

# Relevance of Sea Water as Mixing Water in Concrete

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**ABSTRACT:** The World Resource Institute warned that the world's fresh water are in peril. It predicted that 'by 2025', at least 3.5 billion people nearly 50percentage of world's population will be face water scarcity. In order to keep safe our drinking water, use of sea water in concrete industry seems pioneering idea. In this article, the importance of sea water as mixing water of concrete were tested based on literature review and experimental based studies. In literature studies, 9 articles were collected and 9 papers had positive opinion about concrete mixed with sea water by adding chemical admixture. In experimental studies, the effect of concrete with sea water and normal water on compressive strength and splitting tensile strength, in which the cement is replaced with flyash and Ground Granulated Blast Furnace Slag (GGBFS) were investigated. Replacement of cement with 25%, 30% & 35% of flyash were tested and observed that in 3days, 7days and 28days compressive strength and splitting tensile strength are increased for 30% of flyash. Mixes made by replacement by cement with 40%, 50% & 60% of GGBFS, 3days, 7days and 28days compressive strength and splitting tensile strength are increased for 50% of GGBFS. Hence the strength obtained in sea water as mixing water have more strength than normal water as mixing water.

**KEYWORDS:** Sea water, Normal water, Fly ash, Ground Granulated Blast Furnace Slag, Compressive strength, Splitting tensile strength.

## I. INTRODUCTION

Because of population growth and economical development, water resources in many regions of world are pushed to their natural limits, in terms, the ability of cities and countries to grows, attractive investment, meet the fundamental needs of populations and ensure the economical protection will be increasingly threatened if water resources are not smartly managed. According to the report of World Meteorological Organisation (WMO), more than half of world population would not get enough drinking water, by 2025.

Water scarcity can lead to practical business risks for a wide range of cement Industries. CSI of world business council for sustainable development (WBCSD) in protocol for water reporting. Concrete in the second most consumed substance in the world, after water. In concrete industries, several billion tonne of fresh water is annually used as mixing, curing and cleaning water around the world. From the view point of saving fresh water, it believe that possibility of sea water as mixing water in concrete will be an innovative one. If use of sea water as mixing water is permitted, it will be more convenient, economical in the construction field, especially in coastal region.

One of the practical solution to economise the water usage, the replacement of cement with fresh water and sea water with supplementary cementitious materials like flyash and GGBFS with variable mixing ratio. During recent years there has been a growing emphasis on the utilisation of cementitious material in construction materials.

Replacement of cement and water is not only helps in there strength and durability. It also helps in reducing the cost of cement and fresh water and also has numerous benefits. These experiments had stated that, supplementary

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Vol. 5, Issue 9, September 2016

cementitious material, such as flyash and GGBFS could be used as partial replacement to cement with out affecting mechanical properties of concrete.

In the present study, concrete made with sea water and normal water adopted. Concrete grade M30 design mix were used in this study. Fly ash and GGBFS has been replaced by cement used to study the effect on compressive strength and splitting tensile strength (3,7 & 28 days) on M30 concrete. In this test mechanical fresh properties and values were considered. Compared GGBFS concrete with proportion 40%,50% & 60% and Fly ash with proportion 25%,30% & 35% replacement of cement are adopted. Therefore a concrete mix consists of substantial amount of supplementary cementitious materials like fly ash and GGBFS as partial replacement to cement and both potable water and sea water is used as mixing and curing process. Ordinary Portland Cement Chettinadu of 53 grade is used. Natural aggregate of 20mm size and Manufactured sand zone – II are collected from Madapparambil crushers, Thodupuzha are used. A super plasticizer Master Glanium ACE 30 is used to improve the workability of concrete

In this study a conventional M30 mix is prepared both portable water and sea water as mixing water. Mixes characterised by different contents of fly ash (25%, 30% & 35%), GGBFS (40%, 50% & 60%) as replacement of cement both are mixed and cured with portable water and sea water are examined. They are along with M30 mixes tested for mechanical properties like compressive strength and splitting tensile strength ( 3 day, 7 day & 28 day) and fresh properties like slump test and consistency test. They are tested for mechanical properties and fresh properties and values are compared with properties of M30 mix

## II. RELATED WORK

Mix design was done as per IS-10262:2009.M30 grade of concrete was adopted for this study. Maximum size of coarse aggregate is 20mm and Zone II grade of manufactured sand is used. The water cement ratio adopted for concrete mix was 0.40 and for a slump of 100 +/- 20mm with super plasticizer addition. The quantity of materials required for 1M<sup>3</sup> of M30 concrete mix is given below.

