10. Building Stone & Masonry
Introduction

- **Natural stone**: obtained from rocks that constitute the earth’s crust.

- Rock and stone are essentially the same materials, except that after the rock has been quarried, it is called **stone**.

- **Dimension stone**: stone fabricated to required dimensions, texture, surface finish, and so on, and meets the requirements for durability, strength water absorption and the like.

- The term includes stone cladding panels, veneer stone, counter- and table tops, wall copings, stair treads and rises. It specifically excludes broken or crushed stone.

- Stone is a natural material, so its characteristics (properties and appearance) are inconsistent.
Types of Natural Building Stones

Granite

- Igneous rock.
- Strongest and densest.
- Takes an extremely good polish.
- Commonly used in the exterior cladding of significant buildings.
- Contains 25% to 40% quartz and 3% to 10% mica; the remainder (50% or more) is feldspar.
- Quartz is the strongest and more durable of the three minerals. It is more difficult to process (sawing, profiling, grinding).
- A granite low in quartz is generally darker in color.
- Black granite (basalt) is commonly used as table or countertops.
- It is not used where high strength or abrasion resistance is necessary, such as floors and stair treads.
- Quartzite is a stone that is almost 100% quartz. It is commonly used as an aggregate to produce ultra-high-strength concretes.
Limestone

- a sedimentary rock,
- consisting primarily of the carbonates of calcium and magnesium, with small amounts of clay, sand, and organic material such as seashells and other fossils.
- generally nongranular, with a relatively uniform surface appearance.
- softer than both marble and granite hence easier to quarry, saw and shape.
- Color: white to gray.
- Calcium carbonate reacts with acids. Most foods contain acids therefore, limestone is not used for kitchens or tabletops.
- Several historic buildings with limestone facades have performed quite well in the absence of reactive atmosphere.
- Used commonly for concrete aggregate (like in Cyprus).
Marble

- Geologically different from limestone because it is metamorphic rock.
- Chemically similar to limestone.
- In fact marble is limestone, which under centuries of high pressure and heat in the earth’s crust changed from a sedimentary rock to metamorphic rock.
- Because of pressure and heat, marble is stronger and denser than the original limestone.
- Takes a good polish.
- Color: white to black, pink, and so on.
- Vulnerable to acid attack.
Travertine

- sedimentary rock obtained from the sediments of limestone dissolved in spring-water.
- Springwater (particularly hot springs) running over limestone deposits dissolved the limestone, which subsequently sedimented (deposited) in a nearby location.
- Is a porous stone and slabs are pitted with voids.
- They are softer.
- They do not take polish.
- Denser varieties are referred as *travertine marble*.
- used is building exteriors as masonry walls.
- When used as flooring material, surface can collect dirt which requires greater maintenance.
Sandstone

- sedimentary rock
- Formed by layers of sand (quartz) particles with oxides of calcium, silicon and iron as cementing agents.
- If cemented primarily of oxide of silicon, sandstone is light in colour and strong.
- If cemented by iron oxide sandstone is brown or red in colour and softer.
- Large amount of calcium oxide makes sandstone more vulnerable to disintegration.
Production of Finished Stone

- Produced by stone fabricators from quarries in the form of large blocks.

- Blocks are of irregular sizes (see figure 1).

- Blocks are converted into slabs and other cross-sectional profiles in stone fabrication plants.

- The conversion is done by sawing the blocks—a process similar to sawing lumber, except that water is used continuously during the sawing process to keep the saw blades cool (see Figure 2)
Figure 1  Natural building blocks of irregular sizes.
Figure 2 Sawing process of natural building blocks.
The saw uses a blade that can move in horizontal and vertical direction.

Complex ornamental work requires hand tools (see figure 3).
Figure 3 Ornamental works with natural building stones.
Finishes on Stone Slabs & Panels

- The surface of stone slabs and panels can be finished in several ways.

- This finish also effects the durability of stone.

- *The following are some of the commonly used finishes on stone slabs and panels:*
Sawn finish:
If stone is not finished after sawing, it is called sawn finish.
Saw marks are visible.

Honed finish:
When a sawn finish is ground smooth with an abrasive material, a honed finish is obtained.

It requires repeated honing (grinding) with increasingly finer abrasives.

