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Acid and Base Attack on Concrete by Partial Replacement of Cement with GGBS, Silica Fume and Addition with Fibers

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ABSTRACT

In construction world concrete plays a vital role, around 60% of structure consists of Concrete. However, the production of Portland cement, an essential constituent of concrete, leads to the release of significant amounts of CO_2*, depletion of natural resources and environmental degradation. This paper investigates the compressive strength of concrete by replacing cement with GGBS and silica fume effect of glass fibers on performance of concrete is studied. In this present work a humble attempt had been made to evaluate and compare the compressive strengths of GGBS blended concrete cubes with controlled concrete cubes cured under ACID and BASE for 28 days. By conducting the tests on the cubes, conclusions were drawn after plotting and analyzing the results. Compressive strength test is conducted on the samples after 28 days. The optimum value is obtained at 15% replacement with GGBS and 5% with Silica fume. In this study again we trailed addition with Glass fibers with the percentage of 0.5%,1.0%,1.5%, compressive strength have been studied. Finally at 1.0% addition we get maximum strength compared to controlled mix*

KEYWORDS:- *GGBS, Glass fibers, Sea water Compressive strength.*

I. Introduction

Concrete occupies a unique position among modern construction materials. It is the only material manufactured at construction sites. It gives considerable freedom to the architect to mould the structural element to any shape or form a freedom that is not possible with other materials. Of course, concrete has limitations it cannot, on its own, flow past obstructions and into nooks and crannies. Through compaction, often using vibration is essential for achieving strength and durability of concrete. As concrete is produced and placed at construction sites, under conditions far from ideal, we do often end up with unpleasant results rocks pockets, sand streaks and a host of workmanship related problems.

The extensive use of concrete is not only in construction of residential buildings but also silos for many factories where sometimes chemicals may have to be stored and even the residential buildings are being constructed beside sea, marine structures like deck bridges etc. undergo contact with lots of salts thus care is to be taken for such constructions since durability of the structure may be affected. Thus many researches are being done for a better durable concrete feasible for use in construction of such structures. Blended concrete, which would reduce the contact area of cement with salts, would be a better solution to overcome any unwanted reactions between minerals in cement and salts in contact. GGBS and Silica fume blended concrete has evolved as an innovative technology, capable of achieving the status of being an outstanding advancement in the sphere of concrete technology. As so many construction companies are using the GGBS in their projects. The utilization of GGBS and Silica fume will reduce the dumping and as well as decrease the construction cost also.

LITERATURE REVIEW

Dina M. Sadek et.al [1] investigated about the possibility of using various types of waste powders, as mineral additives in self-compacting concrete (SCC) generated from marble and granite industry. Fresh properties with Slump flow, V-funnel, and J-ring tests are conducted in self-compacting concrete. Hardened properties with compression, splitting tensile, flexural, water absorption and sulphate attack tests are conducted on SCC. SCC incorporating mixed powder showed the superior performance followed by granite powder mixes, while marble powder has a marginal effect on the performance of hardened concrete. However, Silica fume could be used for the enhancement of marble powder performance.

SuvarnaLatha et.al [2] estimated the GGBS efficiency. The utilization of supplementary cementatious materials is well accepted because of the several improvements possible in the concrete composites, and due to the overall economy. The present paper is efforts to quantify the strength of ground granulated blast furnace slag (GGBS) and high volume fly ash (HVFA) at the various replacement levels and evaluate their efficiencies in concrete. In recent years GGBS when replaced with cement has emerged as a major alternative to conventional concrete and has rapidly drawn the concrete industry attention due to its cement savings, energy savings, and cost savings, environmental and socio-economic benefits. The present study reports the results of an experimental study, conducted to evaluate the strengths and strength efficiency factors of hardened concrete, by partially replacing the cement by various percentages of ground granulated blast furnace slag and high volume fly ash for M20, M40 and M60 grades of concrete at different ages. The overall strength efficiency was found to be a combination of general efficiency factor, depending on the age and a percentage efficiency factor, depending upon the percentage of replacement. Here an effort is made towards a specific understanding of the efficiency of GGBS and Fly ash in concrete, considering the strength to water cement ratio relations, age and percentage of replacement. The optimum GGBS and Fly ash replacement as cementitious material is characterized by high compressive strength, low heat of hydration, resistance to chemical attack, better workability, and good durability and cost-effective. From this study it can be concluded that, since the grain size of GGBS is less than ordinary Portland cement, its strength at earlyis less but continues to gain strength over a long period.