Table 4.1: Proportions of different mixes for 1M<sup>3</sup>

Mix	Cement (kg)	Water (Litres)	Fine Aggregate (kg)	Granite Stone (kg)	Fly ash (kg)	GGBFS (kg)	Super plasticiser (litres)
STD	355	142	835	1156	0	0	1.67
FA 25	266.25	142	835	1156	88.75	-	1.67
FA 30	248.5	142	835	1156	106.50	-	1.67
FA 35	230.75	142	835	1156	124.25	-	1.67
GGBFS 40	213	142	835	1156	-	142	1.67
GGBFS 50	177.5	142	835	1156	-	177.5	1.67
GGBFS 60	142	142	835	1156	-	213	1.67

i) *Cement*: Ordinary Portland Cement manufactured by Chettinad was used to cast specimens. Properties of cement used are specific gravity 3.1, consistency test 30%, initial setting time 180minutes and final setting time 314 minutes .

ii) *Flyash*: Fly ash, the most widely used supplementary cementitious material in concrete, is a by-product of the combustion of pulverized coal in electric power generating plants . The particle sizes in flyash vary from 1 micro meter to 100 micro meter with the typical particle size measuring under 20 micro meter. Flyash of specific gravity 2.78 was used for the study.

iii) *Ground granulated Blast Furnace Slag (GGBFS)*: Granulated Blast furnace slag was first developed in Germany in 1853. Ground slag has been used as a cementitious material in concrete since the beginning of the 1900s. Ground Granulated Blast furnace slag, when used in general purpose concrete in North America, commonly constitutes between 30% and 45% of the cementing material in the mix. Some slag concretes have a slag component of 70% or

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 9, September 2016

more of the cementitious material. ASTM C 989 classifies slag by its increasing level of reactivity as Grade 80,100, or 120. In India we produce about 7.8 million tons of blast furnace slag. The blast furnace slag is mainly used in India for manufacturing slag cement.. The relative density (specific gravity) for ground granulated blast furnace slag is in the range of 2.85 to 2.95. Ground granulated Blast Furnace Slag of specific gravity 2.90 was used for the study.

iv) *Fine Aggregate*: The locally available manufactured sand of Zone II was used as fine aggregate in the study. The properties of fine aggregate are Specific gravity – 2.61, Bulk density – 1.43kg/l, water absorption – 1.4%.

v) *Coarse aggregate*: Granite stone was used as coarse aggregates. Locally available crushed well graded angular shaped Granite stone of size 20mm as coarse aggregate and the properties of coarse aggregates are specific gravity - 2.75, bulk density -1.66kg/l, water absorption-2.1% was used for the study.

vi) *Normal Water*: Ordinary potable water available was used for mixing and curing of concrete. The amount of water needed for adequate workability is practically always greater than that needed for complete hydration of the cement. The mixing water to be used as clean as possible, and free from any kind of chemical or organic material that can affect the properties of the resulting concrete adversely.

vii) *Sea Water*: Sea water is collected from the Arabian sea at Cochin. Sea water, normally has a salinity..This sea water was used for mixing and curing of concrete for the study.

viii) *Super Plasticizer*: In this study Master Glenium ACE 30 was used as super plasticizer. Master Glenium ACE 30 is an admixture of a new generation based on second generation poly carboxylic ether polymer with high early strength gains. It is free of chloride and low alkali. It is compatible with all type of cement. Optimum dosage of Master Glenium ACE 30 should be determined in trial mixes. Generally a dosage range of 500 ml to 1000 ml per 100kg of cementitious material is recommended. This was obtained from BASF Construction Chemicals (India) Pvt. Ltd. Master Glenium ACE 30 have light brown liquid in colour, specific gravity 1.06, chloride iron content < 0.2% and pH > 6.

