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Technical Paper 1 EXPERIMENTAL STUDIES ON MECHANICALPROPERTIES OF GEOPOLYMER CONCRETE*

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Abstract

Ordinary Portland cement (OPC) is the important material used to prepare concrete. But in manufacturing of OPC it has many disadvantages like reduction of raw materials like Limestone, Clay etc. Quantity of carbon dioxide released by each ton of cement is hazardous to environment. To overcome this a material named Geopolymer concrete is invited. The Geopolymer concrete has many advantages and also it is environmental friendly. The current research is to know variation in strength for different molarities, also in durability by testing specimens for water absorption tests.

The specimens were tested for both compressive and tensile strength test. It shows increasing trend in molarity range for 8M, 10M, 12M and 14M after which it shows decreasing trend in the molarity range of 16M. The compressive strength increases for 8M to 14M by 21.79% for 7 days and by 31.99% for 28 days. But compressive strength decreases for 14M to 16M by 10.56% for 7 days and by 6.46% for 28 days. The tensile strength increases for 8M to 14M by 38.15% for 7 days and by 32.19% for 28 days. However, there is decreasing trend in tensile strength for 14M to 16M by 16.66% at age of 7 days and by 2.88% at age of 28 days.

Water absorption results shows decrease in percentage of change in mass upto 14M and increases for 16M. Outcome of the overall investigation shows high value for strength parameters for 14M.

Keywords

Fly-ash, GGBS, Sodium silicate, Sodium hydroxide, Compression test, Split tensile test and Water absorption test.

1 Introduction

Ordinary Portland cement is used worldwide for construction. While manufacturing cement which leads to release of carbon-di-oxide in huge amount, to overcome this we can use the other cementations material which is environmental friendly and gives good strength as that of cement. The Geo-polymer is one of the replacements. It prepared by using the materials GGBS and fly ash as replacement of cement. To overcome the effect of weathering action, chemical attack, and abrasion it is required to test the durability of concrete. Geopolymer concrete is a creative material and which can replace the conventional concrete. Geopolymers are type of inert polymer that is developed at chamber temperature by using industrial waste materials to form a solid binder which possess similar properties that of ordinary Portland cement. The fly ash is mixed with alkaline solution to produce binder. The Geopolymer paste binds the loose finer aggregates, coarse aggregates, and some unreacted materials together to form the Geopolymer concrete.

The fly ash is available worldwide easily as a substitute and alternative for Ordinary Portland cement to manufacture concrete. When fly ash is used as replacement for Ordinary Portland cement which reacts with calcium hydroxide during the hydration of cement to form calcium silicate hydrate gel. The research is to know variation in strength for different molarities, also in durability by testing specimens for water absorption.

2 Literature Review:

Research was carried out the work to know the properties of Geo- polymer concrete with M-Sand here the materials used were fine aggregates, fly ash, coarse aggregates, sodium silicate and sodium hydroxide (Aleem & Arumairaj, 2012). Here concrete cubes of size 100mmx100mmx100mm, cylinder specimen of dia 150mm and of height 300 mm and beam of size 100mmx100mmx400mm were prepared for both the geopolymer concrete with m-sand and conventional concrete, for same mix. Compressive strength, split tensile strength and flexure tests are conducted for 7days, 14days, 21days and 28 days. The strength of geopolymer concrete with m-sand has high compressive strength up to 52N/mm² when compared with conventional concrete. The compressive strength of gpcm for 7,14,21 and 28 days is increased by 144%, 160%,176% and 136% respectively when compared to opcc. Tensile strength of gpcm for 7, 14 and 28 days is increased by 10%, 10% and 50% respectively when compared to OPCC. Flexural strength of GPC for 7, 14 and 28 days the strength of gpcm is 20%, 50% and 100% more than OPCC.

In another research, the materials used in this work were Fly ash, bottom ash, silica fume and Varity of cement (Normal Portland cement and Rapid-hardening Portland cement) (Aruoglu, Girgin, & Aruoglu, 2006). The tests conducted are Compressive strength, Split tensile strength. A simple power function is proposed to evaluate the ratio of the tensile to compressive strength as a function of the cylinder compressive strength. On the basis of error analysis tested for 4 to 120 Mpa, irrespective of proportion of mixture, the nature of the cementitious materials, temperature and time of curing. The level of concrete strength influences the ratio of tensile strength to compressive strength. At low compressive strength, the splitting tensile strength are as high as 10 per cent of the cylinder compressive strength.

The authors carried out the experiment to know the strength properties of Geo-polymer Concrete (Voraa &

Daveb). The materials like Fly Ash, coarse aggregate, M- sand and sodium hydroxide in flake form were used. After the preparation of the alkaline activator the specimens were casted in 100x200mm cylinder and were oven cured. After the compressive tests it was observed that, the compressive strength of geo-polymer concrete is not depends on age of concrete. But increase in curing time improves the polymerization process resulting in higher compressive strength up-to 80MPa. As there is increase in the curing temperature results in increases the concrete compressive strength (70MPa), especially up-to 75°c

An investigation was done to find out the Effect of molarity in geo-polymer concrete. For comparison 8 to 18M of NaOH were taken to prepare geo-polymer concrete (Djwantoro Hardjito, 2004). In this the cubes of size 150X150X150mm were casted (3 cubes each for 7 and 28 days of 8 to 18M NaOH). The concrete mix was prepared such that to get 15 to 52MPa. The concrete was prepared by taking the NaOH solution by 40g of NaOH in 1ltr water for 1M. The specimens were prepared and tested for 7 and 28 days strength in CTM. The Change in compressive strength for different molarities was observed. In that they got the highest strength for 14M cubes. In this investigation they were used the oven curing method, means the specimens were placed in oven for 24 hrs at 80°C and tested.

3 Materials and Methodology

3.1 Fly Ash

Class F fly ash is used for the research purpose the properties of which are found as per IS: 3812-2003 and are tabulated in the Table 3-1.

Table 3-1: Properties of fly ash

SL. No.	Nature of the Test	Results
1.	Fineness	6%
2.	Specific Gravity	2.28

3.2 Ground granulated blast furnace slag

The properties of Ground Granulated Blast Furnace Slag are indicated as in the Table 3-2.

Table 3-2: Test results

SL. No.	Nature of Test	Test Results
1.	Fineness	2.45%
2.	Specific Gravity	2.786

3.3 Sodium Hydroxide

Sodium hydroxide commercially called as caustic soda, generally available in form of pellets, flakes or granularform. It is highly soluble in water and gives raise to exothermic reaction liberating large amount of heat. Thebasic tests done in laboratory are tabulated in the Table 3-3

Table 3-3: Properties of Sodium Hydroxide

SL. No	Nature of Property	Value
1.	Specific Gravity	2.13
2.	Purity	97%

3.4 Sodium Silicate

Sodium silicate also called as liquid glass or water glass and its availability is in the form of aqueous solution or in solid form. The composition of sodium silicate consists of sodium oxide, silicon dioxide and water. Sodium silicate is added to increase the rate of polymerization. The basic tests done in laboratory are tabulated in the Table 4.

Table 3-4: Properties of Sodium Silicate

1.	Specific Gravity	1 20	
		1.39	
	Composition:	Mass (%)	
	a. Sodium Oxide (Na₂O)	14.7	
2	b. Silicon dioxide (SiO ₂)	29.4	
۷.	c. Water	55.9	

3.5 Manufactured Sand (M Sand)

In the current research work the manufactured sand (M sand) passing through IS sieve 4.75mm was used as fine aggregates. The tests are conducted as per IS: 383-1970 (Reaffirmed 2007)

3.6 Coarse Aggregate

Coarse aggregates are sieved in 20mm sieve and those passing through that are used for the research work. The tests conducted are based on IS 383-1970 standards.

4 Experimental Program

The objective of this study is to know the various existing literature review on geo-polymer concrete. To characterize the materials like GGBS, M-Sand, fly ash and various alkali activator ratios etc. Identify the optimum mix pre-treated M-sand in concrete and that would meet the requirement of standard concrete and mix design as per IS specifications. To study the compressive strength and split tensile strength for 7 and 28 days respectively. To study the durability of geo-polymer concrete by conducting, water absorption test for GPC.

4.1 Concrete mix design

Due to non-availability of any standard specification on GPC mix design, the methods and techniques employed by the research in past to design the GPC mixes have been studied and followed in the study. Initially, the density of GPC was assumed as 2350 kg/m³ (lower value was assumed due to low bulk densities of FA and GGBS), total mass of combined aggregate was considered as 70% of the mass of concrete, and alkaline solutions were taken as 30% of mass of concrete. Mix proportions of Geopolymer concrete are tabulated in Table 4-1.

Specimen Geopolymer Mortar

Volume 1m³

Fly ash 352kg

GGBS 151kg

Sodium silicate 144kg

Sodium HydroxideSolution 58kg

Coarse aggregate 1069.25kg

575.75kg

50.3kg

Table 4-1: Geo polymer concrete mix

4.2 Casting

M-Sand

Water

- (1) Alkaline solution is prepared by mixing NaOH, sodium silicate and distilled water. Sodium silicate will be in semiliquid state and sodium hydroxide will be in flakes or in granular form. Calculated amount of distilled water is taken in a container and sodium hydroxide pellets are added and stirred completely until all the pellets are dissolved. The solution was used after 24 hours after preparation.
- (2) The molds 'of 100mm dia and 50mm height for Rapid chloride penetration test were made by cutting 100mm dia PVC pipes (15 moulds), for sorptivity test moulds of 75mm dia and 75mm height were made by 75mm dia PVC pipes (15 moulds). The top and bottom faces of the moulds are open which were covered using steel plates.
- (3) For the research work cubes and cylinders were casted. Cubes of 150mmX150mmX150mm for 8M, 10M, 12M,14M and 16M (6 cubes for each molarity) were casted for compressive strength test.
- (4) Cylinders of 150mm dia and 300mm height for 8M, 10M, 12M,14M and 16M (6 cylinders for each molarity) were casted for tensile strength test.
- (5) After getting compressive strength and tensile strength for Water absorption test 3 cubes for each molarity were casted of size 150x150x150mm.

