Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 04, April-2016

Experimental Study on Compression and Flexure Test on SBR Latex Modified Polypropylene Fiber Concrete

Harish G R
Research Scholar & Professor,
Faculty of Engineering – Civil
UVCE, Bangalore University
Bangalore, India.

Dr. Sadath Ali Khan Zai
Associate Professor,
Faculty of Engineering – Civil
UVCE, Bangalore University,
Bangalore, India.

Chandramouli S V
SHM Consultant,
SCM Consultancy and Engineering services
Bangalore, India.

Abstract— **Although, polymer-modified concretes have excellent bonding properties and durability, the relatively low toughness of polymer-modified concretes is still a concern for practical applications under seismic loading or severe service condition, especially for high strength concrete. Few experimental results have shown that there is improvement of mechanical properties such as strain capacity in concrete by incorporating fiber or latex but this is still to be quantified with more experimental tests which will change the design parameters with enhanced ductility of these structures. The issue of ductility and methods of increasing ductility is one of the most active areas in the study of concrete structures. This research include experimental study on compression and flexure test as per the specification of IRS T-39-85 on Styrene Butadiene Rubber (SBR) polymer modified Polypropylene fiber concrete test specimens in comparison with test specimens of other four reference concrete mixes. The results prove that although the compression strength reduces with the addition of SBR latex but for M60+SBR+Fiber test specimens the rate of gain of compression and flexure strength is fast as well with higher flexural strength in comparison with other reference concrete matrices in this investigation.**

Keywords— Polymer-Modified concretes; Polypropylene fiber; Styrene-Butadiene Rubber (SBR); Compression test; Flexural test

I. INTRODUCTION

Developing Countries are trying their best to achieve rapid progress, and major contribution involves large-scale construction activities. Among various construction materials, concrete is a widely used construction material and regarded for its high strength and insulating capability, among other characteristics. Nevertheless, it has several limitations, including low tensile strength and poor environmental durability.

In recent years, considerable interest has developed to solve these problems; various approaches have been tried, for example mechanical method by adding fibers, chemical method by adding latexes, special cements, admixtures and combination of both fibers and latexes.

Among various methods, use of fiber has been recognized as a finer reinforcement. The Addition of fibers, in a correct percentage for structural purposes, improves the post peak ductility performance, pre-crack, tensile strength, fracture strength, toughness, impact resistance, flexural Strength resistance, load carrying capacity, fatigue performance, reduce brittleness, etc. The ductility of fiber reinforced concrete depends on the ability of the fibers to bridge cracks at high levels of strain.

Steel fibers and synthetic fibers (such as polypropylene, polyethylene, PVA and carbon fibers) are now the most common fiber types. Their performance depends on their elastic modulus, aspect ratio, surface texture, and also on the matrix type and the bonding properties between the fibers and matrix. Polypropylene/polyethylene (PP) fibers are currently the most commonly used synthetic fibers. Polypropylene fibers are non-Magnetic, rust free, Alkali resistant, chemically inert, compatible with all concrete chemical admixtures, safe, handled with ease, premixed in a conventional manner, decreases the unit weight of concrete with increases its tensile strength, easy to use and comparatively cheaper. Due to these qualities the concept of polypropylene fiber concrete has added an extra dimension to concrete construction. From the various studies it is observed that the compressive strength did not change significantly, but tensile strength had an increase of about 80 percent, [16]. Improves ductility, energy absorption capacity and impact strength of concrete based on good choice of length and content in fibers [17]. Reduction in water permeability, do not promote shrinkage cracking, particularly effective for arresting shrinkage cracks at early ages and studies have showed has no significant effect on chloride permeability of concrete materials [15] [17].

Additional to the above developments in improvising concrete properties, the conventional concrete materials combined with polymers could yield composites with excellent mechanical and physical properties. Polymer-modified concrete is portland cement concrete with polymer materials added to the mix to achieve certain properties. Polymer materials with wide variations in properties could

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 04, April-2016

provide complex properties to polymer modified concrete, and thus, present an opportunity to design structural materials with tailored properties. Polymer-modified Concrete (PMC) has also been called polymer-Portland cement-concrete (PPCC) and latex-modified concrete (LMC).

