

## A Review Paper on Shotcrete Technology

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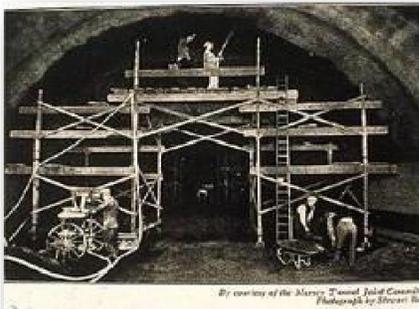
**Abstract :** Shotcrete is high performance concrete sprayed on a surface under pneumatic pressure through a hose at high velocity. It is commonly used for structural reinforcements. Time and again, Shotcrete technology has been regarded as the finest method to construct curved surfaces such as domes, tunnel linings.

**Keywords :** *Shotcrete Technology ,Structural Design*

### 1. INTRODUCTION

Shotcrete is widely accepted used way of placing material that is cementitious in nature for a vast variety of applications. Since 1900, the time it was invented by American taxidermist Carl Akeley it has seen many improvements, be it in the equipments or in the specialized techniques required application of mortar or concrete pneumatically. Today it has become a very vital material because of it being versatile in shape, high strength, endurance, good bond, and in areas of difficult access it can be easily sprayed onto a surface at high velocity making it handy for operation.

Its applications ranges from being accepted for slope and surface protection, for renovating existed structures. Shotcrete is applied to lacerated surface, usually for the reasons such as to safeguard a surface which, when left untreated, would erode or which is unstable due to fracturing and defects. Also, in the mining sector the demand for shotcrete for underground support has skyrocketed in the recent years. The simultaneous working of multiple heading, unusual filling conditions and difficulty in access are some of the problems which are distinctive to underground mining and which require new and innovative applications of Shotcrete technology.



## 2. WHY SHOTCRETE?

- Shotcrete, if properly applied is impervious and structurally sound material which displays excellent bonding characteristics to already present concrete, rock, steel, etc. It can have great strength, little absorption and decent resistance to weathering and chemical attack.
- The unparalleled bonding characteristic of shotcrete as compared to other materials is often an important design consideration. The huge force of impact of this high velocity material on the surface causes compaction of the shotcrete paste and results in good adhesion to the surface.
- Shotcrete is used in lieu of conventional concrete, in most instances, for reasons convenience. Shotcrete is advantageous in situations when framework is cost prohibitive or impractical and where forms can be reduced or eliminated, access to the work area is difficult or normal casting techniques cannot be employed.
- Also, since shotcrete requires only a small portable plant for manufacture and placement further savings are possible.

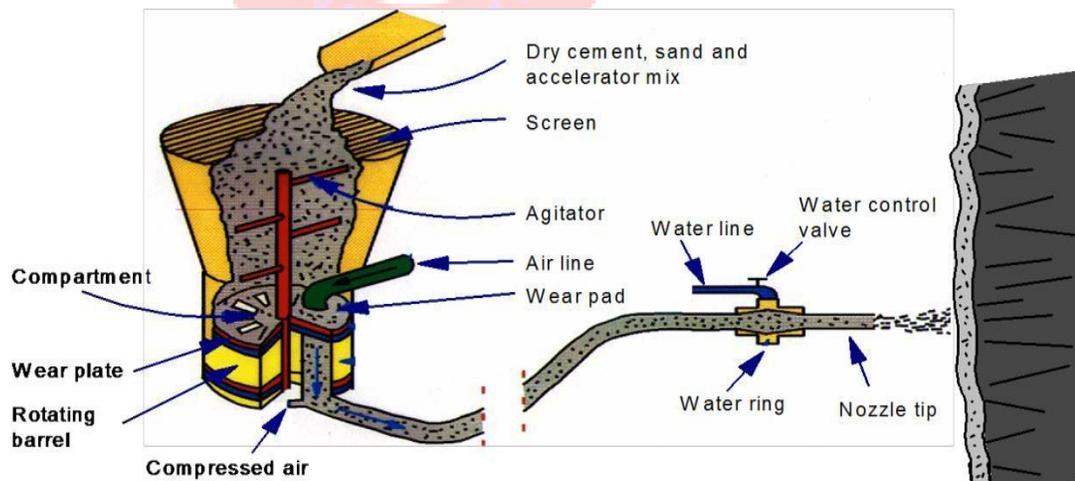
## 3. SHOTCRETE PROCESSES

Shotcrete can be applied by using two different techniques:

### 3.1 Dry-mix Shotcrete.

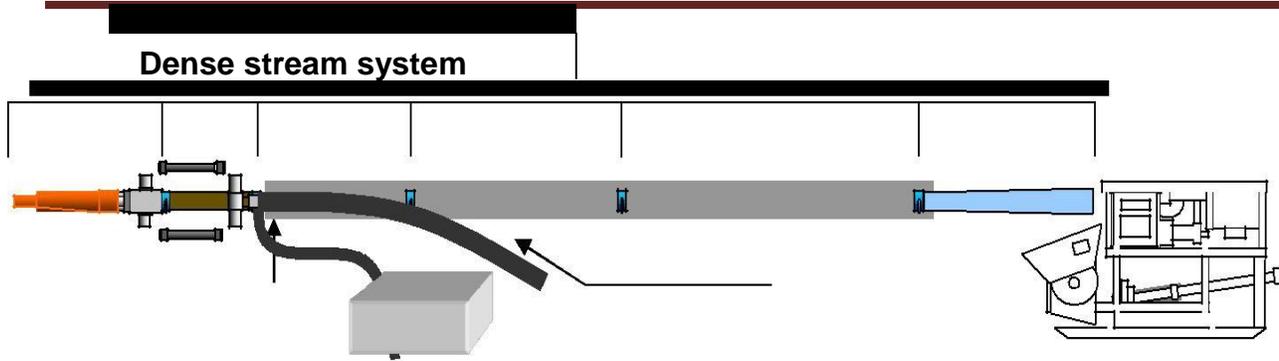
The cementitious material and aggregate are mixed properly and bagged in a dry condition and are transported right to the gun. The mixture is fed to a pneumatically operated gun which delivers a continuous flow of material through the supply hose to the nozzle. The nozzle's interior is fitted with a water ring which uniformly injects water into the mixture as it is being discharged

from the nozzle and propelled against the receiving surface.



