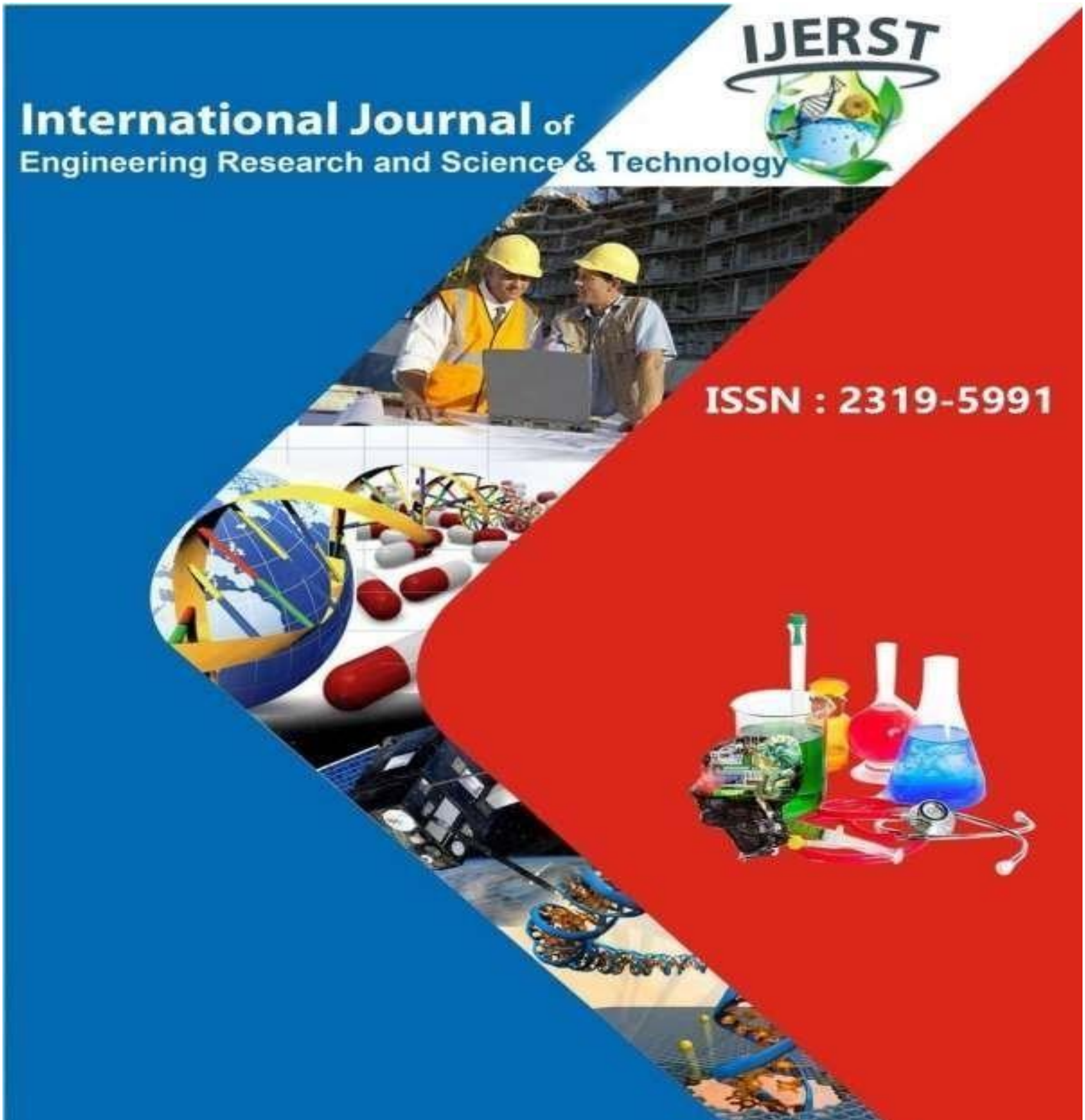


Email: editor@ijerst.com or editor.ijerst@gmail.com

ISSN 2319-5991 www.ijerst.com

Vol. 17, Issue.2, May 2024

EFFECT OF PARTIAL REPLACEMENT OF CEMENT WITH METAKAOLIN AND SAND WITH FOUNDRY SAND IN SELF COMPACTING CONCRETE

P.Anvitha[1a],S.Pooja[1b],M.Bhargavi[1c],Md.Rizwana[1d],P.Dinesh[1e], A. Siva Krishna[2]