Much research and construction experience since 1960 has demonstrated that cement-based composites with a suitable polymer latex exhibit superior bonding to old concrete and to steel rebar, good ductility, lower permeability and better durability characteristics such as improved resistance to freeze-thaw cycling, decreased depth of carbonation, and reasonable chemical resistance.

Several types of polymer such as latex, redispersible polymer powder, water soluble powder, liquid resins and monomers modified concrete are used. Styrene-Butadiene Rubber (SBR) latex is one of the products widely used in practice to prevent the negative effects of deicing salts. Other system include PolyChloroprene Rubber (CR), PolyAcrylic Ester (PAE), Poly (Ethylene-Vinyl Accetate) (EVA) and poly (vinylidene chloride-vinyl chloride) (PVDC) copolymers. Although polymers and monomers are used in cement composites it is very important that cement hydration and polymer phase formation proceed well to yield a monolithic matrix phase with network structure, in which the hydrated cement phase and polymer phase interpenetrate; also the aggregate are bounds by such co-matrix phase resulting in the superior quality of polymer modified concrete compound. In general, Polymer latex modified concrete also provides increased strength and higher impact resistance.

Polymer modified concrete has a longer maintenance-free service life than PC and possesses also other advantages compared to PC such as: increased bond strength (bonding to previously existing concrete ; increased flexural, compressive and tensile strengths Investigations have been made to determine the behavior of latex modified concrete. It is concluded that compressive strength is slightly increased when the polymer-cement ratio used up to 7%. About 40% flexural strength increased for concrete modified with 7% of polymer admixture in relation to the control specimen [12]. The polymer modified concrete beams have a stiffer response in terms of structural behavior, and have more ductility than those made by reference concrete and that refer to good role of Styrene Butadiene Rubber (SBR) polymer on the properties and behavior of reinforced concrete beams . The hardened latex-modified concretes develop good strength, adhesion, pore structure, impermeability, and durability (freeze-thaw resistance, chloride penetration resistance, carbonation resistance, and weatherability) compared to normal concretes. These improvement in the properties depended on the quantity of styrene-butadiene rubber latex, the air-void spacing factor, and the water-cement ratio. [2] [11]

Overall, polymer and fiber combinations appear to have great effects on the impact resistance of cementitious materials. Polymer Modified (PM) concrete can be enhanced by the use of fibers (FRC) to yield improved tensile strength and reduced cracking. The advantages are excellent bond strength to concrete, higher flexural strength, and lower permeability.

Concrete structures rely largely on the deformation and yielding of the tensile reinforcement to satisfy the ductility demand. Ductility is also the basis of modern structural design approaches (for example, moment redistribution). The issue of ductility and methods of increasing ductility is one of the most active areas in the study of concrete structures. Although polymer-modified concretes have excellent bonding properties and durability, the relatively low toughness of polymer-modified concretes is still a concern for practical applications under seismic loading or severe service condition, especially for high strength concrete. Few experimental results have shown that there is improvement of strain capacity in concrete by incorporating fiber or latex but this is still to be quantified with more experimental tests which will change the design parameters with enhanced ductility of these structures.

Progress in the area of polymers and fiber in one concrete system has been fairly slow, partly due to the high material cost which may discourage industrial applications, and partly due to the lack of experimental data on the new composites; thus, the potential high performance of these materials has been neglected. Now, however, concretes, and particularly high strength concrete, containing polymers and fibers are of growing interest .Polymer modified cement-based materials and fiber reinforced cementitious composites show great advantages, especially in repair and rehabilitation in civil engineering applications. From the literature survey it is found that full understanding of the combined use of fibers and polymers or Latex in one system is rarely studied. The aim of this investigation is primarily to study the SBR Latex and Polypropylene Fibers combined with high strength concrete.

II. PRESENT STUDY

In this research, consists of casting and testing of cubes and prisms specimens of five concrete matrices (i) M55 (M55 Grade of concrete), (ii) M60 (M60 Grade of concrete), (iii) M60+SBR (SBR Latex combined with M60 Grade of concrete), (iv) M60+Fiber (Polypropylene Fibers combined with M60 Grade of concrete) and (v) M60+SBR+Fiber (SBR Latex and Polypropylene Fibers combined with M60 Grade of concrete). The experimental studies include casting and testing of thirty (30) cube specimens (fifteen steam cured and fifteen water cured) for compression test, fifteen (15) prism specimens for flexural test. The test is conducted as per IS: 516:1959 [7] and IRS T-39-85 [3] specifications.