Water is used continuously during the process to control dust (see Figure 4).
Figure 4 Polishing of surfaces.
**Polished finish:**

- Polish finish is also honed but with a matt appearance.
- It is obtained by grinding the stone surface beyond the honed finish with finer abrasives and finally buffing it with felt until the surface develops a sheen.
- It brings out the colour of stone to its fullest extend by reflecting like a mirror.

**Flame-cut finish:**

- Also known as “thermal finish”.
- It is a rough finish obtained by torching the stone surface with a natural gas or oxyacetylene torch.
- Before torching, the stone is wetted.
- The heat from the torch expands the absorbed water into stream, which breaks loose surface particles in the stone, leaving behind a rough surface.
- Ideal for floors subject to frequent wetting.
**Bush hammered finish:**
- It is also a rough finish and is obtained by hammering off the surface of stone with picks.

**Split-face (cleft) finish:**
- Stone is split through one of its faces.

**Sandblasted finish:**
- This process yields a rough surface.
Stone Selection

The selection of stone for a particular use is a function of several factors.

- Budget
- Aesthetics (color, pattern and surface appearance) are the two most important factors to be considered for stone used in building interiors.

For exterior use, the history of performance of a stone in the local environment (durability) is obviously another important factor.

Generally the following properties are important:

- Density
- Water absorption
- Compressive strength
- Flexural strength (modulus of rupture)
- Abrasion resistance
Table 1 Common applications of selected stones.

<table>
<thead>
<tr>
<th>Application</th>
<th>Commonly used stones</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exterior wall cladding</td>
<td>Granite, marble, limestone</td>
</tr>
<tr>
<td>Interior wall cladding</td>
<td>Granite, marble, limestone</td>
</tr>
<tr>
<td>Interior flooring</td>
<td>Granite, marble, slate</td>
</tr>
<tr>
<td>Stair treads and risers</td>
<td>Granite</td>
</tr>
<tr>
<td>Kitchen counter top</td>
<td>Granite</td>
</tr>
<tr>
<td>Bathroom counter top</td>
<td>Granite, marble</td>
</tr>
<tr>
<td>Wall copings and balusters</td>
<td>Granite, marble, limestone</td>
</tr>
<tr>
<td>Roofing</td>
<td>Slate</td>
</tr>
</tbody>
</table>
Bond Patterns in Stone Masonry Walls

- In contemporary buildings, natural stone is generally used as thin slabs.
- For exterior or interior wall cladding, slabs vary in thickness from 20 mm to 50 mm.
- For flooring, slab thickness can be as low as 9.5 mm.
- The thinner the stone, the smaller the size of slab in which it is available.
- Stones used in exterior-wall veneers are generally 75 mm to 100 mm thick. Those used in load bearing stone walls are thicker.
- In some cases, stones are so large and thick that they can not be laid by hand but require mechanical hoists.
- Stone veneer and load-bearing stone walls are referred to as stone masonry to distinguish them from thin stone cladding. These walls are laid with mortar, stone by stone, in the same way as bricks.
Bond Patterns in Stone Masonry Walls

- Because natural stone is not available in uniform sizes as are bricks, the bond patterns in stone masonry walls are different from those used in bricks.

Two basic patterns used in stone masonry walls are

1. **Rubble masonry**
2. **Ashlar masonry**
Rubble masonry:

Made from stones whose sides are irregular (not at right angles to each other).

Rubble masonry is further subdivided as “random rubble” and “coursed rubble”.

**Random rubble**: The mortar joints are irregular.
A random rubble wall may consist either of stones obtained from the quarries or rounded riverbed boulders.

**Coursed rubble**: The bed joints line up after every few pieces of stone (see figure 5).
Therefore, the mason has to select the stones in the field (or shape them using a pointed hammer) so that they fit in the available spaces.
Figure 5. Random rubble (irregular joints) and coursed rubble (regular joints) masonry walls.
Ashlar masonry:

- The sides of the stones are dressed square (at right angles to each other). The front and back faces of the stone may, however, be dressed or undressed.

Like rubble masonry, ashlar masonry is also divided into 2:

1. random ashlar
2. coursed ashlar (see figure 6).
Figure 6. Random ashlar and coursed ashlar masonry walls.
Glass Masonry Units (GMU)

- Used as non-load bearing walls in virtually all types of projects-commercial and residential-on the exterior as well as in the interior of buildings.

