ISSN(Online) : *2456-8910*
International Journal of Innovative Research in Applied Sciences and Engineering (IJIRASE)
Volume 4, Issue 9, DOI:10.29027/IJIRASE.v4.i9.2021.885-890,March 2021

Study on Mechanical Properties of Lithium Nitrate in Concrete

Nivetha.D[1], Sathya.S[2]
PG Student, Department Of Civil Engineering,
SNS College Of Technology, Coimbatore, India.
[2]Assistant Professor, Department Of Civil Engineering,
SNS College Of Technology, Coimbatore, India.
Email: nivethadhanabal47@gmail.com[1], sathya169454@gmail.com[2]

Abstract— Alkali aggregate reaction continues to be a very severe problem in terms of concrete durability many despite physical and chemical mitigation techniques that successfully prevent it for extended time, aggregates have been considered inert materials. Alkali silica reaction, many chemicals like lithium, lithium hydroxide, lithium bromide, etc. but lithium nitrate and m-sand are employed during this paper. ASTMC 1260 (mortar-bar-test) and mechanical properties test of concrete is also determined. The mechanical properties of concrete were investigated for a six mix proportion comprising a control mix(0M), lithiumnitrate(0.68M,0.7M,0.72M,0.74M,0.76M) lithiumnitrate not only prevents the ASR gel formation but also has a great influence on mechanical properties of concrete. The results indicate that the concrete with 0.76M lithium nitrate has higher strength values. The compressive strength tests were done on the 7th and 28th days. The maximum compressive strength at 28day of 33.43MPa was achieved for the combination, which contains 0.76M of lithium nitrate. The split tensile strength tests were done on the 7th and 28th days. The maximum split tensile strength at 28day of 2.53MPa was achieved the flexural strength tests were done on the 28th day. The maximum flexural strength at 28day of 6.75MPa was achieved.SEM analysis has to be performed for 0.76M to study the micro characteristics of concrete. If used in concrete, Lithium nitrate controls the cracks due to ASR results in increased strength and durability.