III. MIX PROPORTIONING

A concrete mix grade of M55 and M60 was aimed in the present investigation, the design mix proportion was obtained by Erntroy and Shaklock's Empirical/Graphical Method of mix design for high strength concrete. Based on the same, the target strength of design mix M60 grade concrete was achieved by trial and error method.

The concrete mix investigated in this study is prepared with standard 53 grade Portland cement, fine aggregate, coarse aggregate, portable water, Polypropylene fiber (RECRON-3S, FT2024, 12 mm fiber cut length is adopted), Super-plasticizer (GleniumACE-30), Silica fume(micro silica) and styrene butadiene rubber emulsion (SBR)-latex confirming to specifications of Indian standards were included

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 04, April-2016

in this mix proportion as per the predetermined optimum percentages subject to the required workability.

Tests on trials mixes was carried out & finally a mix proportion that gives required 15 days cube compressive strength in par with IRS T-39-85 Specifications with minimum cement content and required workability of 50 - 100mm was selected. 10% of silica fume is replaced by weight of cement, 10% of SBR-Latex, 0.25% of polypropylene fibers and 0.6% of Super plasticizer by weight of cementitious materials were included into the concrete mix in the present investigation. Final mix proportions for the matrices used in the present investigation.

TABLE I. MIX PROPORTION SELECTED FOR STUDY

Mix	Cement	Fine Aggregate	Coarse Aggregate	w/c	Water	w/B	A/C	SBR	Poly Propylene Fiber	Super Plasticizer	Silica Fumes	Compressive Strength (Steam Cured)	Compressive Strength (Water cured)
	(kg/m³)	(kg/m³)	(kg/m³)		(kg/m³)			(kg/m³)	(kg/m³)	lts	(kg/m3)	Mpa	Mpa
M 55	465	465	1394	0.33	153	-	3.0	-	-	-	-	42	57
M 60	441	450	1354	0.31	151	0.31	3.07	-	-	2.64	49	58	68.9
M 60 + SBR	441	450	1354	0.28	126	0.257	3.07	49	-	2.64	49	42.2	62
M 60 + Fiber	441	450	1354	0.33	151	0.31	3.07	-	1.225	2.64	49	57.8	71.1
M 60+ SBR + Fiber	441	450	1354	0.3	126	0.257	3.07	49	1.225	2.64	49	59.2	63.2

IV. TESTING METHODOLOGY

The experimental test program includes the following tests as per the specification of IRS T-39-85 and As per IS: 516:1959 (Reaffirmed 1999) on test specimens with five different concrete matrixes

- Compression test: The cubes of size 150mm are tested in 200T (2000kN) capacity compressive testing machine to get the compressive strength.
- Flexural test: The flexural strength test for concrete employs a prism specimen of 100x100x500mm size and cured for 15 days. The prism specimens is placed in machine such a way that the load is applied to the upper most surface as cast in the mold, along two – lines spaced 13.3cm apart. The load is applied without shock and increasing continuously at a rate such that extreme fiber stress increased at approximately 0.7 Kg/cm²/min that is, 180 Kg/min, the load is increased until the specimen failure.

V. RESULTS AND DISCUSSION

A. *Result and discussion on Compression test on cube specimen:*

The experimental compressive strength values obtained for different concrete mixes at 3, 7 and 15-days are tabulated in Table 2 and the same is shown in Figure 1 and Figure 2. As per the IRS T-39-85 specifications the minimum compressive strength for 15-days with water curing is 55.00 N/mm².