5 Results & Discussions

5.1 Compressive strength

The compressive strength is obtained by testing the cubes of size 150mmX150mmX150mm for 7 and 28 days respectively in CTM. The test results are tabulated in the Table 5-1 and Table 5-2 and the plot for variation in compressive strength as shown in Figure 5-1 and Figure 5-2.

Table 5-1: Test results for 7 days compressive strength

	Load (kN)			Average	
				Load	7 days compressive
Molarity	Cube 1	Cube 2	Cube 3	(kN)	strength (M Pa)
8 M	879.5	871.5	887.5	879.50	39
10 M	927.7	927.5	926.9	927.37	41.2
12 M	891.2	939.9	1010.9	947.33	42.1
14 M	1068.6	1065	1061	1064.87	47.1
16 M	959.4	961	958.1	959.50	42.6

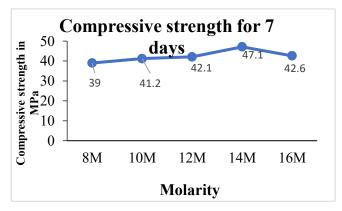


Figure 5-1: Compressive strength for 7 days

From figure 5.1 it is observed that the variation in compressive strength is almost similar for both 7 and 28 days. The compressive strength increases for 8M to 14M by 21.79% and decreases for 14M to 16M by 10.56% for 7 days.

Table 5-2 : Compressive strength for 28 days

	Load (kN) Avera		Average		
				Load	7 days compressive
Molarity	Cube 1	Cube 2	Cube 3	(kN)	strength (M Pa)
8 M	1233.9	1230.6	1232	1232.17	54.7
10 M	1354.8	1384	1386	1374.93	55.7
12 M	1484.7	1493.9	1482.1	1486.90	62.1
14 M	1691.8	1584.6	1650.2	1642.20	72.75
16 M	1532.7	1499	1528	1519.90	68.1

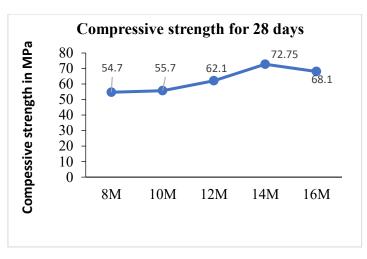


Figure 5-2: Compressive strength for 28 days

From figure-5.2 it is observed that the variation of compressive strength is almost similar for both 7 and 28 days. The compressive strength increases for 8M to 14M by 31.99% and decreases for 14M to 16M by 6.46% for 28 days.

5.2 Tensile strength

The split tensile strength test was conducted on specimens (cylinders) of size 150mm diameter and 300mm length were casted and tested for 7 and 28 days respectively. Test results are tabulated in the Table 5-3 and Table 5-4 and the plot of split tensile strength vs molarity are shown in the Figure 5-3 and Figure 5-4

Table 5-3: Test results for Tensile strength for 7 days

	Load (kN)				7 days Split
Molarity	Cylinder 1	Cylinder 2	Cylinder 3	Average Load (kN)	tensile Strength (MPa)
8M	164.4	157.7	160.2	160.8	2.3
10M	193.0	193.6	194.4	193.7	2.7
12M	210.9	206.5	207.2	208.2	2.9
14M	220.9	225.0	220.6	222.3	3.1
16M	190.0	192.0	191.0	191.0	2.7

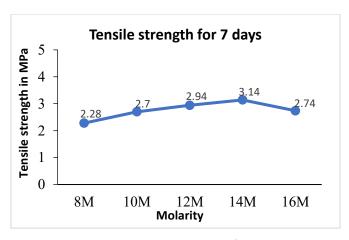


Figure 5-3: Split tensile strength for 7 days

From the figure-5.3 it can be observed that increase in tensile strength for 8M to 14M by 38.15% and decreases for 14M to 16M by 16.66% for 7 days.

Load (kN) Cylinder1 Cylinder2 Cylinder3 28 Average days Split tensile Molarity Load (kN) strength (MPa) 8M 252.9 246.5 245.6 3.56 248.33 10M 301.3 296.3 298.6 298.7 4.23 12M 324.5 317.7 317.9 4.54 320.03 14M 332 344.7 307.7 328 4.64 16M 308 325 324 319 4.51

Table 5-4: Test results for 28 days split tensile strength

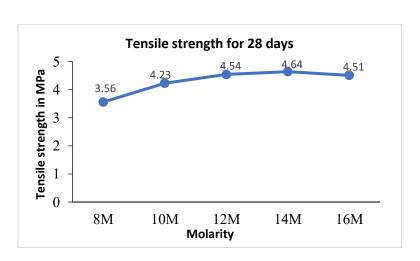


Figure 5-4: Split tensile strength for 28 days

From the figure-5.4 it is seen that the variation of splittensile strength is almost similar for both 7 and 28 days. Thetensile strength increases for 8M to 14M by 32.19% and decrease for 14M to 16M by 2.88% for 28 days.

5.3 Water absorption test

The 3 cubes of 150mmX150mmX150mm were tested forwater absorption and Percentage of change in mass of specimens of different molarities test for water absorption test were tabulated in the Table 5-5 and plot for the same shown in the figure 5.5

	Mass of oven	Mass of wet	Percentage of Change in
Molarity	dried specimen	specimen in	Mass(%) [(m ₂ -m ₁)/
	in kg (m1)	kg (m2)	m ₁]X100
8M	8.1	8.19	1.11
10M	8.05	8.126	0.94
12M	8.01	8.083	0.91
14M	8.035	8.09	0.68
16M	8.08	8.15	0.87

Table 5-5: Percentage of Change in mass for Water absorption test

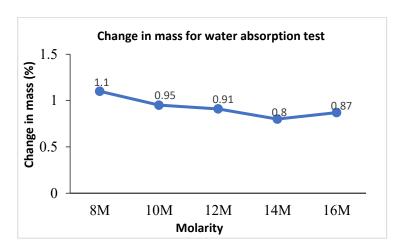


Figure 5-5: Percentage of Change in mass for water absorption test

From figure 5.5 Percentage of change in mass decreases with increase in molarity. Hence, as the molarity increases water absorption of geo-polymer concrete decreases.

6 Conclusions

The conclusion for the current research as per the tests conducted and results obtained are as follows:

- 1. From the test results it is observed that the compressive strength experiment test showed the similar results for both 7 and 28 days. The compressive strength increases from 8M to 14M by 21.79% at the age of 7 days and by 31.99% at the age of 28 days. But plot for variation of compressive strength showed decrease in strength from 14MPa to 16MPa by 10.56% at age of 7 days and by 6.46%at age of 28 days.
- 2. From the tensile strength experiment test showed thesimilar results for both 7 and 28 days. The

tensile strength increases from 8M to 14M by 38.15% at the age of 7 days and by 32.19% at the age of 28 days. However, there is decreasing trend in tensile strength from 14MPa to 16MPa by 16.66% at age of 7 days and by 2.88% at age of 28 days.

3. The water absorption test on geo-polymer concrete results with maximum value for 8M (1.1%), least for 14M (0.8%) and aga0in increases for 16MPa (0.87%) from these results we can conclude that the percentage of change in weight decreases up to 14MPa and increases for 16MPa.

7 References

- (1) Aleem, M. I., & Arumairaj, P. D. (2012, Febrauary). Geoploymer Concrete- A Review. *International Journal of Engineering Sciences & Emerging Technologies*, 1(2), 118-122.
- (2) Arloglu, N., Girgin, Z. C., & Arloglu, a. E. (2006). Evaluation of Ratio between Splitting Tensile Strength and Compressive Strength for Concretes up to 120 MPa and its Application in Strength Criterion. *ACI Materials journal*, 18-24.
- (3) Djwantoro Hardjito, S. E. (2004). FACTORS INFLUENCING THE COMPRESSIVE STRENGTH OF FLY ASH-BASED GEOPOLYMER CONCRETE FLY ASH-BASED GEOPOLYMER CONCRETE. *Civil Engineering Dimension*, *6*, 88-93.
- (4) Voraa, P. R., & Daveb, U. V. (n.d.). Parametric Studies on Compressive Strength of Geopolymer Concrete. *Chemical, Civil and Mechanical Engineering Tracks of 3rd Nirma University International conference on Engineering.* Elsevier.

Technical paper - 2 LOAD-DEFLECTION BEHAVIOUR OF CONCRETE-FILLED STEEL TUBE COLUMNS UNDER AXIAL LOADING

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Abstract

Concrete Filled Steel Tubes (CFST) sections are being used increasingly these days in medium to high rise structures. CFST is a composite material of steel and either plain concrete or reinforced concrete. Hence, CFST sections hasgood toughness because of steel and good compressive strength due to concrete. Some of the benefits include reduced cross section, high strength, improved fire resistance and excellent seismic resistant structural properties like high ductility and energy absorption, that's the reason that CFST beams and columns has now become increasingly popular in the construction industry. This study reviews, development and application of CFST sections in structures laboratory experiments were conducted on different shaped hollow steel tubes filled with normal concrete and self-compacting concrete with or without sand ballasting. CFST sections were experimented under axial compression. Compression test was carried out on square and rectangular CFST columns in Universal Testing Machine to know and compare the load- deflection characteristics of hollow steel tubes as well as CFST sections filled with normal concrete and self-compacting concrete with or without sand ballasting. From the experiments, the square CFST sections proved to be better behaving and givesmore compressive strength than that of rectangular CFST sections. It was also found that sandblasting of inner surface of steel tube before filling concrete in it has minor to zero effect onstrength and behavior of CFST sections.