Keywords—**Alkali silica reaction (ASR), Lithium nitrate, Mortar Bar Test**

I. INTRODUCTION

Concrete is a composite material made out of concrete, fine and coarse total reinforced together within sight of water, solidifying after some time. Splits in concrete are sporadic and can't be forestalled. On the off chance that causes were better comprehended, the disposal of splits would be less troublesome. A split in concrete is predominantly due to insufficient examination of the considerable number of fixings included. Breaking can be the aftereffect of one or a blend of components, for example, substance response, drying, creep and shrinkage, warm splitting, dampness development, flexible distortion, establishment developments and settlement of soil, fabricating abandons. Specific sorts of receptive totals are liable for a soluble base total response. The response begins with the assault of receptive siliceous minerals in the total by hydroxyl particles got from soluble bases in the concrete, bringing about the boundless growing of antacid silicate gel, which prompts interruption of cement, with the spreading of splits and it might, in the end, prompts disappointment of solid structures. There are three sorts of total salt response, in which the antacid silica response is generally referred to as "solid disease". The growing of cement is due to the response between high basic concrete glue and receptive silica in the total within sight of adequate dampness. This response causes extension of the total by shaping dissolvable thick gel sodium silicate $Na_2SiO_3 \cdot n\ H_2O$. ASR prompts extreme splits and prompts serious basic issues, which at long last prompts the structure's devastation. On the off chance that lithium-based admixture is utilized in solid, it responds with silica before the hydroxyl particles, shaping lithium sulfate (Li_2SO_3), filling in as a dissemination obstruction defensive layer to forestall salt silica response, which thus prompts anticipation of splits. Alkali silica reactions **(ASR)** occur with certain sorts of silica (SiO_2) minerals in aggregates that react during a high alkaline (pH) medium in concrete creating an expansive gel. The ASR forms a gel that swells because it draws water from the encompassing cement paste (has a great affinity to moisture). In absorbing water, these gels can induce pressure, expansion, and cracking of the mixture and the surrounding paste. The alkali-silica gels will fill the micro cracked regions both within the mixture and concrete. The continued availability of moisture to the concrete causes enlargement and extension of the micro-cracks, which eventually reach the concrete Lithium nitrate's outer surface is an inorganic compound with the formula $LiNO_3$.It is the lithium salt of aqua fortis. The salt is deliquescent, absorbing water to make the hydrated form, lithium nitrate trihydrate. Its eutectics are of interest for heat transfer fluids. Chemical formula: $LiNO_3$, Molar mass: 68.946g/mol .Jinxin Liu et al. (2019) Studied that the $LiNO_3$ didn't diminish the extension of rock crystals and solid microbars with sandstone until the molar proportion of [Li]/[Na+ K] surpassed 1.66, and development expanded when the $LiNO_3$ focus was underneath the basic fixation. The development stress test demonstrated that Li_2SiO_3 is clearly far reaching and the extension stress was more than 195 MPa toward the test's finish. The XRD and SEM investigations showed that the result of Li_2SiO3 caused a more noteworthy extension of tests, and response expended the reactants having a place with ASR and restrained the development of ASR gel. [1]Justyna Zapała-Sławeta et al. (2018) Studied that acoustic discharge can be utilized as an apparatus for persistent observing of marvels happening during the soluble base total response (SHM strategy).The diminished acoustic action affirmed the decrease of corruption in concrete with responsive totals brought about by the utilization of lithium nitrate. Examination of vitality parameters of acoustic emanation signals. The acoustic movement of the mortars is very much associated with the degree of harm to their microstructure.[2] Sagawa Yasutaka et al. (2017) Studied that the treatment of receptive total with concrete glue (w/c=0.5) containing 3M and 4M of LiOH.H_2O can't prevent the silica in total to reply with soluble base. Responsive totals that inundated in 4M of LiOH.H_2O arrangement in store at temperature 80oC for 5 days can decrease development for andesite-1. [3]Asghar et al., (2016) researched the significant test to the toughness of the solid, which is because of salt silica response. This is because the connection between the organization, properties, and conduct of soluble base silica response isn't comprehended. The impacts of the creation of engineered soluble base silica response gel on pore arrangement, pH, and osmotic weight, rheological and growing properties are researched, and the relapse examinations have been finished. in gels with low calcium and low sodium organization, best return stresses were watched and they demonstrated immaterial osmotic and expanding pressure. [4] Bérubé, M. A, (2016), Tests are done on low and high soluble base concrete glue with and without the expansion of $LiNO_3$ and lithium-bearing glass. The Li/Na_2O_e molar proportion was kept steady at 0.74. The pore arrangement of three sorts of examples was tried, exposed to 23, 38 and 60 degree C in the fixed holder at 3, 7, 28& 91 days. It has been expressed that $LiNO_3$ diminishes pH by 0.1 and lithium glass expands the pH by 0.2.The temperature between 23&60degreeC has no huge impact on the thickness of the pore solution.[5]Jan Olek et al. (2016) Studied that the Physical and synthetic changes in the parts of the shut responsive framework (the model reactant (MR) framework) were explored to decide the impact of Li+ particles on the degree of ASR. In light of the MR test results, the nearness of Li+ particles in the arrangement forestalls the disintegration of receptive silica, which is the underlying advance required for the ASR to happen. The beneficial impact of Li+ particles in controlling the ASR may be the development of physical boundary at confined territories on the uncovered surface of the responsive total by the response items; also, the degree of ASRwas found to rely upon the dose of $LiNO_3$.This shows that the specific least measure of $LiNO_3$ completely forestall the ASR[6] Z.Owsiak et al. (2016) Studied that the rock total utilized right now soluble bases since the extension of the mortars surpassed the edge of potential reactivity determined in ASTM C1260 and ASTM C227. Lithium mixes are viable inhibitors of the extension of mortars made with responsive rock totals. Results of total response with sodium and potassium hydroxides filled the region of the total, and the sodium-potassium-calcium silicate gel contained a lot of sodium and potassium. An expansion of lithium nitrate within the molar proportion of Li/(Na + K) at the degree of 0.74 helped decline the event of mortars made with responsive rock total until it arrived at the safe, non-damaging level. In the adjusted ASTM C1260 test strategy, because of the nearness of lithium nitrate in the arrangement in which the mortar bars were put away, lithium draining was constrained and development diminished to 0.014%.[7] Saouma et al.,(2015). An endeavor has been made to build up a numerical system through which the response energy can be better comprehended. Fleeting advancement of the broad gel arrangement stands out from both large-scale energy and dissemination-based meta-models. Three numerical preservationist laws are inferred. Grouping of gel and the extension of cement under soluble base silica response shows subjective similarities. [8]Metin Arslan et al., (2014) considered that it was discovered that the ideal added substance sum for ASR ought to be determined dependent on length changes as well as mechanical qualities. $LiNO_3$, LiBr, Li_2SO4 and Li_2CO_3 added substances encased the soluble base items, assuming in this manner a job in lessening the ASR instigated developments. It was seen that ASR development and mechanical quality of receptive totals are significantly influenced by the sort and added substance proportion of Li_2SO_4, $LiNO_3$, Li_2CO_3 and LiBr additives.[9].Josef. Schneideret al. (2008)Studied that the treatment of the ASR gel with the $LiNO_3$/NaOH solution produces strong effects on the structure of this silicate compound. The NMR (nuclear magnetic Resonance) experiments show the formation of a disordered network with average silicate connectivity lower than in the original gel, having substantial incorporation of Li^1 ions in close neighborhood of silicate tetrahedral. The observation of crystalline phases containing potassium indicates the release of K^1 ions from the ASR gel.The dissolution of the sodium carbonate originally presents in ASR gel samples was detected, forming new crystalline Na-phases.[10].Collins C. L, (2004), the impacts of lithium added substances -LiOH, LiCl, and $LiNO_3$ on salt silica response were inspected at different doses. The development was beneath the satisfactory furthest reaches of 0.05% at 56 days. The ideal dose of Li_2O/Na_2O_e to control soluble base silica response was around 0.6 for LiOH, 0.8 and 0.9 for $LiNO_3$ and LiCl individually, and the instrument behind the antacid silica concealment because of expansion lithium salts was not satisfactory. Lithium salts either decline the silica disintegration or the precipitation of silica-rich items on the grounds that the broke up silica fixation diminished with increment in a dose of lithium salts [11]