## III.EXPERIMENTAL PROCEDURE

The specimen is prepared for compressive strength for cube size 150mm x 150mm x 150 mm. The concrete is filled in the mould in three different layers and hand compaction is adopted. Water cement ratio of 0.4 were adopted. The concrete was cast into cast iron moulds and the specimens were demoulded after 24 hours of air curing. The specimens were cured in water curing until the test ages 3days, 7 days and 28 days were reached. Three specimens were casted and tested at each age and average values are noted as compressive strength.

The cylinder of height 300 mm and 150 mm diameter was prepared for tensile strength.The concrete is filled in the mould in three different layers and hand compaction is adopted. Water cement ratio of 0.4 were adopted. The concrete was cast into cast iron moulds and the specimens were demoulded after 24 hours of air curing. The specimens were cured in water curing until the test ages 3days, 7 days and 28 days were reached. Three specimens were casted and tested at each age and average values are noted as splitting tensile strength.

Fourteen different mixes were considered in the investigation work. The first mix was a conventional mix which do not contain replacement of cement and the normal water was used for mixing and curing process. The second mix also a conventional mix which do not contain replacement of cement and the Sea water was used for mixing and curing process. The 3<sup>rd</sup>, 4<sup>th</sup> and 5<sup>th</sup> mixes containing the replacement of cement with flyash of 25%, 30% & 35% and the normal water was used for mixing and curing process. The 6<sup>th</sup>, 7<sup>th</sup> and 8<sup>th</sup> mixes containing the replacement of cement with flyash of 25%, 30% & 35% and the Sea water was used for mixing and curing process. The 9<sup>th</sup>, 10<sup>th</sup> and 11<sup>th</sup> mixes containing the replacement of cement with GGBFS of 40%,50% & 60% and the normal water was used for mixing and curing process. The 12<sup>th</sup>, 13<sup>th</sup> and 14<sup>th</sup> mixes containing the replacement of cement with GGBFS of 40%, 50% &60% and the Sea water was used for mixing and curing process. Its properties are then compared with conventional M30 mix.

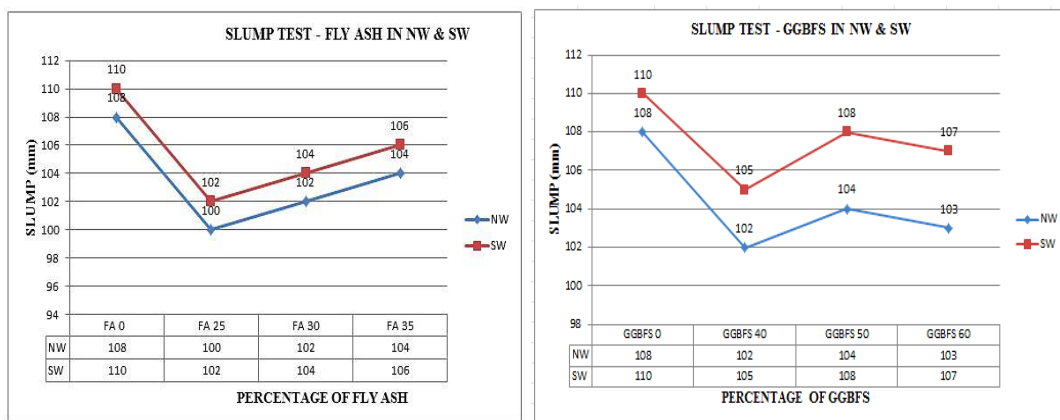
# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 9, September 2016

## IV. EXPERIMENTAL RESULTS

i) *Slump test:* The slumps of almost all the mixes were in the range of 100 to 110 mm. Slump value for concrete mixed in sea water is greater than that of mixed in normal water. ie, workability is more for concrete mixed in sea water.. The differences in the slump value may due to the differences in the rate of water absorption of aggregates.



a

b

Fig.1 Variation of slump in the replacement of cement with (a) Flyash in NW &SW (b) GGBFS in NW &SW

ii) *Compressive strength:* From fig 2, it is seen that maximum compressive strength for concrete with normal water is 38.37 N/mm<sup>2</sup> and concrete with sea water is 42.52 N/mm<sup>2</sup>. This is slightly more than the target compressive strength.

