EXPLORATORY USE OF FOUNDRY SAND AND FLY ASH IN CONCRETE MIX

Aadil Altaf[1], Tapeshwar Kalra[2]

1. M.Tech. in Structural Engineering S.E.C.T, Rajpura (Pb.) 140417.
2. Assistant Professor ,Deptt of Civil Engg S.E.C.T, Rajpura (Pb.) 140417.

Abstract- Concrete is the most widely utilized "man-made" material globally for construction in many developing countries in all types of civil engineering works. Also, concrete is an environmental - friendly material and in areas of growing environment – related awareness that is of prime importance.. It also makes concrete sustainable. In India presently less than 50% of fly ash produced is consumed. The potential for using fly ash as a supplementary cementitious material in concrete has been known almost since the start of the last century . Reusing is acknowledged to be one of the vital bases of supportability. Presently days we are attempting to use all sort of item, regardless of whether they are metal, solid, plastic, wood, or even glass, will in the end transform into squanders that must be arranged. The most ideal approach to manage such sort of squanders is to reusing, recuperation and reuses them as crude materials or modifiers. This will lessen the deplete on the common assets of the crude materials, and it will decrease the spaces utilized as landfills. Among all these fly ash debris and waste foundry sand squander create by the Industrial enterprises.In this study fly ash and waste foundry sand were used to replace natural aggregate depending on the fineness of particles. Concrete has become the most widely accepted and used construction material in civil engineering industry, the incorporation of fly ash and foundry sand particles in concrete would be a very good and promising way to utilize the large quantities of wastes like fly ash and foundry sand. Fly ash and waste foundry sand used as particles in concrete would not only make a use of such waste materials but also help to improve some concrete properties. The concrete containing fly ash and foundry sand have excellent ductility and improved mechanical properties as compared with conventional or controlled concrete. This work studies the effects of fly ash and foundry sand as aggregate and filler as a partial replacement of natural aggregate in the cement concrete. The primary aim of this study was to evaluate the strength property of concrete. This Study has shown that replacing some percentage of natural aggregates by fly ash and foundry sand causes significant change in properties of concrete. The properties studied are 7days, 28days compressive strengths and flexural strength, etc.

***Keywords*- Fly Ash, Foundry Sand, Compressive Strength, Flexural Strength etc.**

1.INTRODUCTION

Concrete is most widely used man-made construction material in the world on the planet. Concrete is primarily made up of four fundamental ingredients, i.e. coarse aggregate, fine aggregate (i.e. sand), cement and water.
Concrete occupies a unique place among modern construction materials. It gives freedom to mould the structure to any shape. When the concrete mixture is placed in mould and allowed to cure, it hardens into a rock-like mass. The hardening of the mixture is caused by chemical reaction between water and cement and it continues for a long time. More than 90% of the structures ranging from buildings, retaining walls, dams, roads and bridges etc. utilize the concrete as a construction material. Good concrete should be able to resist corrosion; wear and it should be water-tight and economical. The concrete is most important construction material which is manufactured at site.

The concrete must be strong enough to withstand all the imposed stresses without injury and the required factor of safety.

2. LITERATURE REVIEW

Khatib and Ellis carried out a research on the compressive strength of concrete prepared with three types of foundry sand as a partial replacement for fine aggregate. *Siddique et al.* determined the effect of spent foundry sand as partial replacement of fine aggregate on the splitting tensile strength of concrete. *Brown, J.H.* study the replacement of fly ash with cement and fine aggregate at levels of 10-40% by volume. *Carette and Malhotra* studied in this research they studied the effect of Canadian fly ashes on the mechanical property of concrete mixes. *Gebler and Klieger* investigated the requirements of Air Entraining Agent for Class-C and Class-F fly ashes. *Ho and Lewis* investigated the carbonation rates of three types of concrete mixes. *Guney et al.* investigated the potential re-use of waste foundry sand in high-strength concrete production. *S. Kolawole*, studied the concrete produced at different percentage of foundry sand ranging from 0% to100% in steps of 25% of dry weight of fine aggregates.

