone that is made to look natural through a highly refined process. Depending on what the project is, the budget, and the design style, the cast stone may be the perfect material to use. The most significant difference between architectural precast concrete and cast stone is that cast stone isn't permitted to contain bug holes or air voids and must have a fine-grained texture. The texture is normally achieved by acid etching.

Cast Stone Pros

In terms of cast stone, there are a few positives.

- Quite often, it is considerably lighter and can be easier and quicker to manufacture and install than its natural stone counterpart. In many cases, it is less expensive than natural stone, but by no means is that always the case.

- Cast stone is often made by mixing natural elements like quartz, granite, limestone, or marble. Cast stone mix is then pushed through molds to give it a look that resembles the density and texture of natural stone. Unlike natural stone, cast stone can be manipulated to be a certain size, shape, and color, so it can be designed to have all the pieces with a similar appearance.

Cast Stone Drawbacks

There are a few drawbacks when considering cast stone.

- For example, cast stone struggles to achieve the same level of detail as carved natural stone. There is only so much one can capture with the precast molds that produce the product, whereas the possibilities are endless when you have a sculptor carving natural stone.

- The hardness and density of the natural stone and the artistic expression of the artisan doing the work add immeasurable value that simply cannot be achieved with the cast stone counterpart. It can also be quite challenging for a cast stone producer to achieve a genuine visual interpretation of veining and overall stone "movement."

Cultured stone is a product that is also referred to as adhered concrete masonry veneer and the installation guide put forth by the Masonry Veneer Manufacturer's Association refers to it as such. But the material is relatively lightweight and is primarily an architectural or design element. The material has no loadbearing capability and should not be used as such.

The product itself is made of the cast, if you will, by blending Cementous material, aggregates, iron oxide, and pigments in a manner that simulates natural stone. In some applications, it is often difficult to differentiate between the two.

Because this is a widely used product in residential construction, today, contractors will spend a significant amount of time discussing the product and the appropriate installation and applications of the product.

Cultured Stone

Another quite common material that is used today in modern construction is a product known as a cultured stone. Cultured stone requires very precise installation procedures, and these procedures are recommended by an organization known as the Masonry Veneer Manufacturer's Association. It is recommended that contractors become familiar with the recommendations that the Masonry

Veneer Manufacturer's Association puts forth when working with cultured stone.

The following terms and definitions are important when working with cultured stone.

- **Adhered Concrete Masonry Veneer (ACMV)** — a lightweight, architectural, non-load-bearing product that is manufactured by wet cast blending cementitious material, aggregate, iron oxide pigments, and admixtures to simulate the appearance of natural stone.
    - Note: The MVMA recognizes there are many names used to describe Adhered Concrete Masonry Veneer products. Manufactured Stone Veneer is used commonly throughout the industry and by some manufacturers. In the International Building Code, Adhered Concrete Masonry Veneer products are referred to as Adhered Masonry Veneer. In the ICC-ES Acceptance Criteria, AC51, the product is called Pre-cast Stone Veneer. This guide will use ACMV (Adhered Concrete Masonry Veneer) when referencing the product.
- **Concrete masonry unit Fasteners** — Corrosion resistant hardware used to secure lath and flashing material to the wall system.
- **Flashing** — Material used to restrict the seepage of moisture around any intersection or projection of materials in an assembly.
- **Lath** — Corrosion-resistant mesh building material fastened to the substrate to function as a base for adhering plaster or mortar.
- **Mortar** — A workable paste mixture of cementitious material, water, and aggregate used to bond masonry construction materials together and filled spaces between.
- **Mortar Grout** — Mortar mixture used to fill joints and cavities in masonry construction.
- **Mortar Scratch Coat** — Base coat of mortar used in the installation. Cross raked to improve the bond of subsequent mortar layers.
- **Mortar Screen** — Sheet material designed to prevent the mortar scratch coat from filling the drainage space.
- **Mortar Setting Bed** — Mortar is used to adhere the ACMV to the substrate or scratch coat.
- **Sealer** — Liquid material used over ACMV to protect against staining and moisture penetration.
- **Wall System** — The constructed exterior or interior vertical framework and substrate of the building.
- **Water Resistive Barrier** — Material used to restrict the transmission of moisture to the surface behind.