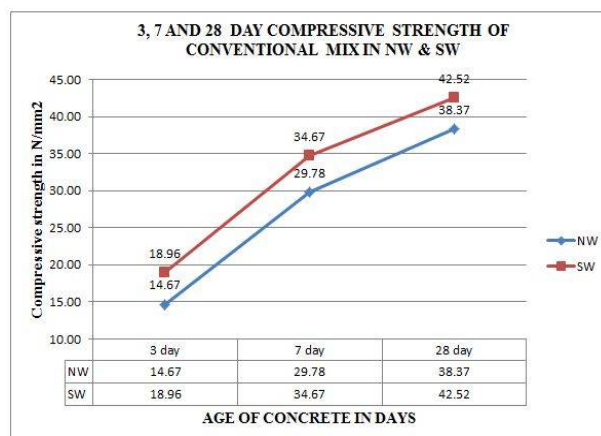


Fig 2 : Variation of Compressive Strength of conventional concrete in NW & SW

## International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 9, September 2016

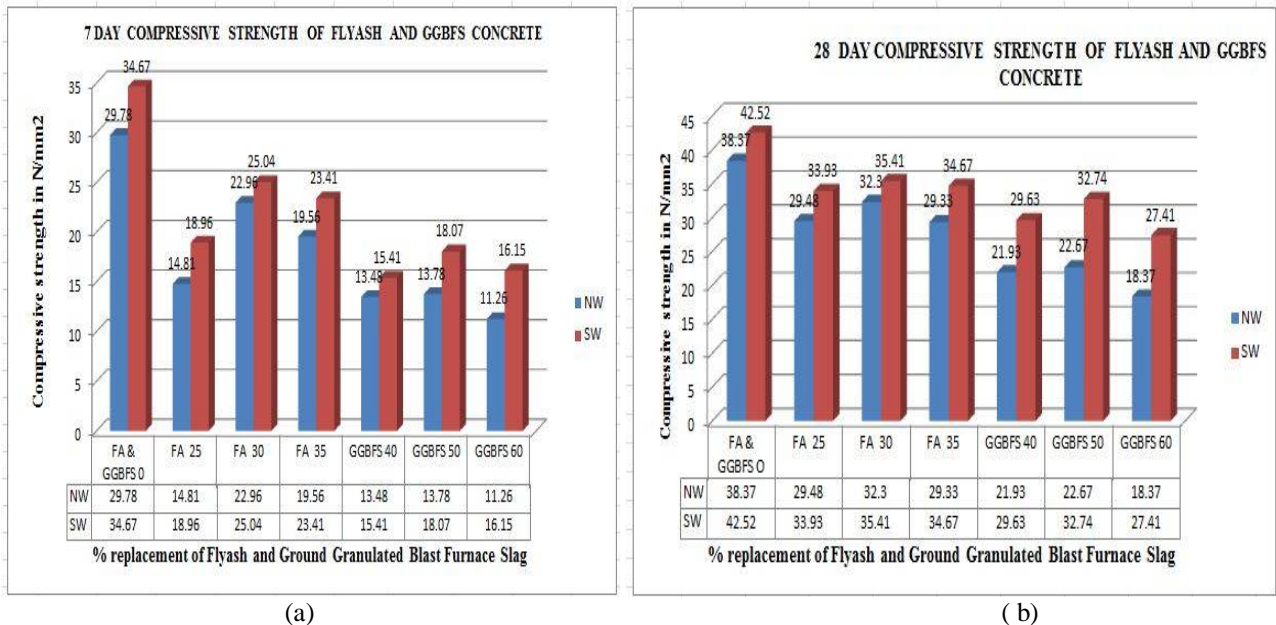


Fig 3 : Variation of Compressive strength with replacement Flyash & GGBFS in NW & SW (a) 7<sup>th</sup> day compressive strength (b) 28<sup>th</sup> day compressive strength