[1]Undergraduates in Civil Engineering,
[2]Assisstant Professor in Department of Civil Engineering.
SVS Group of Institutions,
Hanamkonda, Warangal, T.S, India.
Corresponding Author: anvithayadav111@gmail.com

ABSTRACT :

Self Compacting Concrete (SCC), a recent innovation in concrete technology, has numerous advantages over conventional concrete. Self Compacting Concrete, as the name indicates, is a type of concrete that does not require external or internal compaction, because it becomes levelled and consolidated under its self weight. SCC can spread and fill all corners of the formwork, purely by means of its self weight, thus eliminating the need of vibration or any type of consolidating effect.There has been a growing interest in the utilization of high reactivity metakaolin (MK) as a supplementary cementitious material in concrete industry. MK is an ultrafine pozzolana with particle size generally less than 2μm which is significantly smaller than that of cement particle.

Foundry sand is a high quality silica sand used as a moulding material by ferrous and non-ferrous metal casting industries. It can be reused several times in foundries but, after a certain period, cannot be used further and becomes waste material, referred to as used or spent foundry sand (UFS or SFS). This report demonstrates the investigation performed to evaluate the hardening properties of SCC in which natural sand is replaced with five percentages (0%, 10%, 15%, 20% and 25%) of waste foundry sand by weight and cement is replaced with fixed percentage (10%) of metakaolin by weight. Strength properties were evaluated at age of 7, 14 and 28 days. Water / cement ratio (w/c) = 0.43 was taken. To increase workability 1% admixture (Auramix 200) was used. Results showed that there is increase in strength properties by incorporating waste foundry sand as partial replacement by natural sand upto 10%.

KEY WORDS: Metakaolin, Foundry sand, Coarse aggregate, Fine aggregate, Cement, Compressive strength test, Split tensile test, Flexural strength test.

ISSN 2319-5991 www.ijerst.com

Vol. 17, Issue.2, May 2024

1. INTRODUCTION

Concrete is the man-made material which has the vastest utilization worldwide. This fact leads to important problems regarding its design and preparation to finally obtain an economic cost of the product on short and long time periods. The material has to be also "environment friendly" during its fabrication process and also its aesthetical appearance when it is used in the structures. Concrete's performances have continuously rise in order to accomplish the society needs. Many studies have been made concerning the use of additives and super-plasticizers in the concrete by using less water content for a good workability of a concrete. As a result of this, high performance concretes develop having a superior durability.

FIG. 1.Metakaolin

Metakaolin is a dehydroxylated form of the clay mineral kaolinite. Metakaolin is commonly used in the production of ceramics, but is also used as cement replacement in concrete. Metakaolin has a smaller particle size (~1–2 µm) and higher surface area compared with portland cement, but a larger particle size than SF.

Foundry sand can be used as a partial replacement of fine aggregate. In this investigation, fine aggregate has been replaced by foundry sand accordingly in the range of (10-60% at the interval of 10%). Concrete mixes were cost and tested for workability and compressive strength.

Fig.2. Foundry sand

1.1 DEVELOPMENT OF SELF COMPACTING CONCRETE

In 1983, the problem of the durability of concrete structures was a major topic in Japan. To make durable concrete structures, sufficient compaction by skilled labour is required. One solution for the achievement of durable concrete structures independent of the quality of construction work is the employment of SCC, which can be compacted into every corner of a formwork, purely by means of its own weight

International Journal of Engineering Research and Science & Technology
ISSN 2319-5991 www.ijerst.com
Vol. 17, Issue.2, May 2024

and without the need for vibration compaction. The necessity of this type of concrete was proposed by Professor Hajime Okamura in

1986.studies to develop SCC, including a fundamental study on the workability of concrete, were carried out by Ozawa and Maekawa at the University of Tokyo.