TABLE II. SUMMARY OF 3, 7 AND 15 DAYS COMPRESSIVE STRENGTH OF TEST SPECIMENS

	Compressive strength				
Age	M55	M60	M60+ SBR	M60+ Fiber	M60+ SBR+ Fiber
Days	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²
3	15.55	24.84	19.00	22.00	16.50
7	37.52	39.16	38.20	44.00	38.55
15	57.00	68.88	62.00	71.11	63.20

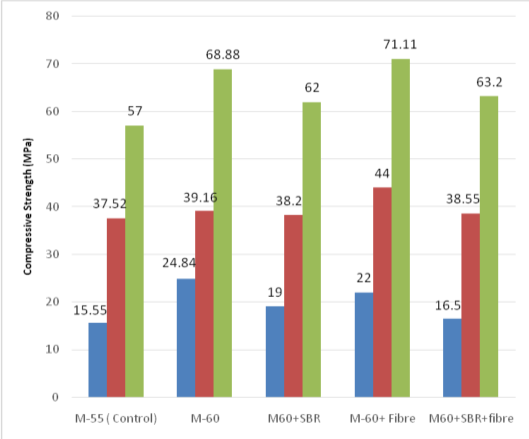

Fig. 1. Comparisons of Compressive Strength of different concrete matrices

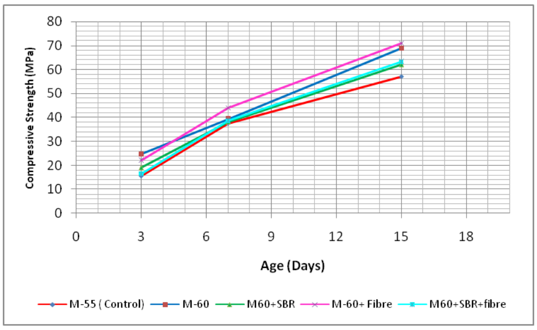

Fig. 2. Comparison of Compressive Strength with Age of different concrete matrices

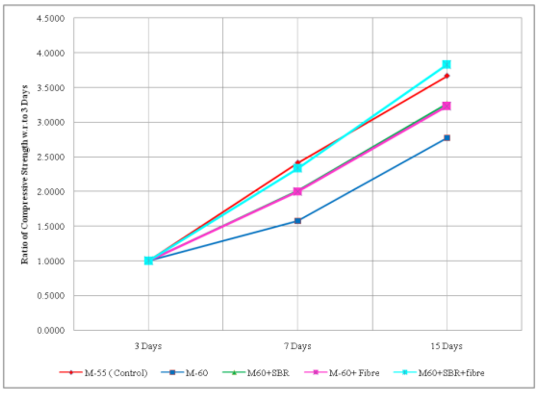

Fig. 3. Ratio of Compressive Strength with Age in terms of 3 Days Strength

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 04, April-2016

From the Table 2 the compressive strength of M-55(Control), M-60, M60+SBR, M-60+Fiber and M60+SBR+Fiber is 57.00 N/mm^2, 68.88 N/mm^2, 62.00 N/mm^2, 71.11 N/mm^2 and 63.20 N/mm^2 respectively which is more than the prescribed strength as per IRS T-39-85 and the same is higher than the minimum specified by IRS T-39-85 by 3.64%, 25.24%, 12.73%, 29.29% and 14.91% respectively. Figure 3 indicates the rate of gain of compressive strength with age of different concrete matrices in comparison to 3 days reference strength. It can be noted that the rate of gain of the strength is highest for M60+SBR+Fiber in comparison with other concrete matrices used in this investigation.

B. Result and discussion on Flexural Strength test on prism Specimen

Flexural strength is expressed in terms of "Modulus of rupture" which is the maximum tensile (or compressive) stress at rupture. Table 3 shows the results of 3, 7 and 15 days flexural strength and comparison of flexural strength of various concrete matrices M 55, M 60, M 60 + SBR, M 60 + Fiber, M 60+ SBR + Fiber concrete prisms and the corresponding graphs are shown in Figure 4 and Figure 5.

As per IRS T-39-85 specifications: Third Edition 2009, the test for 15 day modulus of rupture of concrete shall be carried out on concrete beams of 10 x 10 x 50 cm size as specified in IS:516, flexural strength of concrete should not be less than 5 N/mm^2, when cracks occur within middle third of the span.