Keywords

Concrete, steel tubes, concrete filled steel tubes, sand ballasting, compression, load, deflection

1 Introduction

Concrete filled steel tubes (CFST) are composite units made up of hollow steel tubes which are filled with either plainconcrete or reinforced concrete. In these CFST members, both longitudinal reinforcement and transverse reinforcements is provided by the steel tubes. Since modulus of elasticity of steel is high, hence CFST sections has better stiffness than normalconcrete sections. Also, steel resists bending moments and tensile forces. Infilled concrete is confined by steel tube veryefficiently in a CFST sections which results in increased compressive strength. Where infilled concrete resists theinward bucking of steel tube, spalling of inner concrete is resisted by the steel tube to some extent. The CFST sections are now-a-days being used in buildings and bridges as columns, beams etc. In structures, good seismic resistant structural properties such as high strength, high ductility, excellent fire performance, large energy absorption capacity etc. can be provided by concrete filled steel tubes members. High tensile strength and ductility is provided by steel sections whereas compressive strength and stiffness is provided by concrete sections. CFST sections can be of different cross- sections such as square, rectangular, circular, polygonal etc. CFST columns provides increased load carrying capacity without losing economy of construction. One of the other advantages of CFST columns is that they provide better load carrying capacity with reduced cross-section. Also, formworkis not required which further decreases the cost of construction and speeds up the construction time.

2 Literature Review

A study was carried out on strength variation in CFST columns by varying cross-sectional area and concrete grade (Zhang & Zhang, 2015). Based on their work, researchers suggested circular shaped CFST columns over square and rectangular shaped. Use of fibre reinforced polymer (FRP) was also recommended to further improve the strength of CFST columns. For economical and eco-friendly purposes, it was recommended to use recycled aggregate concrete in CFST sections instead of normal concrete. It can't provide same strength as that of normal CFST sections and should not be used in high rise structures and structures of greater significance.

In another research alkali-activated concrete filled steel tubes was studied to understand its mechanical properties (Fan, Liu, & Yuan, 2015). Infill concrete used for this alkali-activated concrete filled steel tube was some commercial alkali-activated binder provided by some industrial partners of the researchers. The specimens were tested under static loading of 5 kN per minute to determine the ultimate axial bearing capacity. Strain gauges were used to measure longitudinal and circumstantial strain in the middle section of steel tubes. Results and load-deformation relationships showed improved mechanical properties as well as improved ultimate axial

bearing capacity as compared to ordinary cement-concrete filled steel tube. The mode of failure of these sections included outward local buckling as well as global buckling of steel tubes.

In another study was carried out to learn the behaviour of CFST columns under axial loading by developing finite element model in software package ANSYS (Kurian, Paulose, & Mohan, 2016). 5 CFST short columns were modelled each with different thickness of 7 mm, 8.3mm, 8.9mm, 9.6mm and 4 mm. Also, ordinary columns of same sections were also modelled. Boundary conditions were applied as fixed from the bottom and roller support at the top end. Buckling analysis of these columns were then carried out. From the analysis, total deformation, maximum and minimum stresses were obtained and comparison was done between CFST columns and ordinary columns. It was seen that total deformation of ordinary columns was more than that of CFST columns but the difference is not that much big like in case of long columns making CFST more advantageous for long columns. Analytical data was also verified against theoretically calculated data, the values were found to be very close with maximum variation being 1%.

Research on square CFST column reinforced by circular steel tube inside was studied for checking the compressive bearing capacity (Harale & P.Kitture, 2017). The test setup consisted of a servo hydraulic machine having a capacity of 5000 kN. The test was conducted under static loading. To measure the vertical and circumferential strain of the tubes, strain gauges were fixed for steel before casting of concrete. an electronic extensometer was used to measure axial deformation. The loading rate was kept 0.15 Mpa/s in stress and then changed in strain to 0.001 Mpa/s after 80% of the theoretical peak compressive strength was exceeded. The mode of failure for CFST sections was outward local buckling.

In this paper, authors carried out parametric investigation on square CFST columns' behaviour (Khudhair, Gupta, & Ahuja, 2013). A total number of 32 3-D nonlinear FE models were developed of square CFST sections of three different sizes of 300 mm square cross-section, 400 mm and 500 mm square cross-section in ANSYS software. Thickness of steel tube, which had yield strength of 400 Mpa, was varied in a wide range. Grade of concrete was kept uniform 32 Mpa for all the columns. Hence, only due to change in steel tube area in all the test columns, change in behaviour of CFST columns was studied. To prevent slenderness effect L/D ratio is kept equal to three in all the specimens.

3 Materials and Methodology

3.1 Hollow steel tubes

The sectional properties of Square and rectangular hollow steel tube (Table-I) sections are used of TATA STRUCTURA confirming to IS: 4923 having a tensile yield strength of 310 MPa. Sectional and technical specifications are tabulated in Table 3-1 and Table 3-2.

Table 3-1: Sectional Properties of Hollow section

Section (B mm x D mm)		'		Inside Hollow Area (mm²)
Square Hollow Section (SHS) (60x60)	4	855	6.71	2704
Rectangular Hollow Section (RHS) (80 x 40)	4	855	6.71	2304

Table 3-2: Sectional Properties of Hollow section

Allowable Stress Values (Mpa)					
Minimum Yield Stress	310				
Minimum UTS	450				
Axial Stress in Tension	186				
Bending Stress in Tens. Or Comp.	205				
Shear stress	140				
Bearing stress	232				
Equivalent stress	279				

3.2 Fly ash

Class F fly-ash was used whose properties were found asper IS: 3812-2003 which are Fineness Modulus=6% and Specific Gravity=2.28. The chemical composition is tabulated in Table 3-3

Table 3-3: Chemical composition of fly ash

	Chemical Composition %							
Binder	Fe2O3	MgO	SO3	Na2O	CaO	SiO2	Al2O3	Chlorides
Fly-ash	1.45	0.745	0.54	0.75	3.21	61.13	31.225	0.065

3.3 Super Plasticizer

Glenium B233 which is a Polycarboxylate Ether (PCE) which may reduce water requirement up to 40%, was used with a low dose of 1% of weight of binding material (cementand fly-ash).

3.4 Epoxy

Araldite AW 106 Standard Epoxy Adhesive was used for sandblasting the inner surfaces of hollow steel tubes. This is used for bonding metal, marble, PVC, plastic, ceramic, wood, as bestos, glass etc.

3.5 Fine aggregates

Locally available m-sand was passed through IS sieve 4.75 mm and then used for concrete. Some tests were carried out to determine the properties of m-sand as per IS: 383-1970, results of which are Fineness Modulus=2.67, Specific Gravity=2.68 and Sieve Analysis=Zone II.

3.6 Coarse Aggregate

Coarse aggregates are sieved in 20mm sieve and those passing through that are used for the research work. The tests conducted are based on IS 383-1970 standards. Results of tests done on as per IS: 383-1970 on the results are Fineness Modulus=6.65 & Specific Gravity=2.64

4 Experimental Program

The objective of this study is to study the various literaturepapers relating to CFST sections. To identify the mix proportion SCC by trying different mix designs to get same strength of SCC and normal concrete, so that their efficiencyand performance can be compared in case of CFST section.. To study the load bearing capacity and load deflection characteristics of square and rectangular CFST short columnsfilled with self-compacting Concrete under axial loads with and without sandblasting. To study the load bearing capacityand load deflection characteristics of rectangular CFST shortcolumns filled with normal concrete under axial loads with and without sand blasting.

4.1 Mix proportion of Normal Concrete after mix design

The normal concrete mix design was carried out as per concrete mix design codebook IS-10262:2009. Grade Designation = 35 Mpa (28 days). The mix proportion is given in Table 4-1

Table 4-1 : Mix proportion of normal concrete

MATERIAL	QUANTITY
Volume	1 m ³
Cement (OPC 43)	492.5 kg
Fine Aggregates	621.33 kg
Coarse Aggregates	1088.102 kg
Water	197 liters
Mix Ratio	1:1.3:2.2
Water/Cement Ratio	0.4

4.2 Mix design of Self compacting concrete (SCC)

Self-Compacting Concrete (SCC), as name suggests is a type of concrete that compacts by itself due to presence of some chemical admixtures such as super-plasticizers and hasrelatively very high fluidity and workability. And it has an ability to flow under its self-weight and filling the formworkfully without any vibration. Hence it is very advantageous touse in sections with difficult conditions such as congested reinforcement where vibration is not possible. Since there is no standard specification is available for mix design of self- compacting concrete, various proportions were tried to get the desired strength and workability and tabulated in Table-III-2. Still there are several methods for mix design of SCC are available such as EFNARC but they only give guidelines and quantity ranges for materials of SCC. The mix proportion for SCC is tabulated in Table 4-2.

QUANTITY MATERIAL TRIAL-1 TRIAL-2 TRIAL-3 Cement (OPC 43) 300 kg/m³ 400 kg/m³ $350 \, \text{kg/m}^3$ 178 kg/m³ 240 kg/m³ 210 kg/m^3 Fly-ash Fine Aggregates 796.5 kg/m³ 796.5 kg/m³ 796.5 kg/m³ 767 kg/m³ 767 kg/m³ 767 kg/m³ Coarse Aggregates Water 175 liters 175 liters 175 liters Superplasticizer 5.4 kg 5.78 kg 5.6 kg Mix Ratio: Binder (cement + fly-1: 1.475: 1: 1.378: 1.42 1.327 1: 1.42: 1.37 ash): FA: CA Water/Cement Ratio 0.324 0.3027 0.3125

Table 4-2: Mix proportion for SCC

4.3 Sand blasting

Sandblasting is a process of smoothening a rough surfaceor sometimes roughing a smooth surface by forcing a propelling abrasive material stream under high speed or pressure. It may also be used to shape a surface or remove surface contaminants. The high pressure is generated bycompressed air, liquid or centrifugal wheels. This process canbe used on steel, brick, cement and concrete surfaces. Materialused for sandblasting may be highly, moderate or mildly abrasive. Metal and sand are highly abrasive. Glass beads andwalnut shells may be used as moderate sandblasting whereasbaking soda may be used mild abrasive material. Most commonly, manually (operator) controlled compressed air isused to force the propel abrasive stream from blast pot to thetarget surface through a nozzle. Automatic sandblasting machines are also available such as centrifugal wheel.