Objectives:

1. To acquire the ideal measurements of Li/Na_2O_e
2. To examine lithium-based admixture conduct in the concealment of alkali-aggregate reaction for the ideal measurement lithium.
3. To decide the lithium-based admixture concrete's mechanical properties at varying proportions 0M (Control Mix), 0.68M, 0.7M, 0.72M, 0.74M, and0.76M.

II. EXPERIMENTAL INVESTIGATION

A. Aggregate Reactivity Test

Accelerated Mortar Bar Expansion Test *(As per ASTM C 1260 standards)*

The fine aggregate was tried for ASR utilizing ASTM measures for potential reactivity of the aggregates. The mortar bars of 25mm x 25mm x 285mm were made with a w/c of 0.47. The cement Mortar ratio is 1: 2.25. In the wake of demoulding, it should be placed in a water bath at 80ºC for the next 24 hours. The underlying length should be estimated after removal from the water bath and afterward, it should be stored in a highly alkaline solution of 1N NaOH at 80ºC. The readings should be taken for 14 days with at any rate 3 subsequent readings. If the length expansion is <0.1%means that the aggregate is non-reactive, 0.1to0.2% means potentially reactive,>0.2% means reactive aggregates.

B. Tests for Hardened Properties of Concrete

Concrete is strong in compression; the higher the compressive quality better is the solidness and bond quality. Protection from the scraped area and volume dependability improve with the compressive quality, which is a significant cement nature. For the compression quality test, the solid examples taken and utilized for throwing shapes are 150mm x 150mm x 150mm. Elasticity is one of the fundamental and significant properties of concrete. The concrete isn't typically expected to oppose the immediate strain on account of its low rigidity and weak nature. Anyway, the assurance of elasticity of cement is important to decide the heap at which the concrete individuals may crack. The cracking is a type of pliable disappointment. In light of the challenges related to the immediate pressure test, various backhanded strategies have been created to decide the rigidity. Thus, parting elasticity test has been done according to Seems to be: 5816 – 1970. Flexure Strength Test is utilized to decide the flexural limit of the solid according to IS: 516-1959with bar form of size 100 x 100 x 500mm