TABLE III. SUMMARY OF 3, 7 AND 15 DAYS FLEXURAL STRENGTH OF TEST SPECIMENS

	Flexural strength				
Age	**M55**	**M60**	**M60+ SBR**	**M60+ Fiber**	**M60+ SBR+ Fiber**
Days	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2
3	4.95	5.82	6.20	6.00	6.04
7	6.75	7.80	8.50	8.00	8.40
15	9.00	10.4	11.2	10.60	11.70

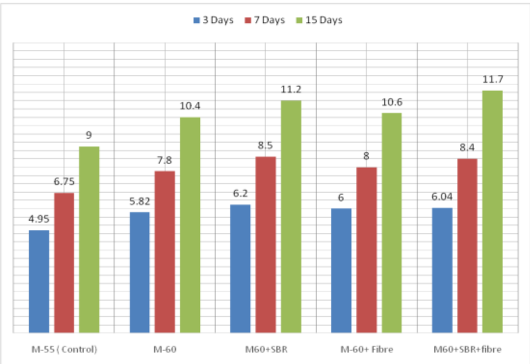

Fig. 4. Comparisons of Flexural Strength of different concrete matrices

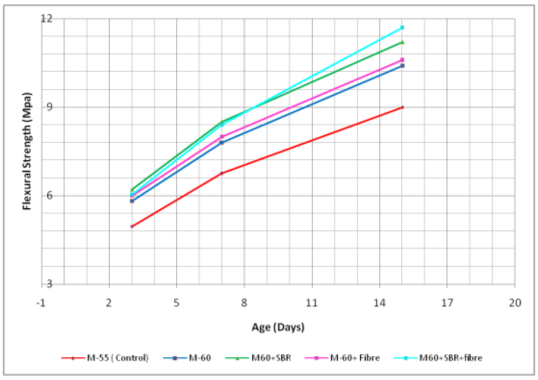

Fig. 5. Comparison of Flexural Strength with Ages of different concrete matrices

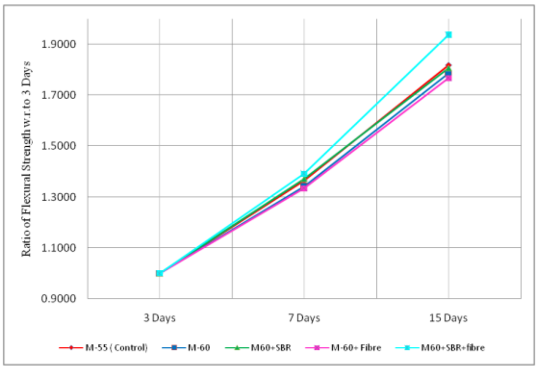

Fig. 6. Ratio of Flexural Strength with Age in terms of 3 Days Strength

From the Table 3 the flexural strength of M-55(Control), M-60, M60+SBR, M-60+Fiber and M60+SBR+Fiber test specimen is 9.00 N/mm^2,10.4N/mm^2, 11.2 N/mm^2, 10.6 N/mm^2 and 11.70 N/mm^2 respectively and the same is about 1.8, 2.08, 2.24, 2.12 and 2.34 times higher w.r.to minimum value as specified by IRS T-39-85. Figure 6 indicates the rate of gain of flexural strength with age in comparison to 3 days reference strength. It can be noted that the rate of gain of strength is highest for M60+SBR+Fiber test specimen in comparison with other concrete matrices and also shows higher flexural strength compared to other concrete matrices in this investigation.

CONCLUSIONS

This research include experimental study on compression and flexure test as per the specification of IRS T-39-85 on Styrene Butadiene Rubber (SBR) polymer modified Polypropylene fiber concrete test specimens in comparison with test specimens of other four reference concrete mixes. From this present study following are the conclusion,

- The compressive and flexural strength of the specimens were increased with addition of polypropylene fiber as the concrete becomes stiffer and decreases with SBR latex as it softens the concrete.
- The significant role of polypropylene fiber is resisting the formation and growth of cracks was observed in all specimens with fiber. As a conclusion, it is understood that polypropylene fiber addition increases the performance of the concrete element.