Here to achieve a rough surface on the inner side of the hollow tubes, Equal amount of Araldite epoxy resin and hardener was taken and mixed it until a uniform colour is observed which means adhesive compound had formed. Thincoat of this compound was applied on all four inner surfaces of square and rectangular hollow sections. Then sand was filled in the hollow sections by compacting. Sand was removed after 24 hours.

4.4 Casting

- *Casting of cubes*: Three cubes of size 150 mm X 150mm X 150 mm were casted for each mix design of SCC and normal concrete. Hence a total of 12 cubes were casted for compressive strength test.
- Casting of CFST sections with Normal concrete: Two numbers each of hollow square tubes and hollow rectangular tubes without sand blasted inner surface were filled with normal concrete.

Two numbers each of hollow square tubes and hollowrectangular tubes with sand blasted inner surface were filled with normal concrete.

Hence a total of 8 Hollow tubes (300mm long) were casted with normal concrete for testing of load-deformation characteristics. The tubes were put standing on metal base plate and concrete was pouredand compacted in the tubes. After 24 hours it was removed from base plate and kept on flat surface withtop and bottom open surface covered with cloth so that there is no evaporation of water.

• Casting of CFST sections with SCC: Three numberseach of hollow square tubes and hollow rectangular tubes without sand blasted inner surface were filled with normal concrete.

Three numbers each of hollow square tubes and hollow rectangular tubes with sand blasted inner surface were filled with normal concrete. Hence a total of 12 Hollow tubes (300mm long) werecasted with Self-compacting concrete for testing of load-deformation characteristics. The tubes were put standing on metal base plate and concrete was poured in the tubes. After 24 hours it was removed from baseplate and kept on flat surface with top and bottom opensurface covered with cloth so that there is no evaporation of water

5 Results & Discussions

5.1 Workability of SCC

To know the workability of the three SCC mix designs done, slump flow test was carried out. The slump flow test measures the lateral flow of concrete which falls freely from the test cone without any obstructions. Generally, concrete with slump more than 500 mm is considered as SCC. Three different workability for three different SCC mix were obtained which are tabulated in Table 5-1 and plotted in Figure 5-1.

Table 5-1: Slump results

Mix with Cement Content	Slump (mm)
300 Kg/m3	650
350 Kg/m3	690
400 Kg/m3	670

Slump for different mix design

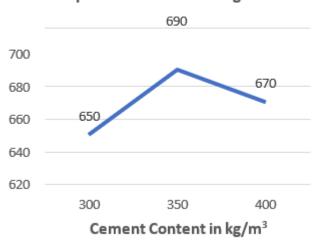


Figure 5-1: Slum test results for different mixes

5.2 Compressive Strength of Self-Compacting concrete

Three Cubes of size 150mm x 150mm x 150mm of each mix design of SCC are tested in compressive testing machine(CTM) for 7 days. Load is applied at a uniform rate and thepeak load is noted after failure of specimen. The test results are given in Table 5-1 and plotted in Figure 5-2

Table 5-2: Test results for 7 days compressive strength

Cement	Load (KN)		Average Load	7 Days Compressive		
Content (Kg/m3)	Specimen 1	Specimen2	Specimen3	(KN)	Strength (MPa)	
300	539	530.5	534.1	534.5	23.75	
350	764.8	763.8	760.5	763.03	33.9	
400	873.6	859.9	790.2	841.3	37.4	

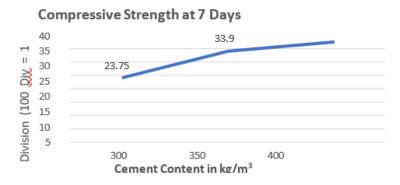


Figure 5-2: Compressive strength for 7 days

5.3 Compressive Strength of Normal concrete

Three Cubes of size 150mm x 150mm x 150mm of mix design of normal concrete are tested in compressive testing machine (CTM) for 28 days. The test results are given in Table 5-3

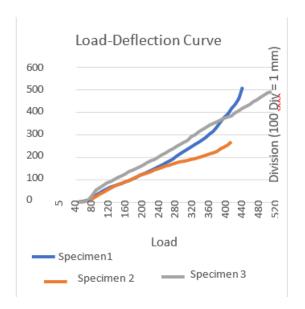
Table 5-3: Compressive strength for 28 days

28 DaysComp. Strength(MPa)	Load (KN)		Average Load	28	Days	
	Specimen 1	Specimen2	Specimen3	(MPa)	Compressive Strength (MPa)	
50	1358.1	1029.9	1170.3	1186.1	52.71	

By obtaining compressive strength of both SCC and normal concrete and comparing, M50 grade was selected of both SCC and normal concrete for filling of CFST sections so that proper correlation can be carried out.

5.4 Load-Deflection characteristics of CFST without Sandblasting and filled with SCC

After 28 days of casting of steel hollow sections without Sandblasting the inner surface and filled with self-compactingconcrete were tested in Universal Testing Machine to determine the load deflection characteristics. A metal base plate was put on the bottom plate of Universal Testing Machine (UTM). Then a CFST section is put on the base plate. A dial gauge is fixed with its needle attached to the bottom plate of UTM to measure the deflections in CFST section. Theload was applied gradually, and the deflection is noted at every5 KN load until the failure of the section. The peak load and deflection at failure was noted. The test results obtained for Square CFST are plotted in Figure 5-3 and the test results obtained for Square CFST are plotted in Figure 5-4.



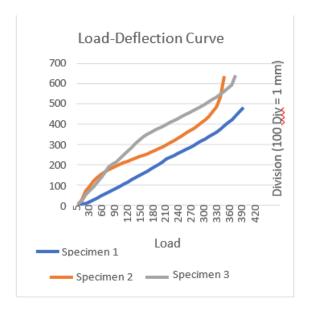
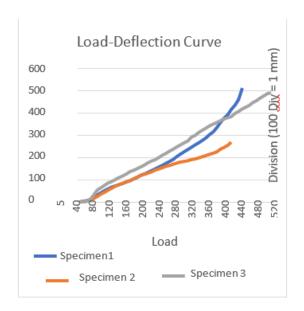


Figure 5-3 : Load-Deflection Curve for Square CFST FILLED WITH SCC (WITHOUT SAND-BLASTING)

Figure 5-4 : Load-Deflection Curve for rectangular CFST FILLED WITH SCC (WITHOUT SAND-BLASTING)

5.5 Load-Deflection characteristics of CFST with Sandblasting and filled with Self-Compacting concrete

After 28 days of casting of steel hollow sections with Sandblasted inner surface and filled with self-compacting concrete were tested in Universal Testing Machine to determine the load deflection characteristics. The test results obtained for Square CFST are plotted in Figure 5-5 and the testresults obtained for Square CFST are plotted in Figure 5-5-6



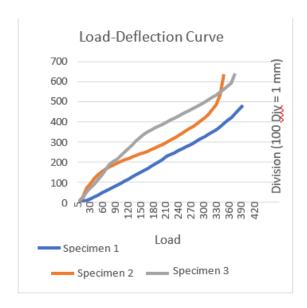


Figure 5-5: Load-Deflection Curve for Square CFST FILLED WITH SCC (WITH SAND-BLASTING)

Figure 5-6: LOAD-DEFLECTION CURVE FOR RECTANGULAR CFST FILLEDWITH SCC (WITH SAND-BLASTING)

5.6 Load-Deflection characteristics of CFST without Sandblasting and filled with normal concrete

After 28 days of casting of steel hollow sections without Sandblasting the inner surface and filled with self-compactingconcrete were tested in Universal Testing Machine to determine the load deflection characteristics. A metal base plate was put on the bottom plate of Universal Testing Machine (UTM). Then a CFST section is put on the base plate. A dial gauge is fixed with its needle attached to the bottom plate of UTM to measure the deflections in CFST section. Theload was applied gradually and the deflection is noted at every5 KN load until the failure of the section. The peak load and deflection at failure was noted. The test results obtained for Square CFST are plotted Figure 5-7 and the test results obtained for Square CFST are plotted in Figure 5-7-8



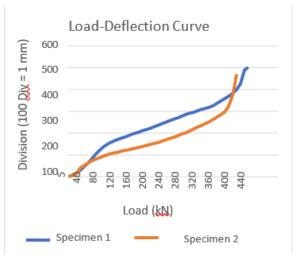


Figure 5-7: LOAD-DEFLECTION CURVE FOR SQUARE CFST FILLED WITH NORMAL CONCRETE (WITH SAND-BLASTING) FILLED WITH NORMAL CONCRETE (WITH SAND-BLASTING)

Figure 5-8: LOAD-DEFLECTION CURVE FOR RECTANGULAR CFST

5.7 Load-Deflection characteristics of CFST with Sandblasting and filled with normal concrete

After 28 days of casting of steel hollow sections with Sandblasted inner surface and filled with self-compacting concrete were tested in Universal Testing Machine to determine the load deflection characteristics. The test results obtained for Square CFST are plotted in Figure 5-9 and the testresults obtained for Square CFST are plotted in Figure 5-9 and Figure 5-9-10.



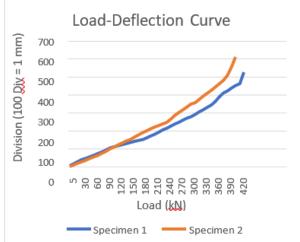


Figure 5-9: Load-Deflection Curve for Square CFST
WITH NORMAL CONCRETE (WITH SAND-BLASTING)

FIGURE 5-10: LOAD-DEFLECTION CURVE FOR RECTANGULAR CFST FILLED FILLED WITH NORMAL CONCRETE (WITH SAND-BLASTING)

Hence from load-deflection values and curves of both thesquare and rectangular CFST sections, it is clear that square CFST sections were behaving better in terms of both load carrying capacity and resistance to deformation. From the visual inspection, it was also seen that rectangular CFST sections showed more buckling than square ones.