C. SEM Analysis

The examples were carbon covered and dissected utilizing Scanning Electron Microscope (SEM) in the back dispersed electron mode with a quickening voltage of 10kV. The back dissipated was set to a similar parameter for each example; through SEM investigation, the powdered example's surface morphology and molecule size can be resolved. Pictures for various examples were taken at different amplifications like X200, X1000, X2000, X5000 to recognize the surface and crack. In this project, SEM analysis is to be done for the optimum lithium nitrate admixture. During the SEM study, ASR, for the most part, happened shrinkage cracks and cleavage. The cracks typically started in the porous structure, spreading then around the void.

III. RESULTS AND DISCUSSION

A. Test results for aggregate reactivity

Accelerated mortar bar expansion test (astmc1290 standards)

The quickened mortar bar development test has been completed for m-sand. The underlying length of the example is estimated before setting the example in the profoundly soluble medium. At that point, the length has been estimated for 3rd, 7th and 14thday. Table 4.1 gives a detailed description about the percentage expansion of length for various specimens.

Table-4.1 Accelerated Mortar bar Expansion Test

Material CM (M Sand)	**Initial Length (mm)**	**Length at 3rd Day (mm)**	**Length at 7th Day (mm)**	**Length at14th Day (mm)**	**%Expansion of Length**
S1	295	296	296	296	0.3
S 2	295	296	296	296	0.3

B. Tests Results for Mechanical Properties of Concrete

i. Compressive Strength

The compressive quality test outcomes are given in table 4.2.The compressive quality tests were done at the 7thand 28th.The most extreme compressive quality at 28th day of 33.43MPa was accomplished for the blend, which contains 0.76M of lithium nitrate. Though, the compressive quality of 30.12MPa, 30.24MPa, 30.88MPa, 31.98MPa were accomplished for concrete containing 0.68M, 0.7M, 0.72M, 0.74M of lithium nitrate on the 28thday separately. The table gives the point-by-point portrayal of the compressive quality—Fig 1thinks about the 7th and 28thday compressive strength.

Table 4.2 Compressive Strength Test Results

Mix ID	**Compressive Strength at7th Day(N/mm^2)**	**Compressive strength at 28th Day(N/mm^2)**
CM	19	28
0.68M	20.32	30.12
0.7M	21.48	30.24
0.72M	23.10	30.88
0.74M	25.91	31.98
0.76M	26.18	33.43

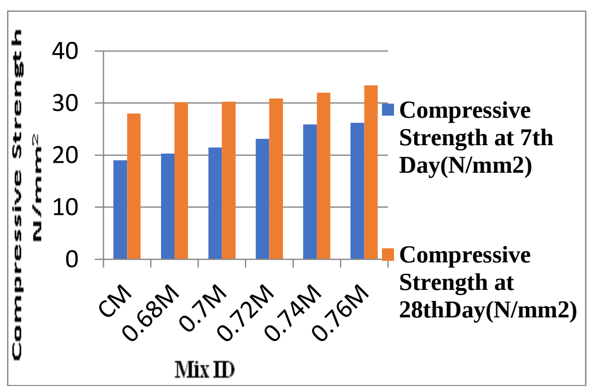

Fig 1 Compressive Strength Test Results for various mixes

ii. Split tensile strength

The split rigidity test is the backhanded strategy to evaluate the elastic limit of the solid. i.e., the rigidity of 2.53MPa was accomplished. The point by point depiction of elasticity for different blends appeared in Table 4.3

Table 4.3 Split Tensile Strength Test Results

Mix ID	Split Tensile Strength at 7th Day(N/mm^2)	Split Tensile Strength at 28th Day(N/mm^2)
CM	1.9	2.1
0.68M	1.53	2.13
0.7M	1.61	2.21
0.72M	1.78	2.38
0.74M	1.82	2.42
0.76M	1.93	2.53