Fig.3.Self compacting concrete

2. OBJECTIVE

- To study the impact on compressive strength and finding the optimum percentage of replacement to gain the maximum strength and comparing it with the strength of ordinary concrete.
- To study the Fresh properties and Hardened properties of concrete for all the mixes.
- To study the possible use of Metakaolin and Foundry sand in concrete production, which would reduce production cost.
- To achieve the desired durability in the given environment conditions.

3.LITERATURE REVIEW

3.1 METAKAOLIN

Luc Courard (2003): Investigated the effects of Metakaolin on properties of mortar.Cement is replaced on mass basis of 5% to 20% for metakaolin. For metakaolin the optimum percentage is between 10% and 15% with regard to inhibition effect on chloride diffusion and sulfate attack.

E.Badogiannis et al(2005): Investigation aimed at the use of produced metakaolin as supplementary cementitious material. Samples of poor Greek kaolin and a high purity commercial kaolin were teste. Evidence was found that poor kaolins can be efficiently used for the production of highly reactive metakaolin.

Rafat Siddique et al (2009): Stated an overview on the use of MK as partial replacement of cement in mortar and concrete. He concluded the Reduction in the slump values and increase in the setting times of concrete. Concrete containing 10% and 15% Metalaolin replacements showed excellent durability to sulphate attack.

3.2 WASTE FOUNDRY SAND

Rafat Siddique et al. (2008) : Investigated on used foundry sand as a replacement of fine aggregate in self compacted concrete. He used foundry sand as a replacement of fine aggregate. Their study showed that in comparison to conventional concrete, adding

ISSN 2319-5991 www.ijerst.com

Vol. 17, Issue.2, May 2024

admixtures increased the split tensile, compressive strength and durability up to 19 percent, 14.5 percent and 12 percent respectively.

Rafat Siddique et al. (2013): Carried out experimental investigation to check durability properties and hardening properties of self compacting concrete in which some amount of natural sand is replaced with used foundry sand. Replacement of 0%, 10%, 15% and 20% by weight was made. There was an increase in durability and hardening properties. There was increase in resistance to sulphate attacks and rapid chloride permeability.

S.RamakrishnaRaju et al(2016): Prepared samples of foundry sand replacing fine aggregate, with the different proportions of 0, 25, 50, 75 and 100 percent by weight. The result in his study showed that with the increase in percent of foundry sand the strength is achieved but workability is decreased. Best result showed when 25 % foundry sand is replaced with sand.

4. MATERIALS

Portland Cement:

Portland cement is used as binder material in concrete mix. It's main aim is to make cohesive property at boom to make good strength .To use cement it's all physical properties and chemical properties are examined to make design mix. It hydration process is examined after curing for its strength.

Coarse Aggregate

Aggregates establish the bulk of a concrete mixture and give order firmness to concrete. They should therefore meet certain provisions if the concrete is to be workable, strong, durable and reasonable. The aggregates must be proper shape, clean, hard, strong and well graded. The maximum sized aggregate used is of 10 mm in size.

Fine Aggregates

The aggregates greatest of which permit through 4.75 mm IS sieve are called as fine aggregates. The sand was sieved through 4.75 mm sieve to remove particles greater than 4.75 mm size. Sieve analysis and physical properties of fine aggregate are tested as per IS: 383-1970.

Water

The potable water is usually measured reasonable for mingling and curing of concrete. This was free from any detrimental contaminants and was good potable quality.

Admixtures

Auramix 200 combines the properties of water reduction and workability retention. Auramix

ISSN 2319-5991 www.ijerst.com

Vol. 17, Issue.2, May 2024

200 is a strong super plasticiser allowing production of consistent concrete properties around the required dosage.

Researchers have mentioned that the most popular mix design method for SCC has been introduced by Okamura.to proceed toward

Design Mix

TR1 - First cement was taken as 480kg/m3, Sand was taken as 977kg/m3 and 10mm aggregates was taken as 570kg/m3 at water cement ratio 0.4 and admixtures 1%.

TR2 - Therefore, cement was increased to 500kg/m3 and water cement ratio to 0.43 and others kept constant.