- By combining the modularity of masonry units and the transparency of glass, glass masonry units give designers a means of expression that is not available in other materials (see figure 7).
Figure 7 A typical glass masonry unit.
Glass Masonry Units (GMU)

- manufactured in several sizes (typical 190 mm x 190 mm x 80 mm).

- generally hollow with air trapped within, although solid units are also available.

- Glass blocks are generally translucent.
  - provides light similar to a frosted window glass.

- Glass block wall gives greater privacy, more security and greater sound insulation as compared with a glass window or a glass curtain wall.

- Where greater transparency is needed, transparent units are used.

- walls also have a higher fire-resistance rating than conventional glass walls.

- A 45-min rating is easily achievable, and a higher rating is available.
Construction of a glass masonry wall

• similar to other masonry walls.
• units are generally laid in stack bond with Portland cement-lime mortar.
• joints are fully mortared as with clay bricks.

• GMUs are non-structural.
• Therefore, a glass masonry wall must be treated as a non-load bearing wall.
• Should not be designed to support any gravity load except its self-load.

• However, it must resist lateral (wind and earthquake) loads and be able to transfer them to the structural frame.

• A large glass masonry panel is treated as a combination of panels held between structural steel or reinforced-concrete framing members
  ◦ (see figure 8).
Figure 8. Staircase enclosure built with glass masonry units.
Detailing of GMU walls

- **Figure 9** shows a detail commonly used for the construction of a glass masonry panel.

- Steel anchors are used at the top and the sides (jambs) to transfer the lateral load from the panel to the supporting members.

- The long leg of an anchor is embedded in the mortar joint, and the short leg is fastened to the jamb or the head of the supporting frame.

- Joint reinforcement is needed to stiffen the panel so that the panel as a whole is able to transfer the lateral load to the structure.

- Generally, the joint reinforcement is placed in the same course as the horizontal anchors.
Figure 9 A typical detail used for the construction of a glass masonry panel.
Fire Resistance of Masonry Walls

- Fired clay, concrete and stone are noncombustible and inherently fire enduring.

- Therefore, the fire-resistance ratings of masonry assemblies is generally high.

- One of the important factors that affects the fire-resistance rating of a masonry wall is the amount of solid content in them.

- The greater the solid content, the greater the fire-resistance rating of a wall.

- Therefore, a grouted wall has a higher fire-resistance rating than an ungrouted wall.
Concrete masonry units are generally hollow, the fire resistance rating of a concrete masonry units wall is given in terms of the wall’s equivalent (solid) thickness.

**Equivalent thickness** is the thickness of the wall excluding the cells (voids).

The equivalent thickness of a fully grouted wall is the thickness of the wall itself.

Another factor that influences the fire resistance rating of a concrete masonry unit wall is the type of aggregate used in the concrete masonry units.

A wall made with concrete masonry units containing lightweight aggregate gives a higher fire-resistance rating for the same equivalent thickness than a wall with concrete masonry units containing normal-weight aggregate.
Figure 10. Approximate fire-resistance ratings of selected masonry assemblies.

- **3-5/8 in.**
  - 4 in. (nominal) clay masonry wall with solid units
  - **FIRE RESISTANCE RATING = 1 HR**

- **7-5/8 in.**
  - 8 in. (nominal) clay masonry wall with solid units
  - **FIRE RESISTANCE RATING = 4 HR**

- **9-7/8 in.**
  - 4 in. (nominal) clay masonry wall with solid units, 1 in. air space, 1/2 gypsum sheathing, 2 x 4 wood (or steel) studs, 2 layers of 5/8 in. thick Type X gypsum board
  - **FIRE RESISTANCE RATING = 2 HR**

- **8-1/4 in.**
  - 8 in. (nominal) CMU wall with 60% solid units
  - **FIRE RESISTANCE RATING = 2 HR** (normal weight aggregate)
  - **FIRE RESISTANCE RATING = 3 HR** (expanded shale aggregate)

- **7-5/8 in.**
  - 4 in. (nominal) clay masonry wall with solid units, 1 in. air space (up to 4 in. of plastic foam insulation optional), 4 in. hollow CMU wall
  - **FIRE RESISTANCE RATING = 4 HR**
Travertine-Limestone

42 total
Stone Quarry
Cutting building stones

42 total
DRY STONE WALLING
The great pyramid, Egypt
Famagusta Castle & walls, Cyprus
Girne Castle, Cyprus
Bellapais Abbey, Cyprus
Salamis, theater
Famagusta-Cyprus