6 Conclusions

The conclusion for the current research as per the tests and the obtained results are as follows:

- (1) From the compressive strength test of SCC for 7 and 28 days, it was observed that by keeping the volume of paste (cement, fly-ash and water) constant and increasing the cement content in the paste, gives higher compressive strength.
- (2) It is clear from the compressive strength tests carried out that load-deflection behaviour columns and rectangular CFST columns respectively.
- (3) It was observed that normal concrete filled steel tube column sections behaved considerably better than SCC filled steel tube column sections.
- (4) By observing the all the tests carried out with and without sandblasting, it is very clear that significance of sandblasting inner surface of steel tubes before filling of concrete is almost negligible

7 References

- (1) Fan, X. C., Liu, Y., & Yuan, B. (2015). The ultimate axial bearing capacity of Alkali- Activated concrete filled steel tubes. *Material Research Innovations*, 525-530.
- (2) Harale, K. R., & P.Kitture, S. (2017). A review on Developments in concrete filled steel tubular columns (CFST). *Journal of Mechanical and civil engineering*, 01-04.
- (3) Khudhair, Z. A., Gupta, P. K., & Ahuja, A. K. (2013). Parametric investigations on behaviour of square CFST columns. *International journal of Scientific and Engineering research*, 107-110.
- (4) Kurian, S. S., Paulose, D., & Mohan, S. (2016). Study On Concrete Filled Steel Tube. *Journal of Mechanical and Civil Engineering (IOSR-JMCE)*, 25-33.
- (5) Zhang, Y. F., & Zhang, Z. Q. (2015). Analysis on composite action of concretefilled steel tube columns reinforced by different confining materials. *Materials Research Innovations*, 236-239.

Technical Paper-3 EFFECT OF SATURATION FLOW AND ITS INFLUENCING FACTORS ON CAPACITY OF SIGNALIZED INTERSECTIONS UNDER HETEROGENEOUS TRAFFIC CONDITIONS

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Abstract

The intersections on urban roads in India generally cater to heterogeneous motorized traffic, along with slow-moving traffic including pedestrians. Traffic signals at these intersections are of greater importance to ensure smooth flow of traffic, and to reduce the number of conflicts between vehicles entering intersections from different directions. Therefore, it is necessary for a proper traffic model considering varying characteristics of all the road users to effectively design and efficiently manage signalized intersections. Hence for the design of signals, it is necessary to consider saturation flow for mixed traffic conditions to evaluate the overall operation of signalized intersections. This paper presents the results of the study on analyses of saturation flow rate conducted at signalized intersections with mixed traffic conditions in the city of Bangalore, India. Studies were carried out at 10 signalized intersections in the city of Bangalore. The base saturation flow (So) and the influencing factors of geometric and traffic factors in calculating saturation flow gave better picture of the computation at signalized intersection, especially under heterogeneous traffic conditions of an urban area. The adjustment factors and base saturation flow were calculated by Multi Linear Regression (MLR) method. The results from the proposed model had a good correlation with R2 value of 0.75.

Keywords:

Saturation flow, Capacity, Signalised intersections. Heterogeneous traffic, Heavy vehicles.

1 Introduction

The traffic stream in developed countries mainly consists of cars and heavy vehicles (buses and trucks). The proportion of heavy vehicles in the traffic stream of such countries is generally small and the dynamic characteristics of the heavy vehicles vary marginally from those of cars. The characteristics of traffic flow under such homogeneous traffic conditions, with cars constituting about 80% or more of the vehicles, displaying lane discipline becomes easily predictable. On the other hand, in developing countries like India, road traffic in general and urban roads traffic is highly heterogeneous, comprising vehicles of widely varying static and dynamic characteristics. Further the vehicles share the same road space without any segregation.

Intersections play crucial role in road networks because the efficiency of intersections would strongly influence the performance of the whole traffic system. At the controlled intersections, different directions of flow share the same road space and flow is segregated in terms of time. Intersections should be able to serve their varying traffic demands, provide minimum delay in passage, and maximum safety to all types of users especially pedestrians. One generally evaluates the functioning of a typical signalized intersection in terms of two parameters: (1) capacity, i.e., volume to-capacity (v/c) ratio, and (2) the level of service (LOS), with its delay and queue ranges. These parameters are functions of traffic volume characteristics, signal characteristics, and geometry of the intersection. To evaluate the above said parameters, saturation flow rate plays a major role and hence a better understanding of saturation flow and its influencing factors have a greater importance in signalised intersections.

2 Literature Review

The important parameter in signal plan is the "saturation flow rate (SFR)". SFR is defined as "the maximum rate of flow at which the vehicles from an approach to an intersection can clear the intersection if green time is available uninterruptedly". SFR is an important factor in the design of signal timing. As mentioned in Highway Capacity Manual (HCM), there are number of factors that affect the SFR of an intersection. If the SFR can be computed precisely, the performance of the signalized intersection can be evaluated. Several studies have been carried out on US-Highway Capacity Manual (HCM) (1) signalised intersection model, its applicability, and on its modifications. This section addresses some of the important aspects of traffic models proposed so far, for modelling heterogeneous traffic movement at signalized intersections. Researchers have developed various models to evaluate the effectiveness of signalized intersections in terms of their capacity and level of service (LoS). Some of the research works related to saturation flow rate for signalised intersections have been presented in this section.

2.1 Highway capacity manuals

The Highway Capacity Manual (HCM) is published by the Transportation Research Board (TRB) of the National Academies of Science in the United States. It gives concepts, guidelines, and computational procedures for calculating the capacity and quality of service of various highway facilities, including freeways, highways, arterial roads, round-about, signalized and un-signalized intersections, rural highways, and the effects of mass transit, pedestrians, and bicycles on the performance of these systems.

There have been five editions with improved and updated procedures from 1950 to 2010, and two major updates to the HCM 1985 edition, in 1994 and 1997. The HCM has been a worldwide reference for transportation and traffic engineering scholars and practitioners, and it has also serving as a base for several countries- specific capacity manuals. In India, the Central Road Research Institute (CRRI) one of the research institute under the umbrella organisation Council of Scientific and Industrial Research (CSIR), had undertaken a national study to develop the Indian Highway Capacity Manual (Indo-HCM) (2)

2.2 Study of capacity of signalised intersections

While IRC 106-1990 (3) gives an insight into the capacity of urban roads in plain areas, it does not mention about SFR and LoS for signalised intersections. IRC SP41- 1994 (4), Guidelines for the design of at grade intersections for rural and urban area, has defined saturation flow as S=525* w, PCU/hg (S-saturation flow in PCU/hr, w-Width of road in m) for roads having a width above 5.5 m, and gives saturation flow rate based on radius of right turning vehicles. However, it does not specify anything about defining LoS for signalised intersections.

In one of the study (5) conducted in India and Thailand, it has been observed that HCM techniques have limited application for heterogeneous traffic situation prevailing in the developing countries. Another study based on simulation has affirmed that the adoption (through developing adjustment factors) of the roadway capacities determined for developed countries would not yield realistic results (6).

Studies carried out at Makkah, Saudi Arabia, (7) has shown that saturation flow rate and capacity adjustment factors for signalized intersections will vary from HCM recommendations. However, the outputs can form the basis formulating a HCM for the country and the estimated parameters may be useful for signal design and traffic system performance analysis in Saudi Arabia.

A study conducted in India (8) has confirmed that the methodology for SFR, put forward by HCM can also be used in India. However, parameters should be systematically calibrated, based upon widespread study, before they can be used effectively in the practice of traffic control in India. Based on the results that have been obtained using simulation in another study (9), it has been shown that the passenger car equivalent (PCE) values changes per the speed flow relationships along the road.

Given the above background and importance, the present study provides an insight in to the traffic flow parameters influencing the capacity and SFR at signalised intersections of Bangalore, India urban area. Further the focus will be on assessing base saturation flow rate (So) and the impact of adjustment factors, such as factor of gradient, factor of through traffic, factor of right turn, factor of left turn, factor of side friction and factor of composition on calculation of SFR and the capacity of signalised intersections under heterogeneous traffic conditions.

3 Objectives

The main objectives are: (1) development of base saturation flow rate (So), (2) development of adjustment factors that account for the proposed modifications and (3) comparison of proposed model with the field SFR and IRC model.

4 Details of the study area.

10 signalized intersections from the central business district (CBD) of Bangalore area were selected for the study.

Figure 4-1 indicates the Bangalore map, showing study area and

Table 4-1 high lights the junction details of the study area.

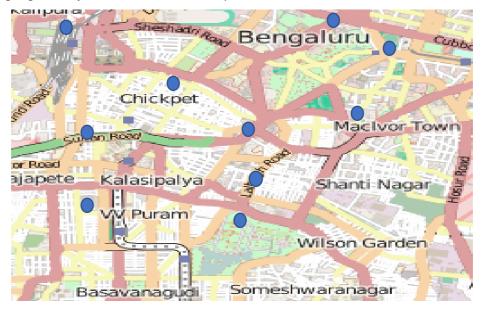


Figure 4-1: Bangalore area map highlighting study area

Table 4-1: Junction details of study area

SI No	JUNCTION NAME	Cycle Time (Peak hours) Sec				
1	Manipal Hospital	195				
2	Sagar Apollo Junction	225				
3	Bileka halli Junction	195				
4	Sadashivnagar Junction	190				
5	Manipal Centre Junction	160				
6	Vani vilas road & Shankarmutt road junction	155				
7	Chamrajpet 5th Main Junction	220				
8	Basappa Circle	220				
9	Malleswaram 18th Cross Junction	120				
10	Kamraj Road Junction	190				

5 Data Collection

During primary survey, data relating to land use, traffic, topographical and environmental features of the study area were collected. The data collection was divided into three parts as geometric data, traffic data and signal data. The traffic data was collected by the videography method. The Traffic Management Centre (TMC) (10) at Bangalore city, is the hub of a transportation management system, where information about the transportation

network are collected and combined with other operational and control data to manage the transportation network and to produce traveller information. Videos were obtained from TMC, Infantry road, Bangalore and supplemented by site visits. Based on the above procedure the following data were obtained: (1) through flows, right-turn flows, and left turn of traffic entities and (2) geometrical characteristics of the intersections and (3) signal timings of each phase and cycles. Representation of the geometric data, traffic data and signal data for a typical junction is shown in *Figure 5-1*, *Figure 5-2*, *Table 5-1* respectively.