TR3 - Therefore, cement was again increased to 530kg/m3 and water cement ratio to 0.43 and others kept constant.

After obtained the trial mix, different mix proportions were made by replacement of cement with metakaolin by 10% (constant) and sand is replaced with foundry sand at 10%, 15%, 20% and 25% with a water -cement 0.43 and admixture 1% kept constant

Table-3.1.Mix proportions for various trial

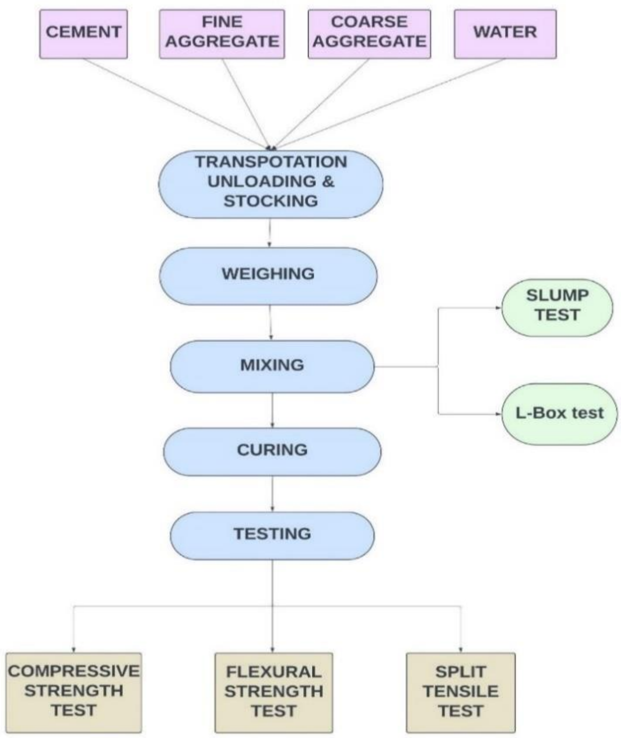
Sr.no.	Mix	Cement(kg/m)		F.A(kg/m)		C.A (kg/m)	S.P(%)	W/c ratio	Slump Flow (mm)
			%(MK)		%(FS)				
1	Nominal mix	500		977		570	1%	0.45	420
2	TR 1	450	50(10%)	977	0(0%)	570	1%	0.45	490
3	TR 2	450	50(10%)	879.3	97.7(10%)	570	1%	0.45	660
4	TR 3	450	50(10%)	830.45	146.5(15%)	570	1%	0.45	670
5	TR 4	450	50(10%)	781.6	195.4(20%)	570	1%	0.45	690
6	TR 6	450	50(10%)	732.75	244.2(25%)	570	1%	0.45	710

5.METHODOLOGY

International Journal of Engineering Research and Science & Technology

ISSN 2319-5991 www.ijerst.com

Vol. 17, Issue.2, May 2024



6.EXPERIMENTAL TESTS

6.1 Slump Flow Test

The slump flow test is used to assess the horizontal free flow of SCC in the absence of obstructions. On lifting the slump cone, filled with concrete, the concrete flows. The average diameter of the concrete circle is a measure for the filling ability of the concrete.

6.2 L-Box Test

The passing ability is determined using the L-box test. The vertical section of the L-Box is filled with concrete, and then the gate lifted to let the concrete flow into the horizontal section. The height of the concrete at the end of the horizontal section is expressed as a proportion of that remaining in the vertical section (H2/H1).

6.3 Compressive Strength of Concrete

Cube specimens of size 150 mm x 150 mm x 150 mm were taken out form the curing tank at the ages of 7, 14 and 28 days and tested immediately on removal from the water. The load (P) is applied gradually i.e. 5.1KN/sec. without shock till the failure of the specimen occurs and thus the compressive strength was found. The magnitude of compressive stress (C) acting uniformly on cube of applied loading is given by formula:

$$C=P/A$$

Where P = Applied load, A = Area of cube

Fig.1.Compressive Strength test of Cube

6.4 Split Tensile Strength of Concrete

The split tensile strength of concrete is determined by casting cylinders of size 100 mm x200mm. The cylinders were tested by placing them uniformly. Specimens were taken out from curing tank at age of 7, 14 and 28 days