In order to properly install cultured stone, there are certain structural requirements that should be adhered to in order to ensure a proper installation of the material.

The wall system itself should consist of wood or steel studs that are placed no more than 16 inches in the center.

The sheathing should be a semi-rigid to rigid sheathing consisting of gypsum wallboard, plywood, OSB, fiberboard, or non-rigid insulation that is a minimum of 1/2 inch thick. The failure to adhere to these requirements can result in the failure of the attachment of the cultured stone.

Over the structural components, the Masonry Veneer Manufacturer's Association also recommends that a water-resistant barrier be installed over the exterior sheathing. That barrier should be composed of:

- Minimum 2 Layers of #15 Felt
- 2 Layers of Grade D Paper
  (water permeable/weather resistant paper)
- 1 Layer of House Wrap

The Masonry Veneer Manufacturer's Association also requires that a minimum of 2.5-pound corrosion-resistant metal lath be applied to the exterior wall. This 2.5-pound 18-gauge woven wire must be installed using corrosion-resistant fasteners. If an installer uses a method other than this, it can only be done so by providing documentation

and a product evaluation report from the product manufacturer.

On top of the metal lath, a mortar scratch coat must be applied. This scratch coat should be a minimum of 1/2 inch thick and be comprised of type N or type S as masonry mortar. Once the scratch coat is applied, it should be scratched using either a notched trowel or a scratch tool on the surface once the surface material is thumbprint hard. In many instances, an insufficient scratch coat is applied, and metal lath can be seen between the cultured stone.

When flashings are required at or near the cultured stone, including at rooflines or above windows and doors, all flashing must be corrosion resistant and must be installed at all through the wall penetrations.

Most manufacturers of cultured stone and most local building codes require the installation of a drainage plane behind the stone to allow for the escape of incidental water, improve the drying time of any moisture that gets behind the cultured stone. And it creates a capillary break or airspace between the cladding and the primary water-resistant barrier.

Weep screed is placed at the bottom of a frame wall at the foundation level. Weep screeds must be of corrosion-resistant material, normally plastic. And they were there required to be a specific size. Plastic weep screeds must have a vertical flange for attachment and to ensure the secure installation of the weep screed.

Often times there is a need to install cultured stone over concrete or masonry foundation or basement walls. In order for this to be successfully accomplished, the masonry or concrete wall must be free of dirt, not have any waterproofing material installed, be free of paint or oil, and have a rough texture in order to achieve an adequate bond. In some instances, the installation of a metal lath and a scratch coat may be required in order to ensure proper adhesion.

Autoclaved Aerated Concrete – Manufacturing and Applications

Another masonry product that may be relatively unfamiliar to contractors is a product known as autoclaved aerated concrete. Although the product is not a new product, its use in the United States is relatively uncommon. Some experts have referred to autoclaved aerated concrete as a near-perfect building material. The product was originally patented by a Swedish architect in 1924, and its common ingredients were Portland cement, lime, very fine nagger it is such as silica, sand, or fly ash. Often times a small amount of aluminum powder is also added. The secret ingredient, however, is the expansion agent that makes the mixture rise like bread so that the material contains 80% air. The blocks, once cured or joined together with a thin bed of mortar or thin-set in the components of autoclaved aerated concrete, can be used for walls, floors, and roofs.

The lightweight material offers excellent sound and thermal insulation, and like all cement-based materials, is strong and fire-resistant. In order to be durable, autoclaved aerated concrete requires some type of applied finish, such as a polymer-modified stucco, natural or manufactured stone, or siding.

- Autoclaved aerated concrete combines insulation and structural capability in one material for walls, floors, and roofs. It is lightweight/cellular properties make it easy to cut, shave, and shape accepts nails and screws readily and allow it to be routed to create chases for electrical conduits and smaller-diameter plumbing runs. This gives it design and construction flexibility and the ability to make easy adjustments in the field.
- Durability and dimensional stability. A cement-based material, autoclaved aerated concrete resists water, rot, mold, mildew, and insects. Units are precisely shaped and conform to tight tolerances.
- Fire resistance is excellent, with eight-inch thick autoclaved aerated concrete achieving a four-hour rating (actual performance exceeds that and meets test requirements for up to eight hours). Because it is non-combustible, it will not burn or give off toxic fumes.
- The lightweight means that *R*-values for autoclaved aerated concrete are comparable to conventional frame walls, but they have higher thermal mass, provide airtightness, and, as just noted, are not combustible. That lightweight also gives a high sound reduction

for privacy, both from outside noises and from other rooms when used as interior partition walls.