Xerses N. Irani et, al. studied experimental investigations were performed such as compressive strength test, Split tensile strength test, flexural strength test on the concrete containing (0%, 10% and 100% replacement of e foundry waste sand in place of fine aggregat*J. Virtanen,* evaluated the freezing and thawing resistance concrete made with fly ash. *Owens* in his study reported that with the use of fly ash containing large fraction of particles coarser than 45µm or a fly ash with high amount of unburned carbon, exhibiting loss on ignition more than 1%, higher water demand was observed. *Joshi and Lohtia* in their paper tested a large number of fly concrete mixes made by using three different fly ashes containing about 10% calcium oxide. The replacement level varied between 40 and 60% by weight of cement. *Naik et al.* in their research evaluated the influence of addition of large amounts (50 and 70% cement replacement) of Class C fly ash on the chloride permeability of concrete. *Lohtia et al.* studied the creep and creep recovery of plain and fly ash concretes at stress-strength ratios of 20 and 35%. *P.K. Mehta,* concluded that fly ashes are amongst the group of pozzolans that significantly increase the life expectancy of concrete exposed to sulfate attack. *R. Siddique,* studied the abrasion resistance of concrete proportioned to have four levels of fine aggregate replacement (10 to 40%) with Class F fly ash. *Saraswathy et al.*investigated the influence of activated fly ash on the compressive strength of concrete. *R. Siddique,* studied the effect of partial replacement of fine aggregate (sand) with varying percentages of Class F fly ash on the compressive strength, splitting tensile strength, flexural strength and modulus of elasticity of concrete up to the age of 365 days. *Atis et al.* assessed the drying shrinkage of mortar mixtures containing high calcium non standard fly ash up to the age of 5 months. *Chalee et al.* studied the effect of W/C ratio on covering depth required against the corrosion of embedded steel of fly ash concrete in marine environment up to 4-year exposure. *Demirboga et al.* investigated the Thermal Conductivity (TC) of HVFA concrete at the age of 28 days. Cement was replaced with 0, 50, 60, and 70% of Class C fly ash. *Siddique et al.* studied the mechanical properties of concrete mixtures in which fine aggregate (regular sand) was partially replaced with used-foundry sand.

3. PROPERTIES OF MATERIALS

3.1 Fly Ash

Fly ash used in the study was obtained from Bathinda. Its physical and chemical properties are given in Table 3.1 and Table 3.2 respectively. Fineness modulus of fly ash was 100 µ -90 µ.

Table 3.1 Physical properties of fly ash.

Characteristics	Value
Colour	Whitish grey
Bulk density (kg/m^3)	1125
Specific Gravity	2.15
Fineness	2830 cm^2/gm

Table 3.2 Chemical properties of fly ash.

Constituent	Component in %
Silica (SiO_2)	46.1
Alumina (Al_2O_3)	23.9
Ferric Oxide (Fe_2O_3)	13.6
Calcium Oxide (CaO)	1.4
Magnesia (MgO)	1.3
Loss of Ignition	7.3

3.2 Foundry Sand

Foundry sand procured from *Delux Foundry* from Mandi-Gobindgarh, Patiala. For laboratory applications it was crushed using manual means. The physical and chemical properties of the foundry sand used in this investigation are listed in Table-3.3 and Table-3.4 respectively. F.M of foundry sand is 1.19.

Table 3.3 Physical properties of Foundry Sand.

Characteristics	Value
Water absorption	1.69%
Bulk density (kg/m^3)	1460
Specific Gravity	2.68
Porosity	38.47%
Voids Ratio	0.62
Moisture Content %	0.1-10.1

Table 3.4 Chemical properties of Foundry Sand

Constituent	Value
SiO_2	87.91
Al_2O_3	4.70
Fe_2O_3	0.94
CaO	0.14
MgO	0.30
SO_3	0.09
Na_2O	0.19
K_2O	0.25
TiO_2	0.15
Mn_2O_3	0.02
SrO	0.03
LOI	5.15
Total	99.87

3.3 Portland Cement

Portland cement is a fine, grey powder. Cement is mixed with water and materials such as sand, gravel, and crushed stone to make concrete**.** In this work Birla Plus of 43grade was used for casting cubes and cylinders for all concrete mixes. The various tests conducted on cement are initial and final setting time, specific gravity, fineness and compressive strength. Cement used fulfill requirement as per IS: 8112-1989.