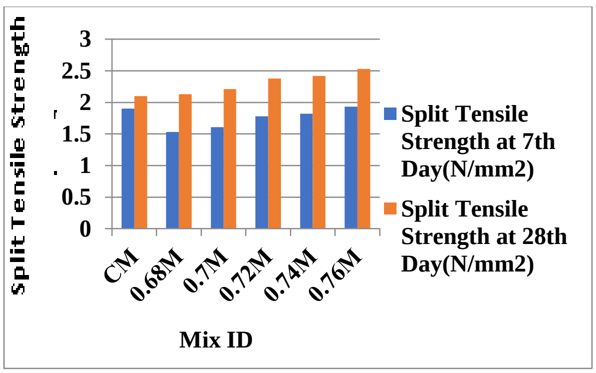

Fig 2Split Tensile Strength Results for various mixes

iii. Flexural Strength

The flexural quality assessments of various cement blends following 28 days of restoring exposed to two points stacking. The flexural quality of the reference concrete is 6.75MPa which fulfills the flexural quality according to Seems to be: 456 – 2000. The flexural quality for 0.76M demonstrated higher flexural quality than different blends. Flexural quality test outcomes are indicated in Table 4.4

Table 4.4 Flexural Strength Test Results

MIX ID	Flexural strength at 28th Day(N/mm^2)
CM	6
0.68M	5.7
0.7M	5.85
0.72M	6.15
0.74M	6.45
0.76M	6.75

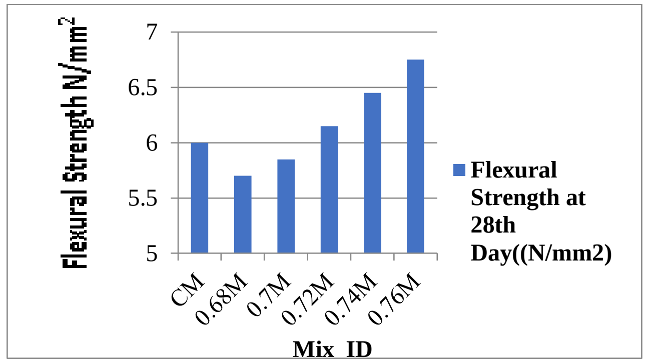

Fig 3 Flexural Strength Results for various mixes

C. SEM Analysis

The examples were carbon covered and examined utilizing scanning Electron Microscope (SEM) in the back dissipated electron mode with a quickening voltage of 10kV. The back dispersed was set to a similar parameter for each example. Through SEM investigation, the powdered example's surface morphology and molecule size were taken at different amplifications like X200, X1000, X2000, X5000 to distinguish the surface and crack.

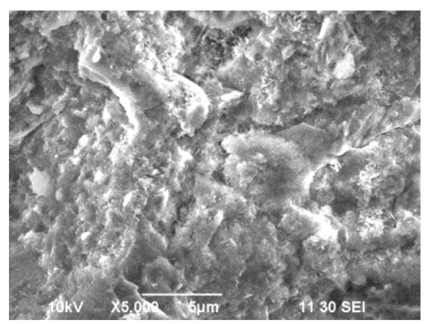

Fig 4 SEM image for 0.76M of magnification X5000

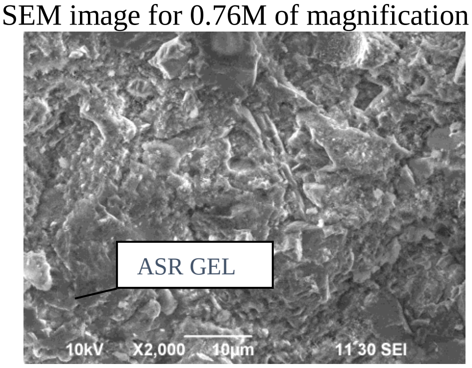

Fig 5 SEM image for 0.76M of magnification X2000

IV. CONCLUSION

The treatment of the ASR gel with the $LiNO_3$solution produces strong effects on the structure. The maximum compressive strengthof33.43MPa was achieved for the combination, which contains 0.76M of lithium nitrate. The maximum Split lastingness of 2.53MPa was performed for the combination, which includes 0.76M of lithium nitrate. Compare to standard concrete, lithium nitrate obtain high strength. The maximum flexural strength of 6.75MPa was achieved for the combination, which contains0.76M of lithium nitrate. SEM images highlighted the way that ASR products for the foremost part, framed in voids, in aggregate cracks and among aggregate and cement. This project indicates that the concrete with 0.76M lithium nitrate has low ASR gel formation and should be seen in approximately X2000 magnified images. If $LiNO_3$ is added in sufficient amounts, ASR-induced expansion is often decreased.