### 3.2 Wet-mix Shotcrete.

The cementitious material, aggregate, water and admixtures are properly mixed, similar to what is done for conventional concrete. The mixture of material is supplied to the delivery equipment, like a concrete pump, which pushes the mixture through the delivery hose by positive displacement or by compressed air. Supplementary air is added at the nozzle to escalate the nozzle discharge velocity.



#### **4. DRY-MIX VS WET-MIX**

##### **4.1 Bond strength:**

Generally dry-mix shotcrete has higher bond strength as compared to wet-mix shotcrete.

##### **4.2 Rate of application:**

Wet-mix shotcrete can be applied at much faster rate than dry-mix shotcrete.

##### **4.3 Rebound:**

Wet-mix rebounds lesser as compared to dry-mix.

##### **4.4 Strength:**

Wet-mix displays lower strength quite similar to conventional concrete whereas with dry-mix exceptional strength can be attained.

##### **4.5 Maintenance costs:**

It costs much lower to maintain equipments for dry-mix shotcrete.

#### **5. SHOTCRETE MATERIALS**

Cement, Water, Sand and Aggregate are the basic materials used in Shotcrete along with various plasticizers and admixtures to enhance its functioning. High Water-Cement ratio gives slow setting and influences end quality while moisture content in sand/aggregate is also keenly measured. Optimal W/C ratio is around 0.45.

Composition of Sand/Aggregate depends upon water demand, workability, accelerators, rebound, shrinkage and durability.

### 5.1 Admixtures:

Super plasticizers for very low W/C ratios and high workability.

1. Hydration control admixtures for maintaining workability from 3 to 72 hours.
2. Alkali free accelerators for safety and durability.
3. Micro Silica and Slump retainers.
4. Addition of steel and high performance polymer fibers and micro silica slurries.

Hydration stabilizers are used for controlling the hydration of cements. The addition of Shotcrete accelerators restarts the hydration process and causes immediate setting.

## 6. SHOTCRETE APPLICATIONS

The final quality of Shotcrete mainly depends upon the application procedure used. Starting from the surface preparation, nozzling technique to the skill and training of the crew, every part of the spraying activity is crucial in determining the quality of Shotcrete ultimately.

- Surface Preparation- Dry, loose and light rock surfaces are generally washed away using a water jet to avoid any wastage of Shotcrete paste. Damp and moist rock surfaces are suitable for applying the initial layer of Shotcrete paste.
- Nozzling Technique- The equipment is always held at 90 degree angle and about 1 to 1.5 meter away from the surface. Larger distances between the surface and nozzle result in poor compaction and greater rebound. The nozzle man always starts spraying from the lower part of the surface and gradually moves upwards. The Shotcrete is sprayed in circles.  
The air supply inside the nozzle should be fast and steady enough to maintain uniform flow of Shotcrete on the surface. This technique results in better compaction and lesser rebound or over spraying.
- Skills of the Crew- Proper training and skills of the crew are essential in developing a better Shotcrete. When the place is well-lit and well ventilated, it is easier to apply Shotcrete. Crew members should be aware of all the hand signals needed inside the tunnel or the civil engineering site they are working in. Applying Shotcrete for a longer period of time is tiresome and results in fatigue especially in the case of overhead spraying. In such cases robotic machines are used for spraying.

## 7. USES

- Mining- Shotcrete has a wide range of use in underground excavations and mining. Its typical uses include sealing up of rock surfaces, channeling flow of water, installation of temporary support and permanent linings. It is also used in replacing conventional materials like laggings and steel sets and for the advancement of tunnels.
- Slope protection- Shotcrete is used in covering up of slopes either on a temporary basis or permanently by applying it on the loose and eroded part of the rock. It helps in further avoiding deterioration of rock or rock erosion. It is also beneficial in preventing surface water infiltration.
- Building new structures- Shotcrete is often used in concreting thin layers or sections.

Nowadays, it is extensively used in building swimming pools and inside linings of water tanks. Large aquariums have also been built recently using Shotcrete. Surfaces like domes at residential housing and warehousing are constructed using Shotcrete.

- Repair work- One of the most common application of Shotcrete is its use in repair work of various structures, It is used in following ways:
  1. Bridges- Repair work of bridges is generally undertaken by applying Shotcrete. It is uneconomical for full thickness repairs but is used primarily for beam repairs of variable depths, abutments, wing walls, underdecks, etc.
  2. Buildings- Shotcrete is used in repairing structures damaged by fire or earthquakes. Encasing of steel structures is often completed by shotcreting. Repair of beams, columns and bars are common using Shotcrete.
  3. Marine structures- Damage to marine structures can occur due to thawing and freezing action, erosion, corrosion, physical abrasion from waves, sand, gravel, impact loading or structural distress. Shotcrete is useful in repairing such structures and defects by applying a thin layer of concrete paste effectively.

## 8. CONCLUSION

The use of Shotcrete is perhaps the most versatile method available for construction, repair work and restoring existing structures. With further advancements in its research and development, the use of Shotcrete for concrete construction is amassing day by day. It is probably one of the most documented researches in concrete technology which needs further improvement so as to develop as a new age innovation.

## 9. ACKNOWLEDGEMENTS

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