International Journal of Engineering Research and Science & Technology

ISSN 2319-5991 www.ijerst.com

Vol. 17, Issue.2, May 2024

of moist curing and tested after surface water dipped down from specimens.The load (P) is applied gradually i.e. 2.1KN/sec. The magnitude of tensile stress (T) acting uniformly to the line of action of applied loading is given by formula

T= 0.637P/DL

Where,

T = Split Tensile Strength in MPa

P = Applied load, D = Diameter of Concrete cylinder sample in mm.

L =Length of Concrete cylinder sample in mm.

Fig.2.Split Tensile Strength test of cylinder

6.5 Flexural Strength of Concrete

The flexural strength of concrete is determined by casting beam of size 100 mm x100 mm x 500mm.Specimens were taken out from curing tank at age of 7, 14 and 28 days of moist curing and tested after surface water dipped down from specimens. The load (P) is applied gradually i.e. 0.1KN/sec. Beams are tested for two point loading. At 1/3rd from support from both ends. Formula used for flexural strength ‘fb’

fb = PL/bd2

Where,

a = the distance between the line of fracture and the nearer support, measured on the centre line of the tensile side of the specimen

b = width of specimen d = failure point depth.

(When a > 20.0cm for 15.0cm specimen or > 13.0cm for 10cm specimen) or fb = 3Pa/bd2 (when a < 20.0cm but > 17.0 for 15.0cm specimen or < 13.3 cm but > 11.0cm for 10.0cm specimen.)