But the material does have some limitations. It is not as widely available as most concrete products, though it can be shipped anywhere. If it has to be shipped, its lightweight is advantageous. Because it is of lower strength than most concrete products or systems, in load-bearing applications, it must typically be reinforced. It also requires a protective finish since the material is porous and would deteriorate if left exposed.

Both blocks and panels are available. Blocks are stacked similarly to conventional masonry but with a thin-bed mortar, and panels are stood vertically, spanning full-story heights. For structural needs, grouted, reinforced cells and beams are placed within the wall section. (Concave depressions along vertical edges can create a cylindrical core between 2 adjacent panels.) For usual applications, a vertical cell is placed at corners, on either side of openings, and at 6- to 8-foot spacings along a wall. Autoclaved aerated concrete averages about 37 pounds per cubic foot (pcf), so blocks can be placed by hand, but panels, because of their size, usually require a small crane or other pieces of equipment.

FINAL EXAM QUESTIONS:

26. The installation of cultured stone should be performed in accordance with standards put forth by.

a. Your local masonry contractor.

b. The general contractor.

c. The Masonry Veneer Manufacturer's Association

d. The American Society of Home Inspectors.

27. When installing cultured stone, the following statements apply EXCEPT for:

a. A water-resistant barrier must be installed behind the lath and scratch coat.

b. The cultured stone can be installed in direct contact with the ground and paved surfaces.

c. Visible lath between the stones should be identified as a deficiency.

d. Caulking should be applied between the stone and dissimilar materials.

28. Select the incorrect fact about autoclaved aerated concrete:

a. It is heavier than concrete and therefore not widely used.

b. It is a lightweight product that offers excellent sound and thermal qualities.

c. It is fire resistant.

d. It is easy to work with and very contractor friendly.

Stucco – Manufacturing and Applications

Stucco is a construction material that is made of aggregates, a binder, and water. It is applied to the surface wet and hardens to a very dense solid. Stucco can be used as a decorative coating for walls and ceilings, exterior walls, and as a sculptural or artistic material. It can be applied on metal, metal lath, concrete, concrete/cinder block, or clay brick and adobe. Stucco can be used as both an interior and exterior finish.

In English, "stucco" sometimes refers to the coating on the exterior of a building, where "plaster" is used when describing the coating of the interior. These materials are often different. Other languages don't have different words. For example, in French,

stucco means plaster and is used for both internal and external descriptions.

Modern stucco is made of Portland cement, sand, and water, whereas traditional stucco is made of lime, sand, and water. Lime can be added to modern stucco to increase the permeability and workability of the stucco. Acrylics and glass fibers are additives that can be added to improve the structural properties of stucco.

There are two different processes for applying stucco, a one-coat system, and a three-coat system.

In a one-coat stucco system, the **base coat** consists of Portland cement, chopped fiberglass, acrylic additives, sand, and water. The stucco is modified like this because it is much thinner, so the fiberglass particles and acrylic additives give it a little bit of strength and make it a little bit more water-resistant. The one coat method speeds up the three-coat stucco process by combining the scratch and brown coat into a single application that is 3/8″ to 1/2″ thick.

In a traditional three-coat stucco system, the scratch coat is the first layer of the system, which is installed on top of the metal lath and the water-resistant barrier. Originally the lath material was horizontal strips of wood installed on the wall. There were spaces between the horizontal strips that would support the wet plaster until it cured. When used on exterior walls the lath is installed over a weather-resistant asphalt-impregnated felt or paper sheet that protects the framing from the moisture that can pass through the porous stucco for exterior wall applications. The scratch coat is field mixed with Portland cement, sand, lime, and water, which is applied to the wall and then has a series of horizontal or vertical lines scratched into the surface. This scratch coat provides adhesion for the next layer in the stucco system, that next layer is the brown coat.