Fig 3 (a) & (b) shows the 7<sup>th</sup> & 28<sup>th</sup> compressive strength of concrete in which the cement is replaced by FLYASH AND GGBFS. The compressive strength both of the concrete is less than the conventional mix. This decrease in strength due to the replacement of cement with flyash can be attributed to the decrease in initial hydration due to the incorporation of flyash. Ultimate strength is obtained as 30% replacement of cement with fly ash and 50% replacement of cement with GGBFS. More over the compressive strength of flyash replacement with cement more than the compressive strength of GGBFS replacement with cement. Also the concrete with sea water as mixing water shows more strength than that the concrete with potable water as mixing water.

iii) *Tensile strength*: From fig 4, it is seen that maximum Tensile strength for concrete with normal water is 2.13 N/mm<sup>2</sup> and concrete with sea water is 2.93 N/mm<sup>2</sup>. This is slightly more than the target tensile strength.

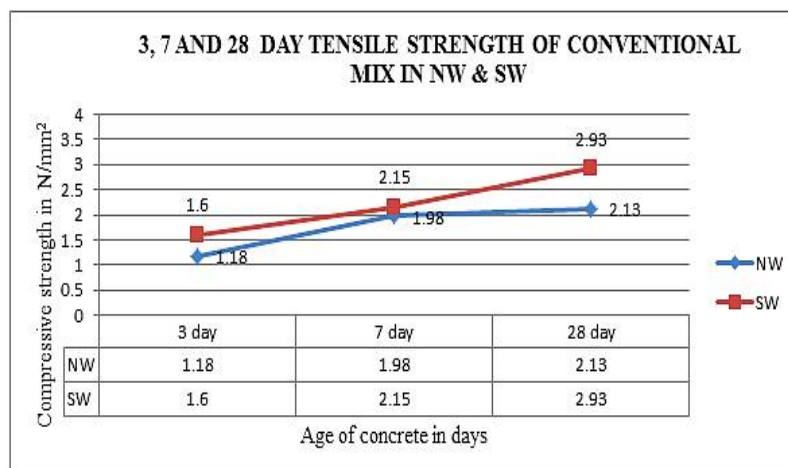


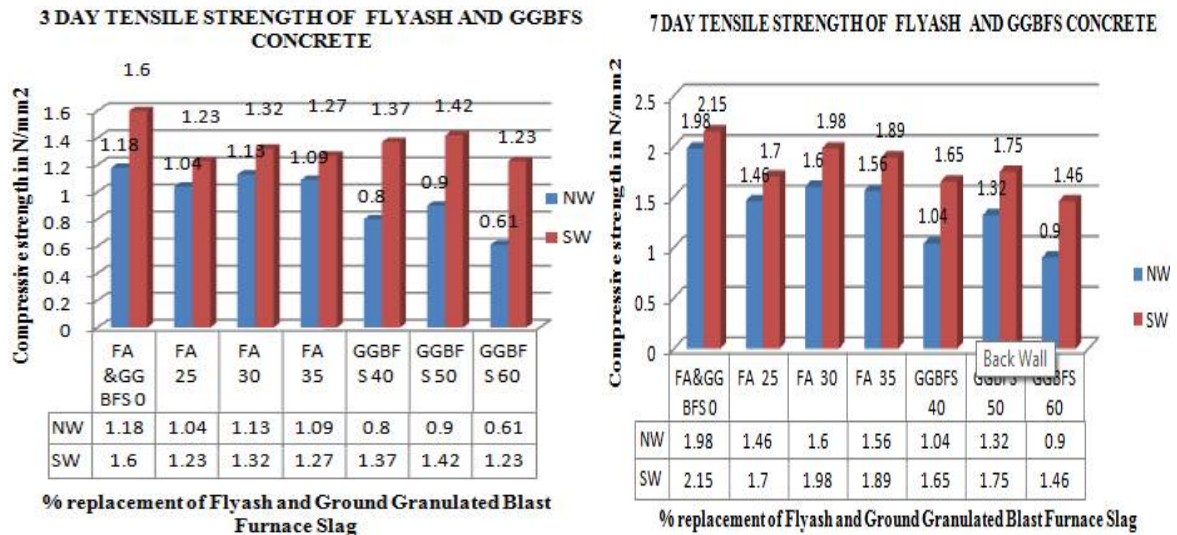
Fig4 Variation of Tensile Strength of conventional concrete in NW & SW