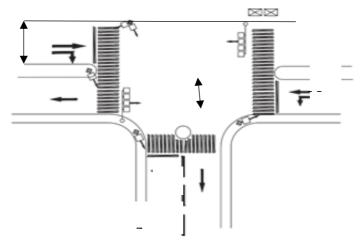


Figure 5-1: Geometric data collection for a typical junction



Figure 5-2: Traffic data collection for a typical junction by videography

			TIMINGS DATA								CYCLE		
			PHA	PHASE									E 11
	ROAD	FROM	1	1			2		3			4	TIME
Data	Α	Basappa Road	R	L	S		L						
<u></u>	В	Shivashankar Rd					L	S		L		rian	
	С	Minto Rd						R	L			Pedestrian	
Timings	07:00	08:30	30	•	•	40)	•	30			10	110
ngs	08:30	11:00	60			80)		35			10	185
	11:00	16:00	45	45		65	•		30			10	150
	16:00	20:00	55	55		75		35		10	170		
	20:00	23:00	35	35		35		30		10	110		
Sun day	07:00	23:00	35	35		35		30		10	110		

Table 5-1: Summary of the signal data for a typical junction

Note: A, B, C- legs of intersection; R, S, L – Right, straight, left movements at traffic intersections

5.1Basic Model

Saturation flow rate (S) is the flow, which would be obtained if there was a continuous queue of vehicles and they were passed at green time, or the saturation flow is the maximum departure rate, which can be achieved when there is a queue. The saturation flow is generally expressed in vehicles per hour green time. From *Figure* 5-3 it could be seen that the average rate of flow is lower during few minutes, because vehicles are accelerating to normal running speed.

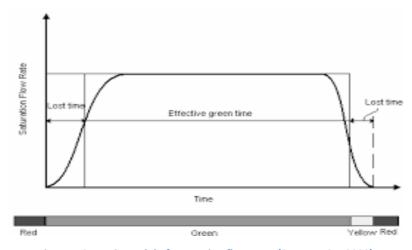


Figure 5-3: Basic model of saturation flow rate, (Source HCM 2000)

Wide variation in the observed saturation flow has resulted in the development of models for predicting SFR, Webster and Cobbe (1966) (11) defined saturation flow as a function of width of road as in Equation (1).

$$S = 180w$$
, PCU/ hg /lane (1)

where, S is the saturation flow in PCU/hour/lane and w is the width of road approach in feet. But the scope of the above formula does not cover the full range of road widths.

The same formula has been adopted by the IRC: 106-1990, with w in meters and suitable adjustment factors are provided to account for the effect of left turns and right turns as in Equation (2)

$$S = 525 \text{w PCU/hg} \tag{2}$$

According to Transport Research Board (TRB), US, the saturation flow rate of an approach at a signalized intersection can be calculated using Equation (3).

$$S = S0 x N x fw x fhv x fg x fp x fbb x frt x flt. PCU/hg$$
 (3)

Where,

S = saturation flow rate under prevailing conditions, expressed in vehicle per hour of effective green time in lane group (PCU/hg)

S0, ideal saturation flow rate which is 1,900 passenger cars per hour of green per lane pcphgpl),

N, the number of lanes in a lane group;

fw , adjustment factor for lane width;

fhy, adjustment factor for heavy vehicles in a traffic stream;

fg , adjustment factor for approach grade;

fp, adjustment factor for the existence of a parking lane and parking activity adjacent to a lane group;

fbb, adjustment factor for the blocking effect of local buses stopping within the intersection area;

fa, adjustment factor for area type;

frt , adjustment factor for right – turns in a lane group;

flt, adjustment factor for left — turns in a lane group.

Many countries have developed their own capacity manuals based on HCM (1), as per their physical and geographical conditions. Results from studies conducted at China proposes methodology to study the heavy vehicles factor on saturation flow rate and suggests the adaptability of HCM to China conditions (12). Heavy vehicle adjustment factor in the HCM is the only factor indicating the composition of traffic.

6 Analysis

In this study, to calculate the SFR, base saturation flow and adjustment factor for heavy vehicles, the following assumptions have been made.

- 1. The junctions have an approach width above 5.5 m as the saturation flow rate formula given by IRC SP: 41-1994 is valid for width above 5.5 m.
- 2. All the right turning vehicles follow a double stream at 3 legged signalised intersections and single stream at 4-legged intersection as per IRC: SP41-1994.
- 3. Majority of junctions have no free left turning movements, contributing for the saturation flow of signalised intersection.
- 4. There are no bus stops near that is within 50 m of the signalised intersections, reducing the saturation flow at the intersection.

- 5. There is no parking provided near the junctions, causing reduction in the saturation flow at intersection.
- 6. The PCU values for different categories of vehicles are considered as given by IRC SP: 41-1994.

6.1Field saturation flow rate (S_f)

The saturated green time is defined by the saturated green time in which traffic flow reach to the saturation state. In a homogeneous traffic, the basic model for analysing the SFR of signalized intersections is based on the hypothesis that the queue discharge increases rapidly to a steady maximum, when the traffic signal turns to green, which is commonly known as the SFR. Hence, the number of vehicles remain a constant, with the highest value occurring during the saturated green time. However, this hypothesis seems not to be correct in a heterogeneous traffic conditions. For example, the number of motorcycles increase rapidly during the initial green time, and then decreases during the latter part of the green time. This phenomenon is called "capacity reduction phenomenon". In this study, the initial lost time for initial green time is not considered, but only the final lost time is considered. From the video recording of each intersection of the study, following information were extracted:

- 1. The number of through vehicles in the queue,
- 2. The number of vehicles making the turn
- 3. The queue discharge time, which is measured when all the vehicles in the queue passes the stop line following the onset of the green interval and until the last previously queued vehicles which crosses the stop line.

Based on the information obtained, the saturation flow rate is computed by

$$S_f = [\textit{Num ber of veh} * \frac{3600}{\textit{Green Time}}]$$
 (PCU/ hr)

where: Sf = Field saturation flow rate (PCU/hour)

The base saturation flow for the 10 intersections, calculated based on the above approach have been tabulated in the *Table 6-1*.

Table 6-1: Calculation of field saturation flow (Sf).

SI No	TRAFFIC STATION NAME	Field saturation flow (Sf) (PCU/hr)	SI No	TRAFFIC STATION NAME	Field saturation flow (Sf) (PCU/hr)
1	Air Port		6	Basavanagudi	
	HAL	6120		Lalbagh West gate	4140
	Domlur	7375		Hanumanth Nagar	3456
				Gandhibazar	5760
2	Mico Layout			Shankarmutt	5040
	Dairy Circle	6840	7	Basavanagudi	
	Jayadeva	7440		Ramakrishna Aashrama	5400
	Tilak Nagar	5554		Ryaan Circle	3900
3	Mico Layout			Mysore Road	4320
	DC halli	5280		K R Market	4620
	Bilekahalli	6192	8	KR Market	
4	Sadashiv Nagar			Market	5085

	Ramaih Hospital	6480		Sajjan Rao circle	5640
	Mekhri Circle	6300		Minerva circle	5904
	Tata institute	6120		Chamarajpet	5112
5	Shivaji Nagar		9	Malleswaram	
	Halsoor Road	7396		Malleshwara circle	6891
	BRV	7855		HDFC junction	7020
	Kariappa	6789	10	Shivaji Nagar	
				BRV	8160
				Manipal centre	8424
				Commercial street	8280

6.2Base saturation flow (S0):

Base saturation flow rate is an important factor used for the timing of traffic signals. Although, the Highway Capacity Manual (HCM) suggests a value of 1,900 pc/h/ln, the base saturation flow rate is not necessarily a constant value as it varies from one city to another depending on the local driver behaviour and traffic environment. Therefore, it is important to estimate (So) under prevailing local conditions. The base saturation flow rate for a country is usually obtained by taking the average saturation flow rate that is obtained by collecting the data across the country. There are two methods that are generally adopted to obtain (So). They are:

- (a). Headway method and
- (b). Width of road method

In developed countries like, USA and Australia, 'headway method' is adopted to obtain SO, which is of course independent of the width of the road. However, in developing countries like Indonesia, So is developed based on 'the width of the road'. To obtain the expression for S₀ from field data, the field saturation flow rate values (S) obtained from field observations are plotted against the width of the road, considering the data from 10 intersections (Figure 6-1). The relationship thus obtained is given by

$$S_0 = 535 * w \text{ (veh/ hr)};$$

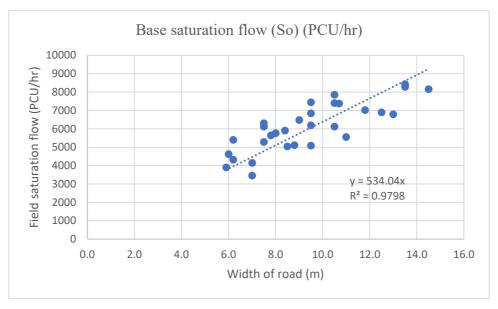


Figure 6-1: Estimation of base saturation flow rate (So)

6.3 Adjustment factors for saturation flow calculation:

The various adjustment factors considered in this study, are also found to be commonly adopted in the highway capacity manuals of some of the comparable developing countries of the world. The adjustment factors are calculated by the MLR method. The ratio between the field saturation flow rate (S_f) and the base saturation flow rate (S₀) is calculated and by making all the other parameters unity, the required or a particular adjustment factor is obtained The adjustment factors considered, and proposed value are tabulated below in the *Table 6-2*.

