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Notation	Full Form
CO_2	Carbon Di-oxide
CA	Coarse Aggregate
CSH	Calcium Silicate Hydrate
CH	Calcium hydroxide
FA	Fly Ash
GGBS	Ground Granulated Blast Furnace Slag
NVC	Normally-Vibrated Concrete
OPC	Ordinary Portland Cement
PC	Portland Cement
PPC	Portland Pozzolana Cement
RCC	Reinforced Cement Concrete
RH	Relative Humidity
SF	Silica Fume
W/C	Water Cement Ratio
SCM	Supplementary Cementitious Material
CSM	Condensed Silica Fume
XRDA	X-ray Diffraction Analysis
FTIR	Fourier Transformation Infra-red
SEM	Scanning Electron Microscopy
HVFA	High Volume Fly Ash
TGA	Thermal Gravimetric Analysis
PCA	Poly Carboxylic Acid

PREFACE

Concrete is the most widely used construction material across the globe. Durability of hardened concrete depends upon several factors and the same is a major concern for civil / structural engineers to ensure sustainability of structures. Detailed study of deterioration of concrete structures, its causes and remedial tools is the need of the hour. As such, no concluding remarks may be made from the studies since the results of different researchers are different. Since concrete structures are widely used and the issue of reinforcement corrosion demands serious concern, it is important to be able to determine carbonation accurately and to be able to design structures accordingly. Carbonation is one of the most important factors upon which durability greatly depends. The natural process of Carbonation of concrete structures in our surroundings is very slow. However, for the purpose of study, carbonation effect on the concrete can be accelerated which simulates the actual behavior of effect of carbonation on concrete. Further, the magnitude of carbonation in concrete can be analyzed through various procedures. It is equally important to assess accurate values of carbonation through the most effective methodology to be able to ascertain correct data for design purpose. Past experiments have also shown that the depth of carbonation is distinctly influenced by multiple factors including both mix proportion and constituents as well as external factors.

In this study, experiments have been conducted on concrete cubes by varying multiple factors such as type of cement, water/cement ratio, effect of super plasticizer, CO_2 concentration, replacement of cement and fine aggregate with fly ash, micro silica and GGBS and curing period, paint, plaster, exposure period and percentage of relative humidity (RH) in order to assess the depth of carbonation under various conditions. Carbonation effect on concrete has been simulated in controlled carbonation chamber in short duration of time. Phenolphthalein indicator method, being the most widely used and economic methodology of determination of depth of carbonation has been used for most samples to assess carbonation depth and analyze the impact of various factors on carbonation in concrete for both OPC and PPC concrete. Further, in this study, concrete samples have also been tested through advanced techniques such as XRD analysis, FTIR method and SEM. Experiments through advanced techniques have been conducted for few samples only by varying type of cement and water cement ratio (W/C), mainly to determine the magnitude of results and accuracy of data.

Experimental investigations have resulted in clear indication of the impact of various factors on the depth of carbonation. It is seen that carbonation increases with the increase of water/cement, CO_2 concentration and exposure period. Carbonation depth decreases with increasing curing period, use of super plasticizers, paint, plaster, partial replacement of cement with fly ash, micro silica and GGBS and replacement of fine aggregate with fly ash and GGBS. Further the trend of increase/decrease of carbonation on account of other factors have also been determined with the help of experimental data and have been graphically represented in this study. It is also found that the depths of carbonation in PPC concrete are higher than that in OPC concrete. Results also show that the carbonation depth values of advanced techniques are nearly double that of the conventional phenolphthalein indicator method.

The results of the experiments can be analyzed to determine the practical depths of carbonation in concrete subject to various conditions. The significance of the carbonation depths for different concrete types and exposure conditions obtained from the experiments will act as a tool to design concrete structures resistant to carbonation.