Peter et.al, [3] explained that the hydraulic potential of blastfurnace slag was first discovered in Germany in 1862. In 1865, lime-activated blastfurnace slag started to be produced commercially in Germany and in 1880 GGBS was first used in combination with Portland cement (Concrete Society, 1991). In Europe, GGBS has been used for over 100 years. In North America, the history of the use of GGBS in quality concrete dates back about 50 years (Yazdani, 2002). In Southeast Asian countries including Mainland China and Hong Kong, GGBS was used in concrete in around 1990. Between 1955 and 1995, about 1.1 billion tonnes of cement was produced in Germany, about 150 million tonnes of which consisted of blast furnace slag (Geiseler *et al*, 1995). In China, the estimated total GGBS production was about 100 million tonnes in 2007 (Chen, 2006). GGBS has been widely used as a partial replacement of Portland cement in construction projects. In Western Europe, the amount of GGBS used accounts for about 20% of the total cement consumed, whereas in the Netherlands it accounts for 60% of the total cement consumption (Tsinghua University, 2004). There are abundant examples of the use of GGBS concrete in construction projects. In New York, the concrete used in the construction of the World Trade Centre has about 40% GGBS replacement (Slag Cement Association, 2005). At the Minneapolis Airport, the airfield pavements were constructed using concrete with 35% GGBS replacement. Other projects using GGBS include the world's largest aquarium - the Atlanta's Georgia Aquarium which used 20% to 70% GGBS replacement. The Detroit Metro Airport Terminal

Expansion used concrete with 30% GGBS replacement. The Air Train linking New York's John F. Kennedy International Airport with Long Island Rail Road trains used concrete with 20% to 30% GGBS replacement. In China, GGBS has been widely used in major construction projects such as the Three Gorges Dam, Beijing-Shanghai Express Rail, and Cross-bay Bridge of Hangzhou Bay. The GGBS replacement level is generally around 40% (China Cements, 2009; China Biz, 2009).

Preeti et.al, [4] stated that the effect of salt water on the compressive strength of concrete was investigated. This paper therefore presents the result and findings of an experimental research on the effect of salt water on compressive strength of concrete. For this concrete cubes were cast using fresh wi and salt water for a design mix of M- 30 1:1.8:3.31 by weight of concrete, and 0.45 water-cement ratio. Half of concrete cubes were cast and cured with fresh water and remaining half cubes were cast and cured with salt water. The concrete cubes were cured for 7,14 and 28 days respectively. The result of the average compressive strength of concrete obtained using fresh water ranges from 27.12 - 39.12N/mm2 and using salt water ranges from 28.45 – 41.34N/mm^2.

Abalaka et.al, [5] concluded that the study investigated the effects of sodium chloride (NaCl) solutions as curing medium at concentrations of 5% and 10% on compressive strength of concrete cubes containing 5% rice husk ash (RHA). Concrete cubes containing 5% RHA in NaCl solutions show early compressive strength increase at 3 and 7 days over control cubes; at 28 days concrete cubes containing 5% RHA cured in NaCl solutions recorded higher strength loss compared to control cubes.

Oultoge et.al, [6] 2014 presents the experimental investigations on the effect of sea water on the compressive strength of concrete. Cement concrete cubes of 150mm x 150mm x 150mm were cast using fresh water and sea water with mix ratio 1:2:4. All the mixes were prepared using constant water cement ratio (w/c) of 0.6 by weight. A total of 140 concrete cubes were made in two batches; half of the cubes were made using fresh water and the other half using sea water. They were cured in fresh and sea water respectively. The curing was done for 7, 14, 21, 28 and 90days, then crushed using the Compressive Strength Test Apparatus at prescribed ages. The study shows an increase in the compressive strength of concrete for concrete specimens mixed and cured with sea water. Compressive strength of the concrete were also affected when the concrete was cast with fresh water and cured with salt water and vice-versa.

