

Comparative Study of Effect of Temperature and Chloride on Silica Fume Concrete and Metakaolin Concrete

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Abstract— Many civil engineering structures are subjected to marine conditions such as dock structures, bridges and oil refinery projects, etc. So this becomes important to study the effects of salted water on the concrete and its compressive strength. Also in some accidental case concrete structures are directly getting exposed to fire, which may cause loss in strength of structural components. In this paper, we have carried out the study of the effect of temperature and chloride (NaCl) on silica fume and metakaolin concrete. For this study, we have used M₂₀ grade concrete, so as to find out effect on general category concrete as it is widely used in practice. The concrete cubes (150 mm × 150 mm × 150 mm) are cast for cement replacement by silica fume and metakaolin with 0%, 5%, 10%, 15% and 20%. The 0% specimens are considered as 'Controlled Specimen'. Then these specimens are tested after 60, 90 and 120 days for 200°C. Similarly, separate cubes are cast for same M20 mix proportion and tested after same days, respectively, as Chloride Attack Test. For this we have kept 5% NaCl consistency. The graphs are studied with respect to 'Controlled Specimen'. These show variations in compressive strength for cement replacement by silica fume, metakaolin concrete for chloride attack and temperature. For chloride attack, results show that up to 10% replacement, concrete gives better compressive strength. And then after compressive strength goes on decreasing, subsequently. Thus 10% give a desirable percentage of replacement. Similarly, compressive strength goes on increasing with age of concrete for temperature exposure.

Index Terms— Chloride Attack, Temperature Exposure, Silica Fumes, Metakaoline, Cement Replacement and Compressive Strength of Concrete.

1 INTRODUCTION

Concrete that has been in service for a fairly long time can be inspected, tested, and evaluated; and the results analyzed; and a conclusion reached that thus far, it has been "durable" or it has not been. "Durable" is not an attribute of concrete in general, or of a given class or given levels of a set of properties, but is rather a conclusion reached about a specific concrete subject to specific service environment. A concrete is "durable" if, in its environment, it has provided the desired service life, without excessive cost for maintenance and repair due to degradation or deterioration. Durability is not a property of concrete. Concrete that would be immune to the effects of freezing and thawing is of no higher "quality" than concrete that has no ability to resist freezing and thawing if it is to be used where it can never freeze in a critical water-saturated condition. Thus the problem faced by the engineer who prepares specifications for concrete for a particular work is to predict the deteriorating influences that could cause degradation of concrete in service in the environment at the project site over the intended service life of the concrete. Having done so, he must then include in the specifications for the work not only all those requirements that are generic to all concrete construction of the class required for the particular project, but also all those specific requirements needed to preclude or minimize the effects of the deteriorating influences at the site of the work whatever they are. These include: freezing and thawing, wetting and drying, heating and cooling, loading and unloading, cavitations, erosion, abrasion, acid attack, sulfate attack, other kinds of chemical attack, corrosion of steel, microbiological attack, penetra-

tion by marine borers, and others. Not only should consideration be given to these as aspects of the external environment, but also, when relevant, the internal environment of the structure. The building was periodically disinfected by steam-while the roof members were frozen, saturated with water. Climate change and global warming resulted by greenhouse gas emission have been a growing concern in recent years. The carbon dioxide, as a major environmental pollutant is a serious worldwide problem leading to the greenhouse effects. It was indicated that the largest growth in the CO₂ emissions has come from electricity generation, transport, industry and, above all, from building operations.

2. OBJECTIVES:

The objectives of this research are to study the chloride effect on silica fume and metakaoline M₂₀ grade concrete with 5% NaCl solution. Also, we are interested to study the temperature effect on silica fume and metakaoline M₂₀ grade concrete exposed up to 200°C. The percentage replacement for both silica fume and metakaoline will be carried out for various percentages as 0%, 5%, 10%, 15% and 20%. The concrete specimens are then allowed for 28 days normal curing. After that, these cubes are cure in 5% NaCl solution for different periods of time as 60, 90 and 120 days. For temperature parameter, separate concrete cubes are cast and again allowed for 28 days normal curing. Then these cubes are tested after 60, 90 and 120 days, up to 200°C temperature exposure. These chloride attack and temperature exposure tests will give us the nature the profile of compressive strength variation. And this variation can be

effectively represented by means of the graphs.