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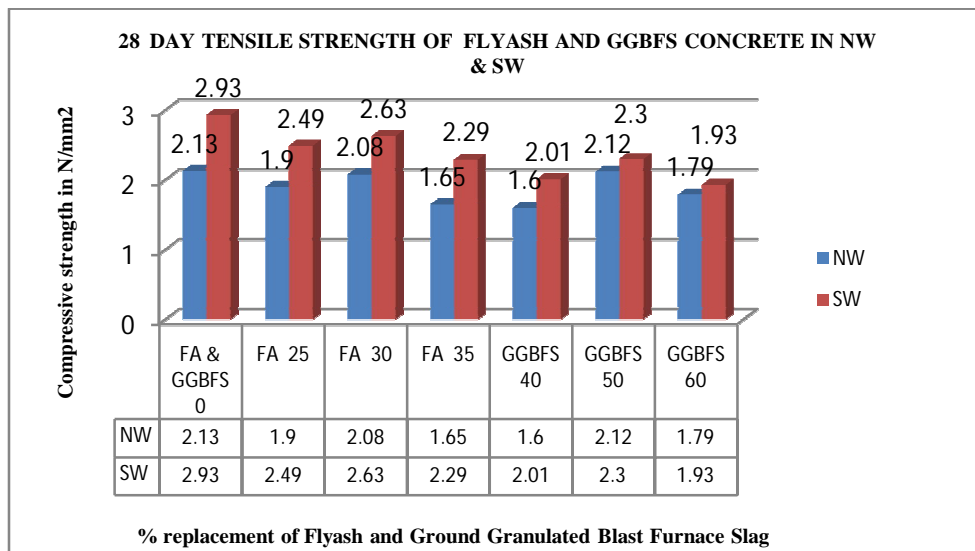
(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 9, September 2016



(a)

(b)



(c)

Fig5 : variation of Tensile Strength with replacement of Flyash & GGBFS in NW & SW (a) 3<sup>rd</sup> day tensile strength (b) 7<sup>th</sup> day tensile strength (c) 28<sup>th</sup> day tensile strength

Fig 5 (a), (b) & (c) shows the 3<sup>rd</sup>, 7<sup>th</sup> & 28<sup>th</sup> tensile strength of concrete in which the cement is replaced by FLYASH AND GGBFS. The tensile strength both of the concrete is less than the conventional mix. This decrease in strength due to the replacement of cement with flyash can be attributed to the decrease in initial hydration due to the incorporation of flyash. Ultimate strength is obtained as 30% replacement of cement with fly ash and 50% replacement

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 9, September 2016

of cement with GGBFS. More over the tensile strength of flyash replacement with cement more than the tensile strength of GGBFS replacement with cement. Also the concrete with sea water as mixing water shows more strength than that the concrete with potable water as mixing water.

## V. CONCLUSION

The Compressive strength and splitting tensile strength of concrete in which cement is replaced by the fly ash decreases as compared to the conventional mix. The Compressive strength and splitting tensile strength of concrete in which cement is replaced by the GGBFS decreases as compared to the conventional mix. Mixes are made by replacing cement with 25% , 30% and 35 fly ash and tested. The 3, 7 and 28 day compressive and splitting tensile strength shows a marginal increase for 30% fly ash. But the strength obtained for same mix in which sea water used as the mixing water have more strength. Mixes are made by replacing cement with 40% , 50% and 60% GGBFS and tested. The 3, 7 and 28 day compressive and splitting tensile strength shows a marginal increase for 50% GGBFS. But the strength obtained for same mix in which sea water used as the mixing water have more strength. The concrete mix with sea water as the mixing water have more strength as compared to the concrete mix with normal water as mixing water. Concrete in which 30% cement replaced with the fly ash shows the ultimate strength. Concrete in which 50% cement replaced with the GGBFS shows the ultimate strength. Slump value for concrete mixed in sea water is greater than that of mixed in fresh water. ie, workability is more for concrete mixed in sea water.

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