SI. No	Adjustment factors	Recommended values	Remarks/ Range
1	Factor of gradient (fg)	$\left[1-\frac{\%g}{135}\right]$	For gradients up to ±6%
2	Factor of through traffic (fth)	$[1 + 0.29 * p_{th}^2 - 0.26 * p_{th}]$	(1-100%)
3	Factor of right turn (frt)	$[1 - 0.09 * p_{rt}]$	(0-60%)
4	Factor of left turn (f _{lt})	$[1 + 0.17 * p_{lt}^2 + 0.17 * p_{lt}]$	(0-50%)
).0.95 (commercial)	
5	Factor of side friction (fsf)).1.0 (Residential)	
			TW-(0-50%
		$[\nabla e_i q_i]$	HV- (0-15%)
6	Factor of composition (fc)	$\left[\sum \frac{\sigma \kappa}{q}\right]$	Auto's & Cars (0-30%)

Table 6-2: Adjustment factors for saturation flow

6.4 Saturation rate flow model

Following model is proposed, for the computing the saturation flow rate at signalized intersections, with heterogeneous traffic prevailing in India.

$$S = S_0 * f_g * f_{th} * f_{rt} * f_{lt} * f_{sf} * f_c$$
 (PCU/hr)

where, S – Saturation flow (PCU/hr); S_0 – base saturation flow (veh/hr) - 535*w; f_g – factor of gradient; f_{th} – factor of through traffic; f_{rt} – factor of right turn; f_{lt} – factor of left turn; f_{sf} – factor of side friction; f_c – factor of composition. It is to be noted that (f_g) and (f_{sf}) relate to the geometric data, whereas, the other factors (f_{th} , f_{rt} , f_{lt} , f_c) relate to traffic data of the intersections.

It should be noted that the above model is applicable both for '3-legged and 4-legged intersections'. However, some of the 'adjustment factors' may be different for the above type of intersections. The saturation flow rates obtained by field method, IRC method (S=525*w) and proposed model method are tabulated below in **Table 6-4** and **Figure 6-2.** The descriptive statistics for the field saturation flow and proposed model are presented in **Table 6-3.**

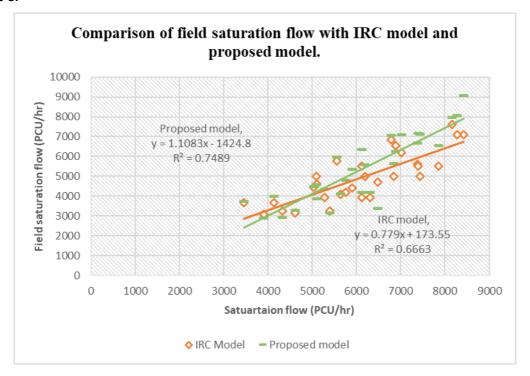


Figure 6-2: Comparison of SFR by IRC SP 41:1994 and new proposed model

The proposed capacity model has a better R² value. The capacity values by IRC SP:41-1994 and the proposed model indicates SFR values by new proposed model gives better and realistic values. This shows that by introduction of adjustment factors of geometric and traffic factors provides a better, clear and a realistic picture of the SFR and realistic capacity values at signalized intersections can be obtained, especially under heterogeneous traffic conditions that are common in countries like India.

DESCRIPTIVE STATISTICS SUMMARY OUTPUT						
Regression Statistics	5					
Multiple R 0.880						
R Square	0.774					
Adjusted R Square	0.765					
Standard Error	721.109					

Table 6-3: Descriptive statistics

Observations	29				
ANOVA					
	df	SS	MS	F	P-value
Regression	1	48029675.86368	48029675.86368	92.36499	0.00232
Residual	27	14039965.97375	519998.73977		0.00000
Total	28	62069641.83743			

Table 6-4: Saturation flow by IRC and Proposed model

No	Junction Name	(Sf) (PCU/hr)	IRC S(PCU/hr)	(S) (PCU/hr)	SI No	Junction Name	(Sf) (PCU/hr)	IRC (PCU/hr)	(S) (PCU/hr)
1	Air Port				6	Basavanagudi			
	HAL	6120	5513	6369		Lalbagh West gate	4140	3675	4012
	Domlur	7375	5618	6682		Hanumanth Nagar	3456	3675	3732
						Gandhibazar	5760	4200	4797
2	Mico Layout					Shankarmutt	5040	4463	4479
	Dairy Circle	6840	4988	5645	7	Basavanagudi			
	Jayadeva	7440	4988	7143		Ramakrishna Aashrama	5400	3255	3164
	Tilak Nagar	5554	5775	5952		Ryaan Circle	3900	3098	2904
3	Mico Layout					Mysore Road	4320	3255	2947
	DC halli	5280	3938	4343		K R Market	4620	3150	3295
	Bilekahalli	6192	4988	5578	8	KR Market			
4	Sadashiv Nagar					Market	5085	4988	4578
	Ramaih Hospital	6480	4725	3396		Sajjan Rao circle	5640	4095	4114
	Mekhri Circle	6300	3938	4190		Minerva circle	5904	4410	5354
	Tata institute	6120	3938	4194		Chamarajpet	5112	4620	3874
5	Shivaji Nagar				9	Malleswaram			
	Halsoor Road	7396	5513	7164		Malleshwara circle	6891	6563	6247
	BRV	7855	5513	6563		HDFC junction	7020	6195	7101
	Kariappa	6789	6825	7054	10	Shivaji Nagar			
		•	•	•		BRV	8160	7613	7969
						Manipal centre	8424	7088	9065
						Commercial street	8280	7088	8053

7 Conclusions

In this paper, 10 signalized intersections in Bangalore urban area with varying traffic parameters were studied. The results obtained can be summarised as follows.

- 1. Field saturation flow rate (Sf) was obtained by MLR method.
- 2. Base saturation flow rate (So) was also calculated by MLR method and was obtained as So =535*w.
- 3. Adjustment factors such as factor of gradient (fg), factor of through traffic (fth), factor of right turn (frt), factor of left turn (flt), factor of side friction (fsf) and factor of composition (fc) were proposed based on the studies (Table 6-2).
- 4. Saturation flow rates (SFR) were calculated by two models namely IRC SP: 41-1994 method and by a proposed SFR model.
- 5. The proposed model was derived based on the lines of HCM, by the introduction of adjustment factors of traffic and geometric conditions, yielded a better R^2 value (0.75) compared to IRC SP-41: 1994 (R^2 =0.66) method.
- 6. From the descriptive statistics it can be observed that P value is very less compared to F value signifying that, model depends on many variables.

This shows that introduction of adjustment factors with base saturation flow can give better picture of field conditions at signalized intersections, especially, under heterogeneous traffic conditions of an urban area in the Indian context.

8 Acknowledgement

The first author would like to express her sincere thanks to the Police personnel in TMC, Bangalore for their help and support in obtaining the field data from the proposed/identified junctions.

9 References:

- 1. 2000, HCM. Highway Capacity Manual. USA: Transport Research Board, 2000.
- 2. Indo-HCM— India's Highway Capacity Manual Project. Kayitha Ravinder, Senathipathi Velmurugan, and Subhamay Gangopadhyay. s.l.: Transport Research Board, 2014, Vol. 295.
- 3. IRC-106-1990. Guidelines of capacity of urban roads in Plain areas. New Delhi: Indian Road Congress, 1990.
- 4. **IRC.** *IRC:SP 41-1994, Guidelines for the design of at grade intersections in rural and urban areas.* s.l.: Indian Road Congress, 1994.
- 5. A comparative study of effect of motorcycle volume on capacity of four lane urban roads in India and Thailand. **Sanjeev Sinha, Pichai Taneerananon, Satish chandra.** Sweden: Journal of Society for Transportation and Traffic Studies (JSTS), 2012, Vol. 3.
- 6. Critical evaluation of roadway capacity of multi-lane high speed corridors under heterogeneous traffic conditions through traditional and microscopic simulation models. S. Velmurugan, Errampalli Madhu, K. Ravinder, K. Sitaramanjaneyulu & S. Gangopadhyay. s.l.: Journal of the Indian Roads Congress,, 2010.
- 7. Signalized Intersection Capacity Adjustment Factors for Makkah, Saudi Arabia. Md. Jobair Bin Alam, Khalid A. Osra, Hamid O. Al-Bar and Shaher Z. Zahran. s.l.: Canadian Journal of Transportation, , 2010, Vol. 4.
- 8. Modification of a Highway Capacity Manual Model for Evaluation of Capacity and Level of Service at a Signalized Intersection in India. **Geetam Tiwari, Niharika Singh, Joseph Fazio, Prateek Choudary, Mariya Khaton.** s.l.: Journal of the Eastern Asia Society for Transportation Studies,, 2011, Vol. Vol. 9.
- 9. Derivation of capacity standards for intercity roads carrying heterogenous traffic using computer simulation. V Thamizh Arasan, Shrinivas S Arkatkar. s.l.: Procedia of social &behaviral sciences., 2011.
- 10. Bangalore traffic police. Traffic Management centre. [Online] http://www.bangaloretrafficpolice.gov.in.
- 11. Traffic Signals. Webster F.V, Cobbe B. HMSO, UK, 1966, Road research technical papers.
- 12. Study on Saturation Flow Rates for Signalized Intersections . Chen, Guoqiang Zhang and Jun. 2009, International Conference on Measuring Technology and Mechatronics Automation.