3.4 Fine Aggregates

The sand used for the work was locally procured and conformed to Indian Standard Specifications IS: 383-1970. The sand was sieved through 4.75 mm sieve. The various other tests conducted are specific density, bulk density, fineness modulus, water absorption and sieve analysis to meet all the requirements of IS 383-1970. The fine aggregated belonged to grading zone II. This Aggregate has absorption of 0.89 %. The Bulk Specific Gravity of the fine aggregate was 2.60 while its SSD Specific Gravity was 2.59.F.M of fine sand is 2.62.

3.5 Coarse Aggregates

The material which is retained on IS sieve no. 4.75 is termed as a coarse aggregate. The crushed stone is generally used as a coarse aggregate. The aggregates were tested as per IS: 383-1970.Coarse aggregate having Fineness Modulus is 6.95

4 RESULT & DISCUSSION.

4.1 Compressive strength

Cubes were molded with a 150 X 150 X 150 mm in size to determine the compressive strength of the concrete mixtures. The cubes were tested at 7 and 28 days as per IS 516-1959. Figure -4.1 & 4.2 shows that the compressive strength of all the specimens at 7 &28 days. Table -4.1, provides the compressive strength of concrete for 7 and 28 days for all the specimens.

Table 4.1: Compressive strength of concrete mixes of specimen size150 ×150× 150 with Foundry Sand and 5% and 10% Fly ash.

Mix	Fly Ash %	Compressive Strength (N/mm^2)		Average Compressive Strength (N/mm^2)	
Days ⟶		7 days	28 days	7 days	28 days
CM	0%	23.79	31.55	24.09	31.72

		24.12	32.87		
		24.36	30.74		
10%	5%	23.77	32.43	23.97	33.47
		24.01	34.37		
		24.15	33.63		
15%	5%	23.87	32.63	24.23	33.85
		24.15	34.49		
		24.67	34.43		
20%	5%	24.45	35.43	24.87	35.84
		24.85	35.47		
		25.31	36.63		
10%	10%	24.78	36.73	25.31	37.34
		25.37	37.47		
		25.79	37.83		
15%	10%	24.91	39.43	25.74	39.21
		25.95	39.07		
		26.38	39.13		
20%	10%	26.17	33.43	27.03	34.19
		26.85	34.47		
		27.54	34.67		

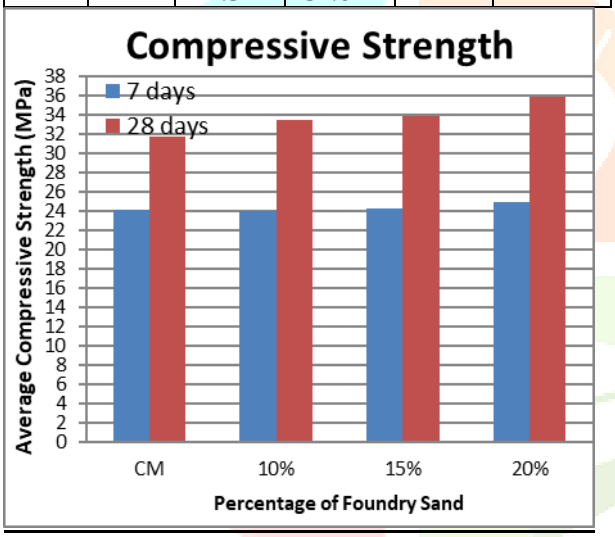

Figure-4.1, Compressive Strength of Concrete with 5% Fly ash as replacement of Cement and variation of Foundry sand as replacement of Fine Sand.(CM= Controlled Mix)

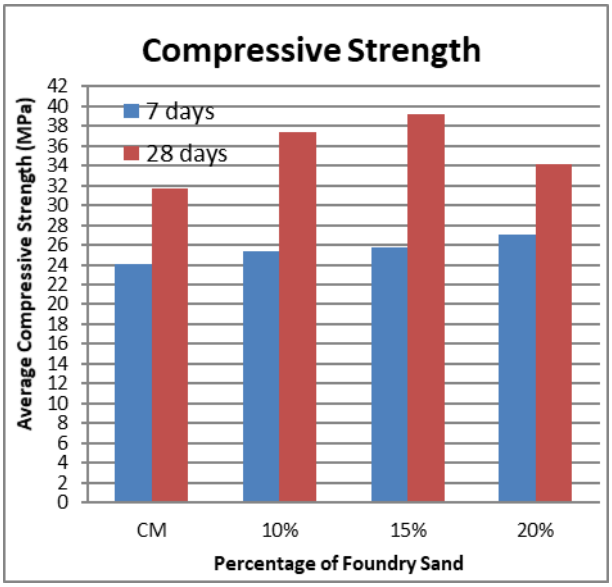

Figure-4.2, Compressive Strength of Concrete with 10% Fly ash as replacement of Cement and variation of Foundry sand as replacement of Fine Sand. (CM= Controlled Mix).