Fig.3.Flexural strength test

7. OBSERVATIONS AND RESULTS

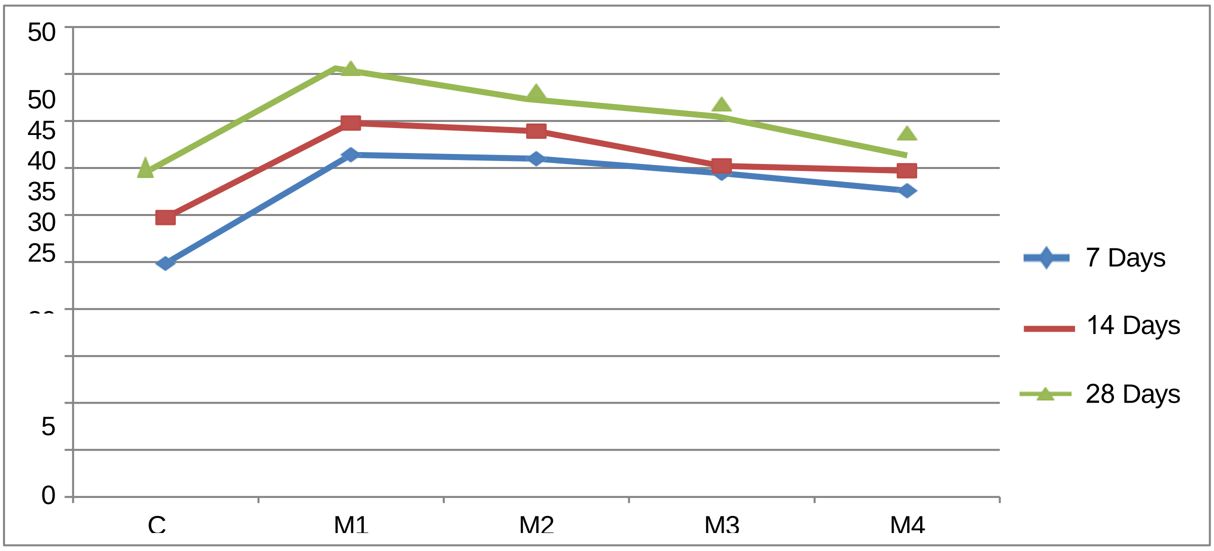
ISSN 2319-5991 www.ijerst.com

Vol. 17, Issue.2, May 2024

7.1. COMPRESSIVE STRENGTH TEST

Table.1.compressive strength test

Compressive Strength (MPa)										
Curing age (days)	**0% MK**		**10% MK**		**10% MK**		**10% MK**		**10% MK**	
	0% FS		**10% FS**		**15% FS**		**20% FS**		**25% FS**	
7	23.1	24.86	36.18	36.4	33.67	35.98	33.34	34.43	30.21	32.6
	26.49		35.76		35.99		35.84		35.1	
	24.99		37.28		38.28		34.12		32.51	
14	26.56	29.72	39.75	39.78	37.12	38.92	32.39	35.23	36.77	34.71
	30.8		41.69		39.45		38.42		34.45	
	31.79		37.9		40.19		34.88		32.9	
28	35.39	37.37	45.91	45.6	42.99	43.18	39.37	41.8	40.12	38.73
	38.23		44.29		44.67		42.34		37.76	
	38.5		46.78		41.89		43.7		38.32	



Compressive Strength test result

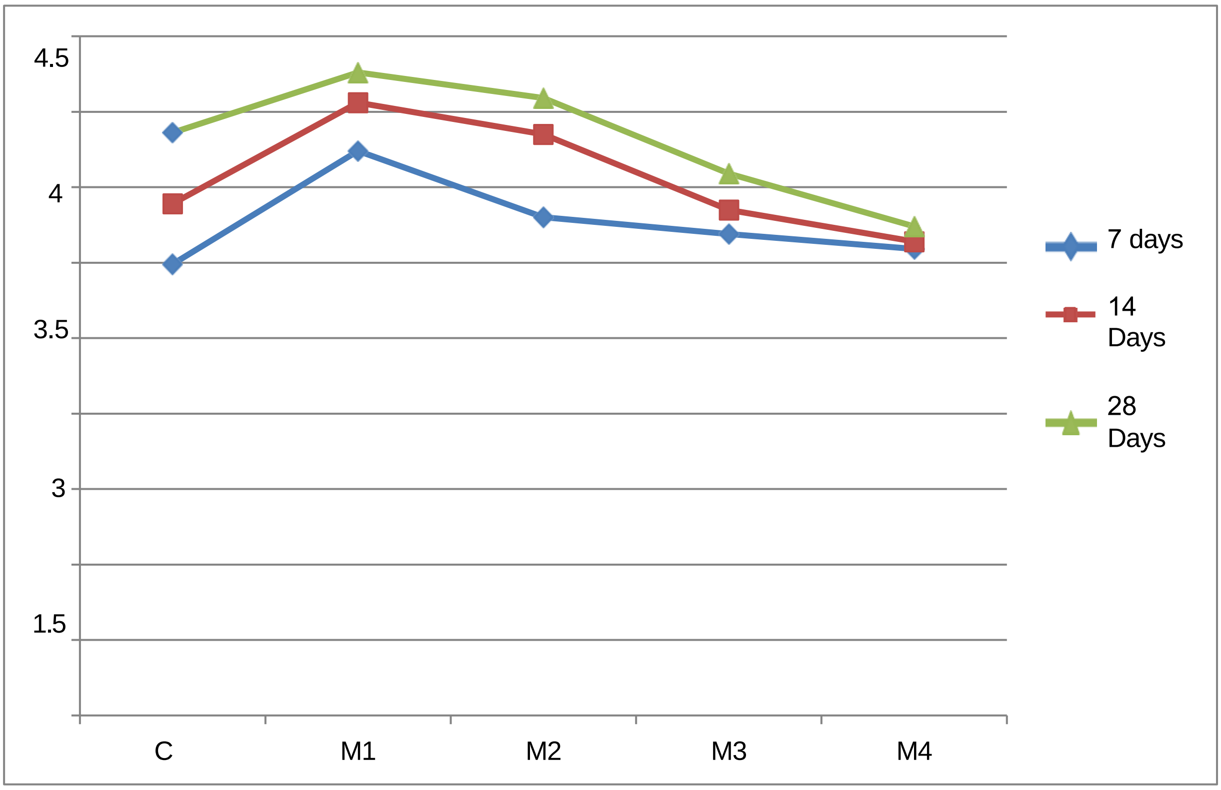
International Journal of Engineering Research and Science & Technology
ISSN 2319-5991 www.ijerst.com
Vol. 17, Issue.2, May 2024