EXPERIMENTAL WORK

CEMENT:-

Cement is a fine, grey powder. It is mixed with water and materials such as sand, gravel crushed stone to make a concrete. The ordinary cement contains two basic ingredients namely argillaceous and calcareous. In argillaceous materials, clay predominates and in calcareous materials calcium carbonate predominates. Ordinary Portland cement of grade – 53 (KCP cement) conforming to Indian standards (IS: 12269-1987) has been used in the present study.

GGBS:-

To produce GGBS, this granulated blast furnace slag is dried and ground to a fineness similar to that of Portland cement. GGBS is normally used in combination with Portland cement. The GGBS and cement are added into the concrete mixer as separate constituents. Where appropriate, the ratio of GGBS to cement can be varied according to the technical requirements for any particular application.

SILICA FUME:-

Silica fume is a byproduct of producing silicon metal or ferrosilicon alloys. One of the most beneficial uses for silica fume is in concrete. Because of its chemical and physical properties, it is a very reactive pozzolanic. Concrete containing silica fume can have very high strength and can be very durable

Physical properties of fly ash & GGBS and silica fume

S.No	IS Code	Tests performed	Results		
			Cement	GGBS	Silica fume
1	IS 12089:1987	Specific gravity	3.13	2.82	2.63
2	IS 12089:1987	Fineness	7.2%	7%	14%

FINE AND COARSE AGGREGATE

Fine aggregate used in this study was locally available river sand of Zone II compliing to IS 383:1970. The specific gravity, water absorption and fineness modulus of fine aggregate used was

2.55, 0.806% and 2.58. Locally procured coarse aggregate from local quarry was used in this investigation. The specific gravity, Bulk density and Water absorption used was 2.9, 1738 kg/m^3 (compacted), 1512 kg/m^3 (loosely packed) and 0.502%.

WATER

Water is a key ingredient in the manufacture of concrete. And in this investigation water participates in the chemical reaction with NaOH pellets. Since it helps to the strength giving binder gel, the quantity and quality of water are required to be looked into very carefully.

SUPER PLASTICIZER

To improve the workability of the silica/RHA based geopolymer concrete, conplast SP 430 super plasticizer which is obtained from FOSROC Constructive Solution Company. And also it served as a high range water reducer. The colour of the conplast is brown liquid and dosage of conplast added as 3% by weight of binder material.

GLASS FIBER

Glass fiber is a recent introduction in making fiber concrete. Fig.5 shows glass fiber reinforced concrete (GFRC) much like you would find in fiberglass insulation, to reinforce the concrete. The glass fiber helps insulate the concrete in addition to making it stronger. Glass fiber also helps prevent the concrete from cracking over time due to mechanical or thermal stress. In addition, the glass fiber does not interfere with radio signals like the steel fiber reinforcement does.

EFFECT OF ACID

The concrete cube specimens of various concrete mixtures of size 150 mm are cast and after 28 days of water curing, the specimens are removed from the curing tank and allowed to dry for one day. The weights of Concrete cube specimen are taken. The acid attack test on concrete cube was conducted by immersing the cubes in the acid water for 28 days and 90 days after 28 days of curing. Hydrochloric acid (HCL) with pH of about 2 at 5% weight of water was added to water in which the concrete cubes are stored. The pH was maintained throughout the period of 28 days and 90 days. After 28 days and 90 days of immersion, the concrete cubes are taken out of acid water. Then, the specimens are tested for compressive strength. The resistance of concrete to acid attack was found by the percentage loss of weight of specimen and the percentage loss of compressive strength on immersing concrete cubes in acid water.

EFFECT OF ALKALI EFFECT

To determine the resistance of various concrete mixtures to alkaline attack, the residual compressive strength of concrete mixtures of cubes immersed in alkaline water having 3% of sodium hydroxide (NaOH) by weight of water was found. The concrete cubes which are cured in water for 28 days are removed from the curing tank and allowed to dry for one day. The weights of concrete cube specimen are taken. Then the cubes are immersed in alkaline water continuously for 28 days and 90 days. The alkalinity of water was maintained same throughout the test period. After 28 days and 90 days of immersion, the concrete cubes are taken out of alkaline water. Then, the specimens are tested for compressive strength. The resistance of concrete to alkaline attack was found by the weight loss of weight of specimen and the % loss of compressive strength on immersion of concrete cubes in alkaline water.