4.2 Splitting Tensile Strength

The splitting tensile strength of the concrete specimens was determined at 7 and 28 days following IS 5816-1999. Cylinders were molded with a diameter of 150 mm and a length of 300 mm. Table -4.2 shows the 7 and 28 days splitting tensile strength on concrete of all the specimens.

$\frac{2P}{\pi/d} = fct$ P = Maximum of applied load in N

d = diameter of the specimen

Table 4.2: Split tensile strength of concrete mixes of specimen size 300 ×150 mm with Foundry Sand and 5% and 10% Fly ash.

Mix	Fly Ash %	Split Tensile Strength (N/mm^2)		Average Split Tensile Strength (N/mm^2)	
Days →		7 days	28 days	7 days	28 days
CM	0%	2.55	2.98	2.65	3.04
		2.75	3.02		
		2.67	3.14		
10%	5%	2.43	3.03	2.54	3.08
		2.57	3.11		
		2.62	3.12		
15%	5%	2.67	3.02	2.78	3.16
		2.87	3.19		
		2.82	3.25		
20%	5%	2.87	3.12	2.85	3.29
		2.77	3.29		
		2.89	3.45		
10%	10%	2.77	3.02	2.49	3.27
		2.43	3.41		
		2.27	3.40		
15%	10%	2.97	3.55	3.12	3.70
		3.15	3.64		
		3.22	3.89		
20%	10%	2.17	3.45	2.45	3.28
		2.49	3.14		
		2.69	3.25		

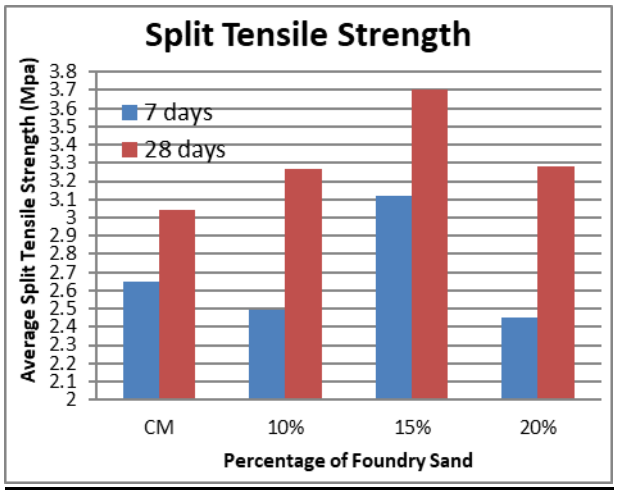

Figure-4.3, Split Tensile Strength of Concrete with 5% Fly ash as replacement of Cement and variation of Foundry sand as replacement of Fine Sand.

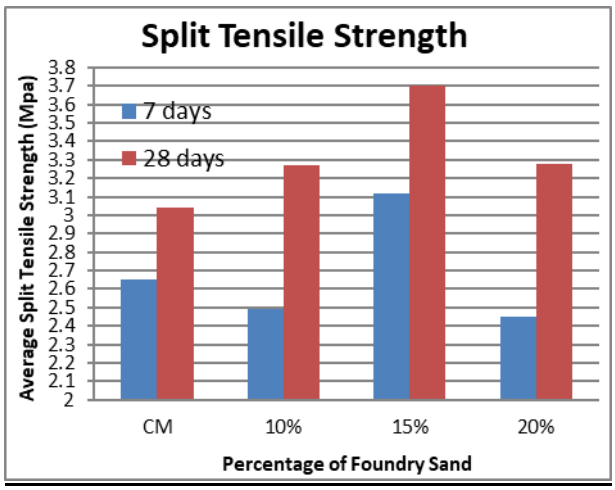

Figure-4.4, Split Tensile Strength of Concrete with 10% Fly ash as replacement of Cement and variation of Foundry sand as replacement of Fine Sand.