- The rate of gain of the compressive strength is faster for M60+SBR+Fiber in comparison with other concrete matrices used in this investigation i.e. 3.83 times than that of 3 days strength while M55, M60, M60+ SBR and M60+ Fiber had 3.66, 2.77, 3.26 and 3.23 respectively.
- The rate of gain of the flexural strength is faster for M60+SBR+Fiber in comparison with other concrete matrices i.e. 1.93 times than that of 3 days strength while M55, M60, M60+ SBR and M60+ Fiber had 1.82, 1.79, 1.81 and 1.77 respectively.
- The M60+SBR+Fiber specimens showed higher flexural strength compared to other concrete matrices in this investigation.
- The results prove that although the compression strength reduces with the addition of SBR latex but for M60+SBR+Fiber test specimens the rate of gain of compression and flexure strength is fast as well with higher flexural strength in comparison with other reference concrete matrices in this investigation.

REFERENCES

[1] Bayasi Z., Melntyre M., "Application of fibrilled polypropylene fibers for restraint of plastic shrinkage cracking in silica fume concrete", ACI Material Journal, Vol. 99, No. 4, 2002, pp. 337-344.
[2] Bordeleau, D., Pigeon, M. and Banthia, N., "Comparative Study of Latex Modified Concretes and Normal Concretes Subjected to Freezing and Thawing in the Presence of a Deicer Salt Solution", ACI Materials Journal, 1992, Vol-89, No 6, pp. 547-553
[3] IRS: T-39-85, Third Revision, Indian railway Standard specification for Pre-tensioned prestressed concrete sleepers for Broad gauge and Meter gauge.
[4] IS: 10262 Concrete mix proportioning- guidelines, Bureau of Indian Standards, New Delhi, India, 2009.
[5] IS: 383, Specification for Coarse and Fine Aggregates from natural sources for Concrete, Bureau of Indian Standards, New Delhi, India, 1970.
[6] IS: 456, Plain and Reinforced Concrete Code of Practice, Bureau of Indian Standards, New Delhi, India, 2000
[7] IS: 516, Methods of tests for strength of concrete, Bureau of Indian Standards, New Delhi, India, 1959.
[8] IS: 5816, Splitting tensile strength of concrete- method of test, Bureau of Indian Standards, New Delhi, India, 1999.
[9] Jankovic, K.and Loncar, L., "Polymer modified concrete with expanded polystyrene grains reinforce with polypropylene fibers", ACI SP-200-29, June, 2001, pp483-490.
[10] Mantegazza, G., Perm, A . M . and Tattoni, S., "Modification of cement mortars by polymeric and their use for repairing concrete", ACI SP148-24, 1994, pp415-433.
[11] Ohama, Y., "Principle of latex modification and some typical properties of latex modified mortars and concretes adhesion; binders (materials); bond (paste to aggregate); carbonation; chlorides; curing and diffusion", ACI Materials Journal, November 1987,Volume-84, Issue-6, pp. 511-518
[12] Radomir J. Folic, and Vlastimir S.R., (1998)," Experimental Research on Polymer Modified Concrete", ACI Materials Journal, 95(4), pp 463-469.
[13] Rajendar Chalisgaonkar, "Computer Aided Concrete Mix Design", Allied Publishers, ISBN 9788177644562.
[14] Segre, N., Tonella, E. and Joekes, I. "Evaluation of the stability of polypropylene fibers in environments aggressive to cement-based materials", Cement and Concrete Research, Vol.28, No. 12, 1998, pp. 1809- 1817
[15] Soroushian P., Mirza, F. and Alhozaimy "Permeability Characterstics of Polypropylene fiber reinforced concrete" ACI materials journal, V.92, No.3, pp 291-295, May-June 1995.
[16] Tavakoli, M., "Tensile and compressive strengths of Polypropylene fiber reinforced concrete", ACI SP-142, Fiber Reinforced Concrete: Developments and Innovations, 1994, pp. 61-72.
[17] Toutanji H., Meneil S., Bayasi Z., "Chloride permeability and impact resistance of polypropylene-fiber-reinforced silica fume concrete", Cement and Concrete Research, Vol. 28, No. 7, pp. 961-986, 1998.
[18] Tu L; Kruger D; Wagener JB; Carstens Pab, "Surface-Modified Polypropylene Fibers For Use In Concrete", Magazine of Concrete Research, Sept 1998, Vol. 50 No.3, pp. 209-217
[19] Zakzria K. A. and Mohammed M. H. (2011, June)."Graphical method of concrete mix design". Al-Rafidain Engineering Journal, Vol. 19, 1-12.