REFERENCE

[1]. J.Millard,K.EKurtis" Effects of lithium nitrate admixture on early-age cement hydration"-Cement and concrete Research, volume-38, Issue 4,(2008) pg 500-510.

[2]. Manju R, Sathya S "Effect of lithium based admixture on alkali aggregate reaction in concrete"– A state of art Report,-*International Journal of Engineering and Technology (IJCIET)*Volume8, Issue 9, September 2017, pp. 299–304.

[3]. Bashar Taha, Ghassan Nounu "Using lithium nitrate and pozzolanic glass powder in concrete as ASR suppressors",–Cement and Concrete Composites, Volume – 30 Issue 6(2008) 497-505

[4]. Farshad Rajabipour,MichaelD.A.Thomas"Alkali-silica reaction: Current understanding of the reaction mechanisms and the knowledge gaps,"–Cement and Concrete Research, Volume -76, Pp 130 –146

[5]. Leemann, Andreas, Lörtscher Luzia Bernard, Laetitia Le Saout, Gwenn Lothenbach, Barbara Espinosa-Marzal, Rosa M.-"Mitigation of ASR by the utilization of LiNO3- Characterization of the reaction products, "Cement and Concrete Research Volume – 59 (2014)Pp-73-86.

[6]. Feng, X., Thomas M. D A, Bremner T. W., Folliard K. J., Fournier B "Summary of research on the effect of LiNO3 on alkali-silica reaction in new concrete."-Cement and Concrete Research, Volume- 40(2010), Issue – 4, Pg 636-642

[7]. Craig W. Hargis, Maria C. G. Juenger, and Paulo J. M. MonteiroAggregate passivation:"Lithium hydroxide aggregate treatment to suppress alkali-silica reaction,"-ACI Materials Journal, Issue 5 volume 110 – 567 –575

[8]. Mohammad S. Islam, Nader Ghafoori "Experimental study and empirical modeling of lithium nitrate for alkali-silica reactivity"- Construction and Building Materials, Volume – 121(2016) Pg 717 –726

[9]. Collins, C. L, Ideker, J. H., Willis, G. S.Kurtis, K. E.-Examination of the results of LiOH, LiCl, and $LiNO_3$ on

[10]. alkali-silica reaction,"-Cement and Concrete Research, Volume- 34(2004), Issue – 8, Pg 1403 – 1415

[11]. Lyndon D. Mitchell "The effects of lithium hydroxide solution on alkali silica reaction gels created with opal,"-Cement and Concrete Research, Volume – 34, Issue- 4 (2004) Pg 64

[12]. Feng, X., Thomas M. D A, Bremner T. W.,"Studies on lithium salts to mitigate ASR-induced expansion in new concrete: A review,"-Cement and Concrete Research, Volume- 35(2005), Issue – 9, Pg 1789 – 1796

[13]. Kawamura, Mitsunori, Fuwa Hirohito "Effects of lithium salts on ASR gel composition and expansion of mortars,"-Cement and Concrete Research, Volume- 33(2003), Issue – 6, Pg 913-919

[14]. Berra,M.;Mangialardi.T.;Paolini.A.E. "Use of lithium compounds to prevent expansive alkali–silica reactivity in concrete"Advance Cement Based. Materials. 2003, 15, 145–154.

[15]. Feng, X.; Thomas, M.D.A.; Bremner, T.W.; Folliard, K.J.; Fournier, B. "Summary of research on the effect of LiNO3 on alkali–silica reaction in new concrete". *CementConcreteResearch.* 2010, *40*,636–642.

[16]. Kim, T.; Olek, J. "The effects of lithium ions on chemical sequence of alkali–silica reaction."-*CementConcrete.Research.*.2016, *79*, 159–168.