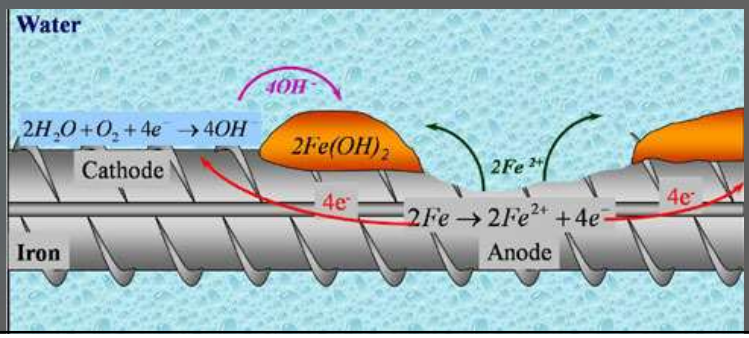
# Carbonation of Concrete

Structural Guide




# What is Carbonation of Concrete

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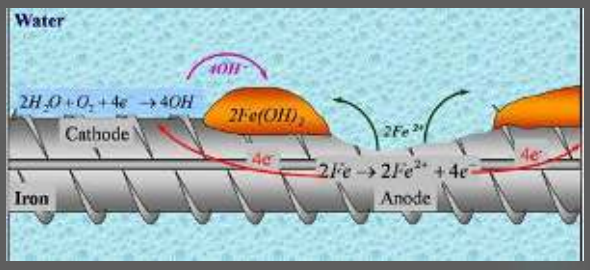
- It is a process of reacting calcium hydroxide in the concrete with carbon dioxide in the atmosphere and creating calcium carbonate and water.
- $Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$
- This process starts with the concrete surface and gradually moves towards the inner of the concrete. The carbonation of concrete is a slow and continuous process.
- When the carbonation front reaches the reinforcement, it could start the corrosion of steel.

# How does Reinforcement Corrode

- The pH value of the concrete is lowered to about 9 during the carbonation reaction.
- The protective oxide layer around the reinforcement breaks at this level enabling the occurrence of corrosion of reinforcements.
- The reinforcement is protected by the alkaline condition caused by the hydrated cement paste. This is neutralized by the carbonation allowing the corrosion in the presence of oxygen and moisture.




# Consequences of Corrosion

- Continuing this process will increase the volume around the reinforcement and then cracks will appear in the cover zone by further exposing the reinforcement to the environment.
- In addition, spalling could also occur due to this corrosion with the increase in the internal volume.
- This will affect the strength of the reinforcement leading to loss of its tensile strength.

# How to Test Carbonation

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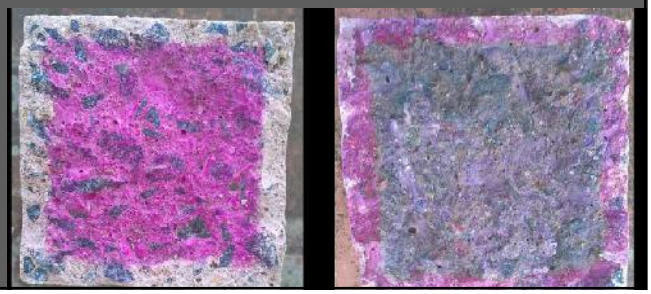
- Depth of carbonation can be found very early with a simple test.
- Phenolphthalein solution having 1% phenolphthalein is sprayed in the newly exposed concrete.
- If the colour of the concrete change to pink, that area of the concrete is not carbonated.
- The area that did not change colour with the application of phenolphthalein is carbonated.
- There are other methods such as IR spectrum analysis of carbonated concrete. The $CO_2$ absorption by the specimen is measured in the method.



# How to Calculate Carbonation Depth

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- **$t = (d/k)^2$**
- t – Time for carbonation, d – Concrete cover, k – Permeability of concrete
- Using this equation, we can find the time required to the carbonation front to reach the reinforcements.
- If we know the age of the building, we can check whether the reinforcements are affected by carbonation.

# How to Avoid Carbonation

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- Since the higher water-cement ratio contributes to the higher depth of carbonation, it could be controlled as possible.
- Adequate curing of concrete and extended curing period will help concrete to react well, and it reduces the cracking of concrete.
- Adequate curing reduces the permeability of concrete and as a result rate of carbonation will reduce.
- Use of admixtures to modify the pore structure and reduce the permeability of concrete.
- Additives like silica fume having a higher surface area could be used to reduce the porosity of concrete.
- The use of protective coatings will improve the durability of concrete and low down the carbonation process.
- It has been proven that self-compacting concrete has better performance against the carbonation of concrete.

# How to Repair the Concrete

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- Clean the affected area properly and remove all loose concrete.
- Clean the reinforcements.
- This could be done manually with a wire brush or a suitable chemical could be applied to remove the rust.
- If reinforcements are damaged in a way that they can not carry the tensile forces, reinforcements should be replaced.
- Apply anticorrosive for reinforcements.
- Apply a bonding agent to the concrete surface for better bonding.
- Apply a suitable mortar. This could be non-shrink concrete or any applicable mortar mix approved by the structural engineer.

# Thank you

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