PHASE I

Percentage of replacements

Mix designation		MSN	MSS	M1N	M1S	M2N	M2S	M3N	M3S	M4N	M4S	Units
Cement		100	100	90	90	85	85	80	80	75	75	%
GGBS		0	0	5	5	10	10	15	15	20	20	%
Silica fume		0	0	5	5	5	5	5	5	5	5	%
Glass fibers		0	0	0	0	0	0	0	0	0	0	%
Fine aggregate		100	100	100	100	100	100	100	100	100	100	%
Coarse aggregate	20 mm	100	100	100	100	100	100	100	100	100	100	%
	10 mm	100	100	100	100	100	100	100	100	100	100	%
Normal water		100	0	100	0	100	0	100	0	100	0	%
Sp		100	100	100	100	100	100	100	100	100	100	%

PHASE II

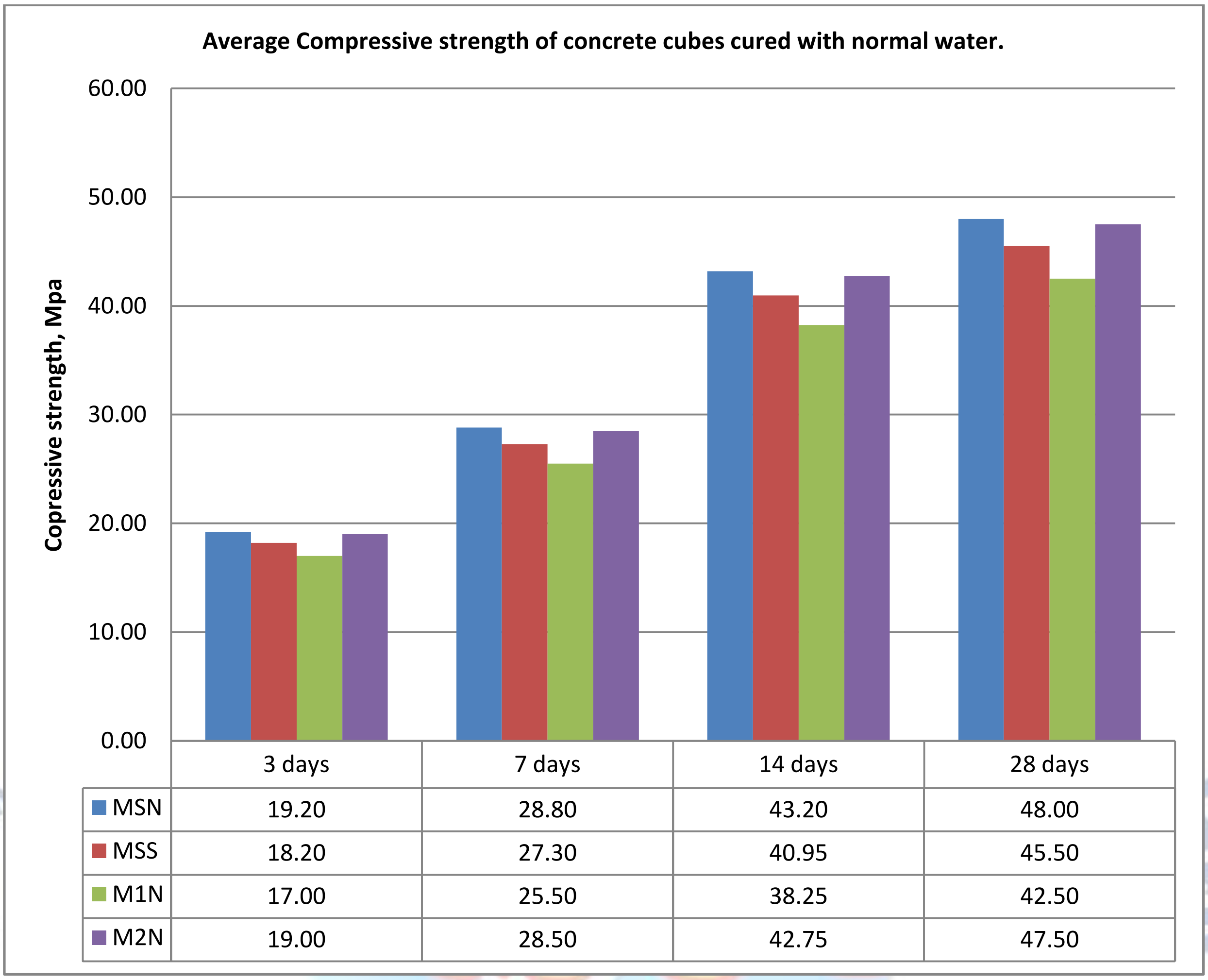
Percentage of replacements

Mix designation		MSN	MSS	M2N	M2NF 1	M2NF 2	M2NF 3	M2S	M2S F1	M2SF 2	M2SF 3	Units