7.2. SPLIT TENSILE STRENGTH TEST

Table.2.split tensile strength test

Split Tensile Strength (MPa)										
Curing age (days)	**0% MK 0% FS**		**10% MK 10% FS**		**10% MK 15% FS**		**10% MK 20% FS**		**10% MK 25% FS**	
7	2.98	2.99	3.75	3.74	3.99	3.3	3.55	3.19	2.81	3.09
	3		3.89		3.21		2.89		3.12	
	2.99		3.59		2.71		3.15		3.33	
14	3.37	3.39	3.97	4.06	4.12	3.85	3.45	3.35	2.92	3.14
	3.39		4.45		3.8		3.32		3.12	
	3.41		3.78		3.62		3.27		3.39	
28	3.81	3.86	4.24	4.26	4.2	4.09	3.36	3.59	2.9	3.24
	3.91		4.59		3.88		3.4		3.26	
	3.86		3.95		4.18		4.01		3.57	

International Journal of Engineering Research and Science & Technology
ISSN 2319-5991 www.ijerst.com
Vol. 17, Issue.2, May 2024



Split tensile strength test results

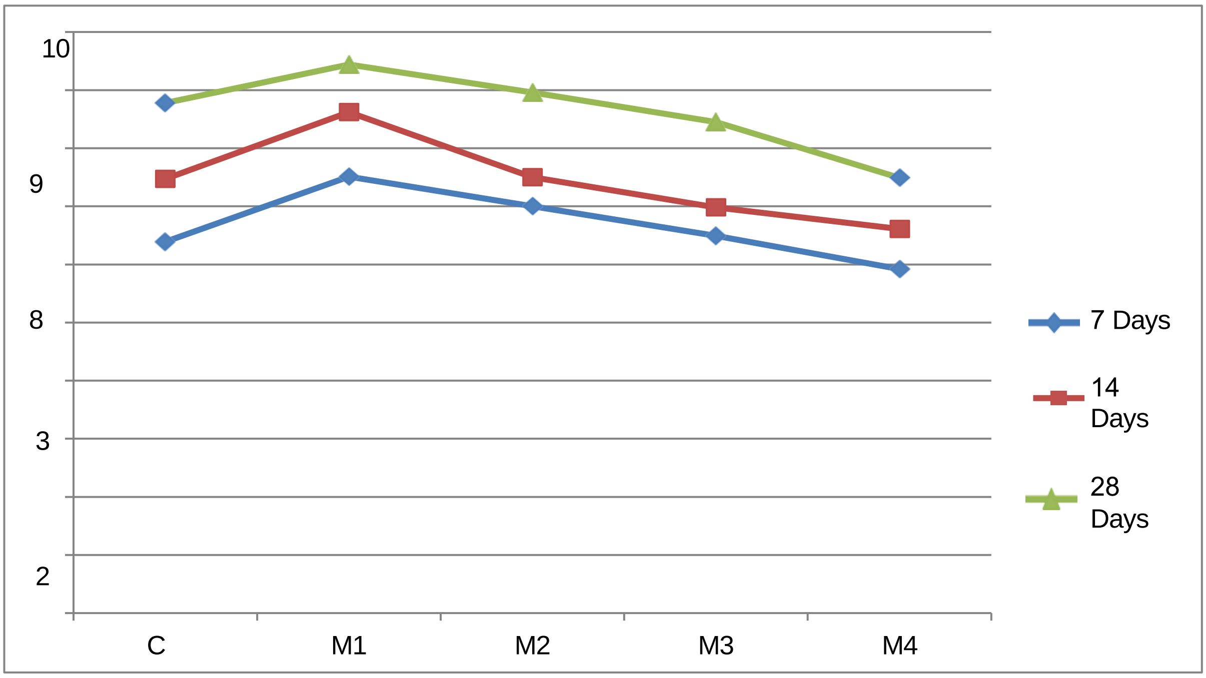
7.3. FLEXURAL STRENGTH TEST

Table.3.flexural strength test

Flexural strength (MPa)										
Curing age (days)	**0% MK**		**10% MK**		**10% MK**		**10% MK**		**10% MK**	
	0% FS		**10% FS**		**15% FS**		**20% FS**		**25% FS**	
7	6.38	6.39	7.61	7.51	7.2	7	6.48	6.49	6.43	5.92
	6.42		7.89		6.93		5.9		5.77	
	6.37		7.32		6.89		7.09		5.58	
14	7.44	7.47	8.22	8.62	7.99	7.5	6.75	6.98	6.97	6.61
	7.49		9.14		7.13		7.2		6.53	
	7.48		8.5		7.38		7		6.34	
28	8.76	8.78	9.45	9.44	9	8.96	8.23	8.45	7.15	7.49
	8.78		9.1		9.09		8.51		7.9	
	8.8		9.77		8.8		8.6		7.43	

ISSN 2319-5991 www.ijerst.com

Vol. 17, Issue.2, May 2024



Flexural Strength test results

CONCLUSION

- It was observed that as the percentage of foundry sand increases, the workability decreases because of the presence of finer particles.
- Due to the addition of 10% metakaolin, high early strengths were observed in the mix.
- It was observed that there is an increment in compressive strength of 22% as compared with control mix after 28days.
- It was observed that there is an increment in split tensile strength of 10.36% as compared with control mix after 28days.
- It was also observed that there is an increment in flexural strength of 7.5%as compared with control mix of 28days.
- The maximum flexural strength of concrete is observed when foundry sand replaces sand by 10%. But on further replacement of sand with foundry sand, the flexural strength decreases.

REFERENCE