3. CHLORIDE ATTACK:

Some of the vital civil engineering projects such as bridges, docks, harbors, oil refinery projects are getting directly exposed to the marine environment. But the constructions like roads, buildings and other civil engineering structures are sometime may be exposed to marine conditions indirectly, as they are situated near to the marine environment. This may cause adverse impact on structural properties. The structural members like columns, beams, foundations, etc. are getting weakened due to concrete and steel erosion. This impact is known as 'Chloride Attack'. The intensity of the chloride attack depends on the amount of chloride and its supplementary content within that structure's environment. For this research work we have kept the maximum chloride proportion at 5%.

4. TEMPERATURE EXPOSURE:

The structure like 'Nuclear Power Plant' subjected to a high temperature up to 1000⁰C, approximately. At this very high temperature the inter molecular structure of concrete gets disturbed and result in failure of the RCC structure for what it is built. This happens when proper planning is not carried out for the handling this very high temperature. The necessary planning can be made only after the accurate analysis is carried out for the higher temperature exposure. For structure like 'Nuclear Power Plant', structural engineers always go for high grades of concrete. But considering the general conditions, engineers prefer a normal grade concrete i.e. M₂₀ grade, for residential buildings, public buildings and buildings mostly constructed in rural areas, etc. In Such cases M20 grade concrete is affordable to owner and also it easily fulfills the structural requirements. Sometimes accidentally, these structures are also exposed to high temperature. But this high temperature can't reach up to 1000⁰C, always. Now days due to fire protection facilities available, the temperature will not rise up to 1000⁰C. This may be up to 100⁰C to 150⁰C. So, for this research work we are deciding the 200⁰C temperature exposure as a parameter.

5. ADMIXTURES:

a. Silica Fumes:

Silica fume is also known as 'Micro Silica'. It is an amorphous (non-crystalline). It is an ultrafine powder collected as a by-product of the silicon and ferrosilicon alloy production and consists of spherical particles with an average particle diameter of 150 nm. The main field of application is as pozzolanic material for high performance concrete. Addition of silica fume also reduces the permeability of concrete, which protects the reinforcing steel of concrete from corrosion, especially in chloride-rich environments such as coastal regions and those of humid continental roadways, runways and saltwater bridges

b. Metakaolin:

Metakaolin is a dehydroxylated form of the clay mineral kaolinite. Rocks that are rich in kaolinite are known as 'China Clay' or 'Kaolin'. It gets traditionally used in the manufacture of porcelain. The particle size of Metakaolin is smaller than cement particles, but not as fine as silica fume. Considering the twice reactivity of most other pozzolans, metakaolin is a valua-

ble admixture for concrete/cement applications. Replacing Portland cement with 8–20% (by weight) metakaolin produces a concrete mix, which exhibits favorable engineering properties, including the filler effect, the acceleration of OPC hydration, and the pozzolanic reaction. It is mostly used for increasing resistance to chemical attack.

6. CONCRETE MIX PROPORTION:

For this paper work we have used the M₂₀ grade concrete. We have casted all concrete specimens by using OPC. Also zone II is selected for the river sand locality of IS: 383(1970). The coarse aggregate is selected which is able to passing through 20 mm and retaining on 10 mm IS sieves. As per IS: 10262:2009 we have carried out mix design procedure for M20 grade concrete. After the designing we got the final mix proportion as follows,

Cement	Fine Aggregate (Sand)	Coarse Aggregate	Water to Cement Ratio
1	1.90	3.72	0.49