Cement		100	100	85	85	85	85	85	85	85	85	%
GGBS		0	0	10	10	10	10	10	10	10	10	%
Silica fume		0	0	5	5	5	5	5	5	5	5	%
Glass fibers		0	0	0	0.50	1.00	1.50	0	0.5	1.00	1.50	%
Fine aggregate		100	100	100	100	100	100	100	100	100	100	%
Coarse aggregate	20 mm	100	100	100	100	100	100	100	100	100	100	%
	10 mm	100	100	100	100	100	100	100	100	100	100	%
Normal water		100	0	100	100	100	100	0	0	0	0	%
Acid attack		0	100	0	0	0	0	100	100	100	100	%
Base attack		0	100	0	0	0	0	100	100	100	100	%
Sp		100	100	100	100	100	100	100	100	100	100	%

RESULTS AND DISCUSSIONS

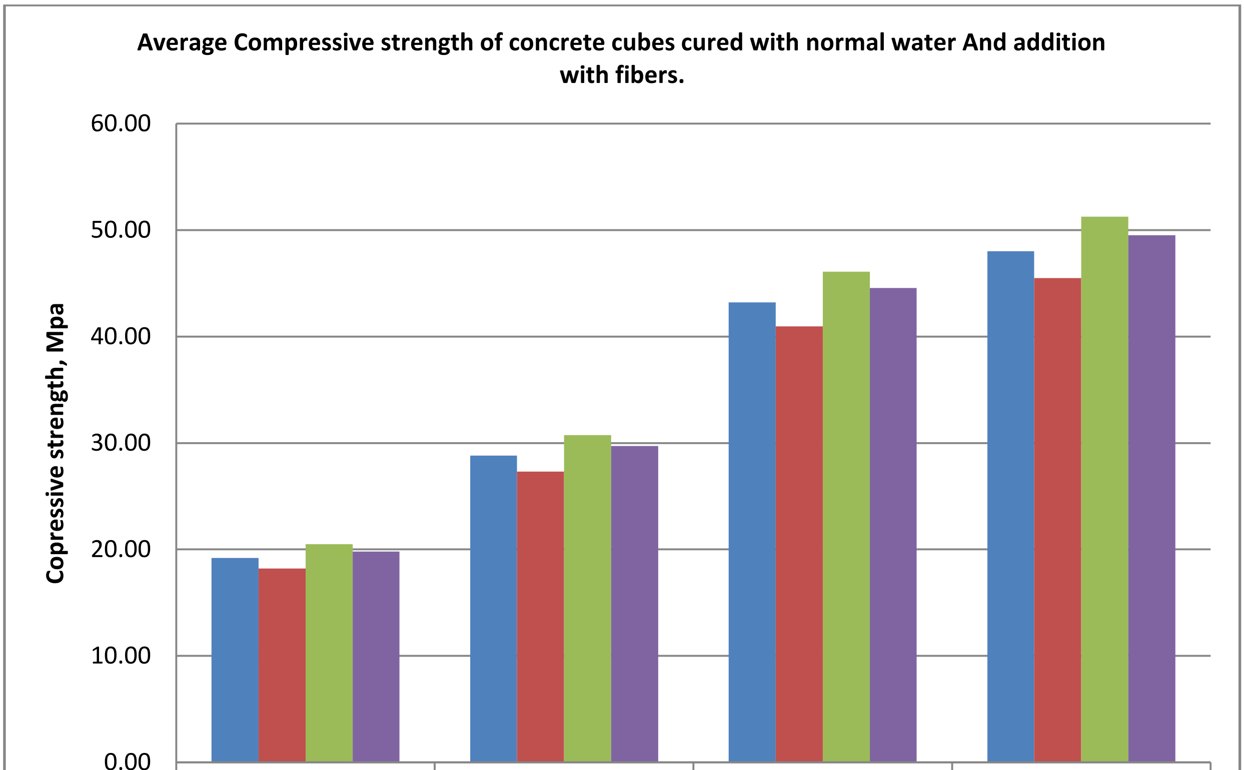
Average Compressive strength of concrete cubes cured with normal water.