5 CONCLUSIONS-

The strength characteristics of concrete mixtures have been computed in the present work by replacement of fine aggregate and cement by 5% and 10% of fly ash and 10%, 10% and 20% foundry sand with the fine aggregate. On the basis of present study, following conclusions are drawn.

5.1 Compressive Strength

- The Compressive strength tends to increase with increase percentages of foundry slag in the mix.
- The compressive strength increases as compared to control mix as the percentage of foundry sand is increased with fly ash as constant 5%. After adding 10% foundry sand in the mix, there is an increase of 6% increase after 28 days as compared to the control mix. By adding 15% and 20% foundry sand (fly ash as 5%), there is not such large amount of increase in percentage i.e. 1%, 2% and 7%, 13% after 7 and 28 respectively.
- The results indicate that the strength of design mix goes on increased by 24% as the percentage of foundry sand increases upto 15% at 28 days as compared to that of control mix, but after 15% there is marginal decrease in strength at by 15% as compared to 20% replacement of foundry sand at 28 days. But this value is 8% higher than the control mix.

5.2 Split Tensile Strength

- The Split tensile strength also tends to increase with increase percentages of foundry sand in the mix.
- The split tensile strength increases with the percentage increase of foundry sand at 5% fly ash as replacement of cement as compared to control mix. After adding 10% foundry sand in the mix, there is an increase of 2% increase after 28 days. By adding 15% and 20% foundry sand, there is increase in percentage i.e. 5%, 8% and 4%, 9% after 7 and 28, respectively.
- The split tensile strength increases with the percentage increase of foundry sand at 10% fly ash as replacement of cement as compared to control mix. After adding 10% foundry sand in the mix, there is an increase of 8% increase after 28 days. By adding 15% and 20% foundry sand, there is increase in percentage i.e. 18%,-8% and 28%, 8% after 7 and 28, respectively.

6. FUTUER SCOPE

- In the present study only up to 20 per cent replacement of fine aggregate by foundry sand has been considered. The other percentages i.e. 25 and 30 per cent need investigation.
- In the present study only design mix w/c ratio have been considered. The other ratios i.e. 0.4, 0.45 and 0.55 need investigation.
- Sulphate resistance of concrete containing foundry sand and fly ash needs to be investigated for larger exposure time.
- In the present study only up to 10 per cent replacement of cement by fly ash has been considered. The other percentages i.e. 15 and 20 per cent need to be investigation.
- Fresh concrete properties of concrete is not studied, need to be more investigation.
- Durability properties are also not studied in this research work.

7. REFFERENCES

[1] Atiş, C. D., Kilic, A., &Sevim, U. K. (2004) "Strength and shrinkage properties of mortar containing a nonstandard high-calcium fly ash". *Cement and Concrete Research*, *34*(1), 99-102.

[2] Brown, J.H. (1982) "The strength and workability of concrete with PFA substitution", In: Proceedings International Symposium on the Use of PFA in Concrete, pp. 151–161.

[3] Carette, G. G., &Malhotra, V. M. (1984) "Characterization of Canadian fly ashes and their performance in concrete", *Division Report, MRP/MSL*, 84-137.

[4] Chalee, W., Teekavanit, M., Kiattikomol, K., Siripanichgorn, A., &Jaturapitakkul, C. (2007)"Effect of W/C ratio on covering depth of fly ash concrete in marine environment", *Construction and Building Materials*, *21*(5), 965-971.

[5] Demirboğa, R., Türkmen, İ., &BurhanKarakoç, M. (2007) "Thermo-mechanical properties of concrete containing high-volume mineral admixtures", *Building and Environment*, *42*(1), 49-354.

[6] Ellis, WE Jr, Rigs, E.H., Butler, W.B. (1991)"Comparative results of utilization of fly ash, silica fume and GGBS in reducing the chloride permeability of concrete". In: Proceedings of the 2nd CANMET/ACI International Conference on Durability of Concrete, Montreal, Canada. ACI SP 126(1), 443–457.

[7] Gebler, S. H., &Klieger, P. (1983) "Effect of fly ash on the air-void stability of concrete (No. RD085. 01T)", *Portland Cement Association*.

[8] Guney, Y., Sari, D.Y., Yalcin, M., Tuncan, A., Donmez, S., "Re-usage of waste foundry sand in high-strength concrete". Waste Management (2010), 1-9.

[9] Ho, D. W. S., & Lewis, R. K. (1983)", Carbonation of concrete incorporating fly ash or a chemical admixture. *ACI Special Publication*, *79*.