1.Luc courard "durability of motar modified with metakaolin", cement and concrete research, 2003.

2.E. Badogiannis, G. Kakali and S. Tsivilis "Metakaolin as Supplementary Cementitious Material", Journal Of Thermal Analysis and Calorimetry, Vol. 81 (2005) 457–462.

3. Rafat Siddique "Influence of metakaolin on the properties of mortar and concrete", Applied Clay Science 43 (2009).

International Journal of Engineering Research and Science & Technology
ISSN 2319-5991 www.ijerst.com
Vol. 17, Issue.2, May 2024

4.Rafat Siddique "Effect of used-foundry sand on the mechanical properties of concrete" Construction and Building Materials 23 (2009).

5. M. Shekarchi "Transport properties in metakaolin blended concrete", Construction and Building Materials 24 (2010).

6. Rafat SIDDIQUE " Properties of Self-Compacting Concrete Incorporating Waste Foundry Sand" 23, July-December 2013.

7. Shakir A. Al-Mishhadani "The Effect Of Nano Metakaolin Material On Some Properties Of Concrete",Diyala Journal of Engineering Sciences, 2013.

8. Kiran K. Shetty " self compacting concrete using red mud and used foundry sand" Volume: 03 Special Issue: 03 | May-2014 | NCRIET-2014.

9. Sadaqat Ullah Khan "Effects of Different Mineral Admixtures onthe Properties of Fresh Concrete,Scientific World Journal Volume 2014.

10. Guang Jiang "Effects of metakaolin on mechanical properties, pore structureand hydration heat of mortars at 0.17 w/b ratio", Construction and Building Materials 93 (2015).

11. O.R. Kavitha " Fresh, micro- and macrolevel studies of metakaolin blended self-compacting concrete", Applied Clay Science 114 (2015).

12.Preeti Pandey "Utilization of Waste Foundry Sand as Partial Replacement of Fine Aggregate for Low Cost Concrete" Dec 2015.

13. P YAZHINI "Experimental investigation on self compacting concrete with foundry sand and tile powder" June 2016.

14.Prof. S.R. Vaniya "A Study on Properties of Self-Compacting Concrete with Manufactured Sand as Fine Aggregate: A Critical Review" *Jan. - Feb. 2016.*

15.S.RamaKrishna Raju "A Study on Compressive Strength of Self-Compacting Concrete Using Portland Slag Cement with Partial Replacement of Fine Aggregate by Foundry Sand" April 20