7. RESULT AND DISCUSSION:

After testing the casted concrete specimens, we have arranged the testing data for getting the defined objectives. The graphical presentation of the same will explain the paper work more effectively. The tests carried out for chloride attacks shows that for the particular percentage replacement, as the age of the concrete go on increasing the corresponding compressive strength of concrete get decreasing. At 5% replacement of cement by SF and MK gives the maximum compressive strength than other percentage replacement by SF and MK. The results also show that up to 15% replacement of cement by SF and MK, we can maintain the strength of concrete greater than control mix. But as we go beyond 15 %, the compressive strength decreases below strength that of control mixes. Thus 20 % replacement proves unsuitable for achieving compressive strength equal to or greater than control mix. Similarly, test carried out for temperature exposure shows that, the age of concrete go on increasing the corresponding compressive strength of concrete get increases up to the 10% replacement of SF & MK, beyond that the compressive strength of concrete goes on decreasing. It is clearly seen that for 60 ,90 &120 days the compressive strength of concrete goes on decreasing from 15% to 20% replacement of SF & MK .The corresponding strength for that replacement is less as compared to the control mixes. So for temperature exposure, 10% replacement gives the better result for replacement of SF & MK.

(a) Test Results for Chloride Attack :-

Table No.1 Compressive Strength for Chloride Attack

Sr. No.	% Replacement of Cement by SF and MK	Average Compressive Strength (N/mm ²)		
		60 Days	90 Days	120 Days
1	0	26.23	25.35	23.84
2	5	51.11	49.70	31.30
3	10	45.10	39.38	36.77
4	15	27.11	27.76	19.42
5	20	22.51	24.85	16.78

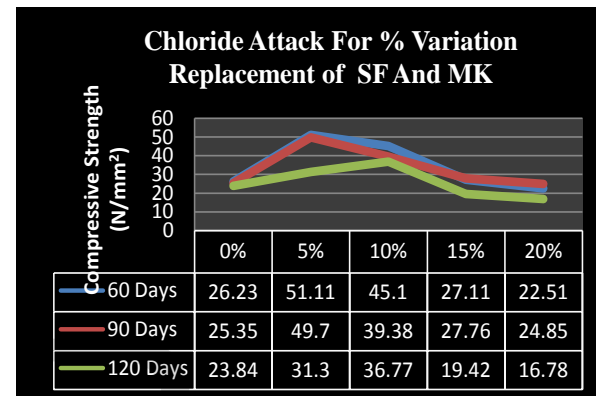
(b) Test Results for Temperature Exposure:-

Table No.2 Compressive Strength after Temperature Exposure

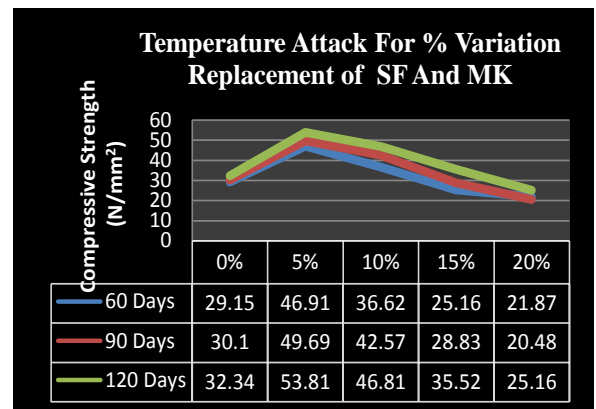
Sr. No.	% Replacement of Cement by SF and MK	Average Compressive Strength (N/mm ²)		
		60 Days	90 Days	120 Days
1	0	29.15	30.10	32.34
2	5	46.91	49.69	53.81
3	10	36.62	42.57	46.81
4	15	25.16	28.83	35.52
5	20	21.87	20.48	25.16

(c) Graphical Representation :

Graph No.1 Compressive strength of Chloride Attack



Graph No.2 Compressive strength after temperature Exposure



8. CONCLUSIONS:

In chloride attack, it is clearly seen that for the replacement of SF & MK the compressive strength of concrete goes on decreasing. But in that decrement, 5% & 10% gives the more compressive strength as compare to 15% & 20% replacement. For 5% & 10% replacement compressive strength is 50% greater than that of 15% & 20% replacement. So 5% to 10% gives beneficial replacement of SF & MK.

In temperature exposure the compressive strength goes on increasing as age of concrete increases. But for 60, 90 & 120 days test result shows that, 5% & 10% replacement of SF & MK gives more compressive strength as compare to control mix, 15% & 20% replacement. So 5% to 10% gives good replacement instead of 15% & 20% replacement.

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