[10] IS: 10262-1982 (Reaffirmed 2004): Recommended guidelines for concrete mix design, Bureau of Indian Standard, New Delhi-2004

[11] IS: 1199-1959 (Reaffirmed 1999): Methods of Sampling and Analysis of Concrete, Bureau of Indian Standard, New Delhi-1999.

[12] IS: 2386 (Part I, III)-1963: Methods of Test for Aggregates for Concrete, Bureau of Indian Standard, New Delhi-1963.

[13] IS: 383-1970: Specification for Coarse and Fine Aggregates from Natural Sources for Concrete, Bureau of Indian Standard, New Delhi-1970.

[14] IS: 456-2000: Code of practice- plain and reinforced concrete, Bureau of Indian Standard, New Delhi-2000.

[15] IS: 516-1959 (Reaffirmed 2004): Methods of tests for strength of concrete, Bureau of Indian Standard, New Delhi-2004.

[16] IS: 8112-1989 (Reaffirmed 2005): Specification for 43 Grade Ordinary Portland Cement, Bureau of Indian Standard, New Delhi-2005.

[17] IS: 9103-1999 (Reaffirmed 2004): Concrete Admixtures-Specifications, Bureau of Indian Standard, New Delhi-2004.

[18] Joshi, R. C., &Lohtia, R. P. (1993) "Effects of premature freezing temperatures on compressive strength, elasticity and microstructure of high volume fly ash concrete", *Third Canadian Symposium on Cement and Concrete, Ottawa, Canada*.

[19] Khatib, J.M., Ellis, D.J., "Mechanical properties of concrete containing foundry sand", ACI special publication SP-200. American Concrete Institute; 2001. p. 733–48.

[20] Lohtia, R. P., Nautiyal, B. D., & Jain, O. P. (1976) "Creep af Fly Ash Concrete" In *ACI Journal Proceedings* (Vol. 73, No. 8).ACI.

[21] Mehta, P. K.(2000) "Sulfate attack on concrete: separating myths from reality."*Concrete International* 22(8): 57-61.

[22] Naik, T. R., & Singh, S. S. (1991, March) "Superplasticized high-volume fly ash structural concrete. In *Presented and Preprint Published at the ASCE Energy Conference on Energy in 1990s, Pittsburgh, PA*.

[23] Naik, T. R., Singh, S. S., &Hossain, M. M. (1994) "Permeability of concrete containing large amounts of fly ash", *Cement and Concrete Research*, *24*(5), 913-922.

[24] Naik, T.R., Patel V.M., Parikh D.M., Tharaniyil M.P., "Utilization of used foundry sand in concrete". Journal of Materials in Civil Engineering, Vol. 6, No. 2, May, 1994. P 254-263.

[25] Naik, T.R., Singh S. Shiw., Ramme W. Bruce., "Performance & Leaching assessment of Flowable slurry", Journal of Environment Engineering (2001), 359-368.

[26] Owens, P. L. (1979). Fly ash and its usage in concrete. *Concrete*, *13*(7).

[27] Saraswathy, V., Muralidharan, S., Thangavel, K., &Srinivasan, S. (2003) "Influence of activated fly ash on corrosion-resistance and strength of concrete" *Cement and Concrete Composites*, *25*(7), 673-680.

[28] Siddique, R. (2003) "Effect of fine aggregate replacement with Class F fly ash on the mechanical properties of concrete", *Cement and Concrete Research*,*33*(4), 539-547.

[29] Siddique, R. (2003) "Effect of fine aggregate replacement with Class F fly ash on the abrasion resistance of concrete", *Cement and concrete research*, *33*(11), 1877-1881.

[30] Siddique, R. (2008) "Waste Materials and By-Products in Concrete"

[31] Siddique, R., Gupta, R., Kaur, I., "Effect of spent foundry sand as partial replacement of fine aggregate on the properties of concrete". In: 22nd International Conference on SolidWaste Technology and Management; 2007.

[32] Siddique, R., Schutter, de G., Noumowe, A., Effect of used-foundry sand on the mechanical properties of concrete. Construction and Building Materials 23 (2009) 976–980.

[33] Virtanen, J. (1983) "Freeze-thaw resistance of concrete containing blast-furnace slag, fly ash or condensed silica fume", *ACI Special Publication*, *79*.