S.No	Mix designation	Compressive strength (MPa)			
		3 days	7 days	14 days	28 days
1	MSN	19.20	28.80	43.20	48.00
2	MSS	18.20	27.30	40.95	45.50
3	M1N	17.00	25.50	38.25	42.50
4	M2N	19.00	28.50	42.75	47.50
5	**M3N**	**20.50**	**30.75**	**46.00**	**51.50**
6	M4N	19.00	28.50	42.75	47.50



Average Compressive strength of concrete cubes cured with normal water And addition with fibers.

S.No	Mix designation	Compressive strength (MPa)			
		3 days	7 days	14 days	28 days
1	MSN	19.20	28.80	43.20	48.00
2	MSS	18.20	27.30	40.95	45.50
3	M3N	20.50	30.75	46.10	51.25
4	M3NF1	19.80	29.70	44.55	49.50
5	**M3NF2**	**21.60**	**32.40**	**48.60**	**54.00**
6	M3NF3	20.40	30.60	45.90	51.00



	3 DAYS	7 DAYS	14 DAYS	28 DAYS
MSN	19.20	28.80	43.20	48.00
MSS	18.20	27.30	40.95	45.50
M3N	20.50	30.75	46.10	51.25
M3NF1	19.80	29.70	44.55	49.50

EFFECT OF ACID

The optimum mix is determined as M3N, thus the effect of Hydro chloric (HCL) acid is tested for 30% replacement. Comparison is made between the compressive strength of the specimen with and without exposure to HCL acid.

The variation in the compressive strength of cubes before and after exposure to HCL acid at 28 and 90 days. The percentage decrease in the strength observed for 28 days and for 90 days.

EFFECT OF ALKALI

The optimum mix is determined as SCC 30, thus the effect of Sodium hydroxide (NaoH) alkaline is tested for 30% replacement. Comparison is made between the compressive strength of the specimen with and without exposure to NaoH alkaline. The variation in the weight of cubes before and after exposure to NaoH alkaline at 28 and 90 days. The percentage decrease in the weight observed for 28 days and 90 days.

CONCLUSIONS

Based on results and discussions following conclusions were made.

- A significant reduction of workability.
- A progressive addition in compressive strength by increasing the percentage of GGBS and silica fume in mix.
- The inclusion of GGBS and Silica fume content in the specimen increases the density and increase the pozzolanic materials addition.
- The replacement of GGBS and silica fume in the mixtures enhances the compressive strength performance of the concrete,
- The addition of fibers in the mixtures improve strength.
- The Compressive strength increases even after adding pozzolanic materials. Due to increase the fibers content. For all replacement levels of Concrete with other mixes goes on decreasing in strength when compared with parent grade ofM40.
- The optimum mix is determined as MSN, thus the effect of Hydro chloric (HCL) acid is tested for 30% replacement. Comparison is made

between the compressive strength of the specimen with and without exposure to HCL acid.

- The variation in the compressive strength of cubes before and after exposure to HCL acid at 28 and 90 days. The percentage decrease in the strength observed is 37.63% for 28 days and 46.17% for 90 days.
- The optimum mix is determined as SCC 30, thus the effect of Sodium hydroxide (NaoH) alkaline is tested for 30% replacement. Comparison is made between the compressive strength of the specimen with and without exposure to NaoH alkaline.
- The variation in the weight of cubes before and after exposure to NaoH alkaline at 28 and 90 days. The percentage decrease in the weight observed is 11.11% for 28 days and 19.5% for 90 days.

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