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This photo is of a house that was initially wrapped in “Tyvek” house wrap. “Barricade” plus drainage was added over that to ensure waterproofing and positive drainage. Metal lath was secured to the structure. Areas prone to movement and cracking have control joint material added.

In this photo, this contractor is beginning to apply the brown coat. This layer is applied with a Darby or a long trowel to make sure that the cement is applied evenly. On this particular home, two brown coats were applied in an effort to help increase the strength of the wall unit and to minimize the possibility of cracking and movement.

This photo shows the final application or finish coat which is put on with a hawk and a trowl and applied either smooth or in a variety of textures. These finish coats can also come in a range of colors so that no additional painting is needed.

It is important for contractors to differentiate between a traditional stucco installation and what is referred to as EIFS or an Exterior Insulation Finishing System (EIFS). An Exterior Insulation Finishing System (EIFS), also known as EWI (Exterior Wall Insulation Systems) or External Thermal Insulation Composite Systems (ETICS), is a type of cladding system that provides exterior walls with an insulated finished surface and waterproofing in an integrated composite material system.

What are the problems with EIFS? The problems with barrier EIFS cladding all stem from water intrusion. These problems include moisture accumulation in the wall cavity, subsequent wood damage, and, in more advanced cases, mold growth and the infestation of pests such as carpenter ants or termites.

Contrary to some reports, water intrusion problems with EIFS are not unique to any part of the country. While the problems with EIFS were first discovered in Wilmington, North Carolina, this in no way means that you could not have similar moisture intrusion problems in other locations. Field investigations of barrier EIFS in other areas of the country have identified excessive moisture accumulation problems in New Jersey, New York, and Pennsylvania. Simply put, the more it rains, the greater the likelihood of water intrusion problems.

There are many sources of water intrusion in barrier EIFS, including improper joints around penetrations, improper joints where EIFS meets dissimilar materials, and lack of proper flashings. Water can also enter the system through cracks in the face of the EIFS, regardless of how small the crack is. Essentially, any joint or penetration in the EIFS material may be suspect.

TYPES OF MASONRY CONSTRUCTION

It is important for contractors to understand the difference between **solid masonry** and **brick veneer**. Solid masonry is just that a wall made up of bricks. Solid masonry walls are load bearing and are used to form the exterior of the home. With solid masonry the wall is more than one brick thick. Because the walls are made up of multiple layers of bricks, often the bricks can be seen on the interior walls as well as the exterior. Solid masonry supports building components including foundations and piers. Today most walls are now constructed as cavity walls.

A brick veneer is a single layer of full-sized bricks that are attached adjacent to the home's exterior. The structural wall is what bears the weight of the structure, not the bricks. The brick veneer is attached to the structural wall's exterior in using a variety of attachment methods. The primary purpose of brick veneer is to improve aesthetic appeal of a wall. Though veneers also provide some resistance to the elements. Because brick veneer isn't load bearing and is added to the exterior of a structural wall; brick veneer can be added to a home at any time during the home's construction as well as added on during a home improvement project. This is not the case with solid masonry.

FINAL EXAM QUESTIONS:

29. Which statement about stucco is the most accurate?

a. Stucco systems always consist of 3 coats.

b. Stucco is applied to the exterior of a home after a waterproof barrier, drainage plane and wire lathe are installed.

c. Control/expansion joints are never installed to control cracking.

d. The scratch coat is the final/finish coat on an exterior stucco finish.

30. Which of the following are true statements about solid masonry and veneer?

a. Solid masonry can be structural as can veneer.

b. Veneer masonry can be structural but solid masonry is not.

c. Solid masonry can hold up the house; but the house holds up the veneer.

d. None of the above

SUMMARY

This course discussed the history of masonry as well as some of the earliest uses of masonry throughout the years. It offered early examples of masonry construction and moved through the development of masonry tools, including how they are used in modern construction. Then detailed the manufacturing process and application of clay brick, concrete block, concrete, masonry mortar, cement, gabion, granite, adobe, cast Stone, natural stone, cultured stone, autoclaved aerated concrete, and stucco. The course concluded by differentiating solid masonry from veneer applications of brick.

Upon completion of this course, contractors should be able to summarize the history of masonry construction, be able to describe diverse types of masonry materials and the method of manufacture and recognize masonry materials and their use in residential construction.

Notes