Technical paper -4

ROLE OF AGRICULTURAL WASTES IN ENHANCING INDOOR THERMAL EFFICIENCY OF A BUILDING

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Abstract

Paper describes the Enhancement of Indoor Thermal Efficiency of a Building by utilization of agricultural waste. This waste is used as a cladding material since it is a porous material. Sustainable concept of designing the building Cladding by agricultural waste assist in reducing the indoor temperature. Hence this may not require any ACs which demand external energy and intern reduces GHG. The sustainability states both a infrastructure and the implementation of a process which is ecologically accountable and resource-efficient throughout a structure life-cycle. The sustainable building emphasis more on natural lighting and concepts of temperature control, as well as reduce the cost of operation. Use of interior flora which absorbs toxic gases nullifying the VOC (volatile organic compounds) materials and usage of passive means which do not produce any greenhouse gases. By adopting passive techniques like vegetative waste fill /cladding here Corn cob waste is used for the preparation of building material. An enormous amount of energy is utilized for thermal comfort in infrastructures like industries, complex, metro transit stations, and residency. Hence in order to avoid such an impact on environment the best way is adopting a passive method of thermal comfort. Huge amount of electricity 70% during operation and maintenance (O&M) phase is consumed in building for thermal comfort, intern GHG are emitted in this process which are harmful to the ozone. (Pintoa, et al., 2011)

Utilization of agro-waste as a resource with zero value. In addition, there will be savings of electrical energy to a tune of 70% hence it is deemed as sustainable innovative concept since the cost of material used for cladding is of zero value.

Keywords

Sustainability, Thermal Efficiency, Passive Techniques, Agricultural waste, Indoor Environment Comfort.

1 Introduction

"Sustainable concept of designing the building, architectural planning, macro and micro level building analysis to achieve sustainability of the building, efficient natural resource utilization in an economic integrated approach". The sustainable building emphasis more on natural lighting and concepts of temperature control, as well as reduce the cost of operation.

India is composed of 6 climatic regions/zones, "Hot and dry", "Warm and humid", "Moderate", "Cold and cloudy", "Cold and sunny", "composite". Excessive daytime temperatures, with very less precipitation and a short and mild winter season describe this climate. Very hot during the day and cold at night. This is due to the swift radiation heat loss from the ground or the building to the clear night sky. In summers, even though the day is hot, nights are cool, and people spend time out on the roof terrace. Because humidity is low, if water was available, cooling by evaporation of water would be an easy and effective way of gaining thermal comfort.

In Bengaluru, the ideal comfortable house is built of hefty walls with high ceiling rooms, with windows that you can shut and open, enclosed by a shade giving verandah.

BRI (building related illness) Building/Infrastructure related illnesses are a cluster of disorders whose cause is linked to the environment of current airtight, energy-efficient buildings. Such Structures are considered by sealed windows and dependence on heating, ventilation, and air conditioning systems for circulation of air. Most cases occur in nonindustrial office buildings, but illnesses can occur in apartment buildings, single-family homes, schools, museums, and libraries. Global Warming Potential is a measure of how much heat a green-house gas traps in the atmosphere up to a specific time horizon, relative to carbon dioxide. It compares the amount of heat trapped by a certain mass of the gas in question to the amount of heat trapped by a similar mass of carbon dioxide and is expressed as a factor of carbon dioxide.

The Global Warming Potential hangs on with the following factors:

- ✓ The immersion of infrared radiation by a given species.
- ✓ The spectral situation of its absorbing wavelengths

Buildings in all environments requires some form of decrease in temperature at some time of the year. There are many ways you can design or modify your home to achieve well-being through passive cooling techniques, as well as fusion methodologies which utilize mechanical cooling systems. The most appropriate passive cooling strategies for your home including orientation, ventilation, windows, shading, insulation and thermal mass are determined by climate, so initial identification is climate zone. Insulating materials are - wood fiber, cellulose, wool, hemp, hemp Crete, cellular glass, straw bales, glass mineral wool, rock mineral wool, aerogel and some are the agriculture waste are corn stalk, coconut husk, rice husk, bagasse, durian peel, corn cob (US Patent No. US6634574B1, 2003). Selection of Waste Material - Corn cob is chosen as the left-over material since the properties and characteristics of it are helpful in regulating thermal efficiency. Corn cobs are the long-rounded

parts of the maize or corn plant on which small yellow seeds grow, and which is taken as a vegetable. (Foley & Hooven, 2012)

Corn cobs has three different layers, layer 1 is macro structure, layer 2 is same as compacted soft wood and 3rd layer is an irregular layer, all these helps in Thermal separation. (Adesanya & Raheem, 2010)

Availability of corn cob material - It is cultivated on nearly 150 m ha in about 160 countries having wider diversity of soil, climate, biodiversity and management practices that contributes 36 % (782 m t) in the global grain production. The average productivity in India is 2.43. Major maize producing stated of India are tabulated in Table 1-1.

Table 1-1: Major maize producing states of India are

States	Production (%)
Andhra Pradesh	20.9 %
Uttar Pradesh	6.1 %
Karnataka	16.5 %
Madhya Pradesh	5.7 %
Rajasthan	9.9 %
Himachal Pradesh	4.4 %
Maharashtra	9.1 %
Bihar	8.9 %

Andhra Pradesh which ranks 5th in area (0.79 m ha) has noted the highest production (4.14 m t) and yield (5.26 t ha-1) in India.

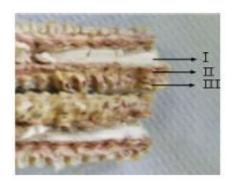
If the implementation of this system in both green field projects and in the retrofitting, buildings could be accelerated, there is a potential to reduce the GHG emission by about 20 million tons by 2022. The selected waste material is mixed with the different binding materials and is casted in a mould of definite size. Passive cooling systems are less expensive means of cooling building which in turn increase the efficiency of the building without any hazardous effect both to environment and living beings.

2 Methodology

Reduction in the amount of energy that is consumed in Heat ventilation and air conditioning (HVAC) using different materials depending upon location of site. The best orientation is to be studied and should be implemented.

Use of interior flora which absorbs toxic gases nullifying the VOC (volatile organic compounds) materials and usage of passive means which do not produce any greenhouse gases.

By adopting passive techniques like vegetative roof/cladding, (also some of the examples which can be adopted are earth air tunneling, passive downdraft evaporative cooling and roof pond which are environmentally friendly.)



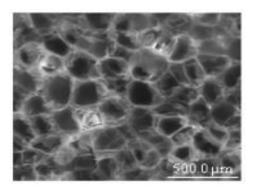


Figure 2-1: (a) Layers of Cob; (b) Microscopic details of Cob

3 Preparation of Composite Corn Cob

Corn cob powder has been mixed with different kinds of binding materials and different materials to improve the efficiency and durability of corn cob powder. (Figure 3-1.) The composite materials prepared out of corn cob powder were left undisturbed for drying. The prepared materials were tested for thermal transmittance in a controlled environment. Controlled environment is maintained since the surrounding atmospheric temperature.







Figure 3-1: (a) Preparation of Cob composite; (b) Different proportion Cob (c) Thermocouple setup

The source of heat for external temperature (T1) was given by hot air gun. Thermally stable and insulating sealant and pipe of diameter 8cm were used to create a controlled environment. Thermo couple apparatus were used for the measurement of the heat supplied and heat transmitted. The thermo couple sensors used were of range -2000C to 13700C and 328 0 F to 24980 F.

Every sample material prepared were tested for thermal transmittance till it attains the temperature of 1000C.

The supplied temperature (T1) and transmitted (indoor) temperature were measured using thermo couple apparatus with respect to time (Figure 3-2). The difference in the temperature is calculated (T1-T2), thereby heat transmission capacity of the material is known.





Figure 3-2: (a) Thermocouple setup 1; (b) Thermocouple setup 2

Sample-1: one proportion corn cob powder +2 cup jaggery +20ml water (Figure 3-3)

In this sample, one proportion of corn cob powder was taken a bowl. Two proportion of jaggery was heated along with the addition of 20ml of water till a viscous jaggery liquid was obtained.

Before the viscous jaggery liquid dries it was mixed thoroughly with the corn cob powder and the mixture was casted in the mould. This proportions are casted in the mould of 20cm*20cm*10mm.





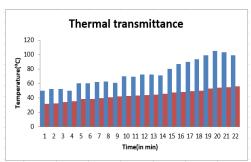


Figure 3-3: (a) Corn Cob Waste (b) Corn Cob sample 1; (c) Thermal transmittance of sample 1

Sample 2: Three proportion corn cob powder + nine proportion cement + 500ml water (Figure 3-4).

In this sample, volumetrically 3 proportion of corn cob powder was taken in a bowl, and then 9 proportion of cement was added and mixed till the color is uniform.

500ml of water was added, mixed and casted within the setting time of the cement. This proportions are casted in the mould of 20cm*20cm*10mm.





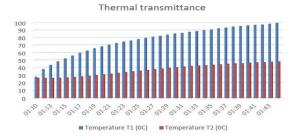


Figure 3-4:(a) Dry Corn Cob; (b) Corn Cob sample 2; (c) Thermal transmittance of sample 2

Sample-3: Three proportion corn cob powder + 6lime + 9 cement + 3 M-sand + 800ml water (Figure 3-5). In this sample, volumetrically 3 proportion of corn cob powder was mixed with 6 proportion of lime, 9 proportion of cement and 3 proportion of M-sand thoroughly till a uniform color is obtained. Then 800ml of water was added, mixed and casted within the initial setting time of cement.

This proportions are casted in the mould of 20cm*20cm*10mm.



Figure 3-5: (a) Dry Corn Cob; (b) Corn Cob sample 3; (c) Thermal transmittance of sample 3

Sample 4: 4 cement + 8 lime + 600ml water + 2 m-sand + 4 propotion corn cob powder (Figure 3-6). In this sample, volumetrically 4 proportion of corn cob powder was mixed with 8 proportion of lime powder, 2 proportion of M-sand, 4 proportion of cement was mixed uniformly. Then 600ml of water was added, mixed and casted before cement sets.

This proportions are casted in the mould of 20cm*20cm*10mm.

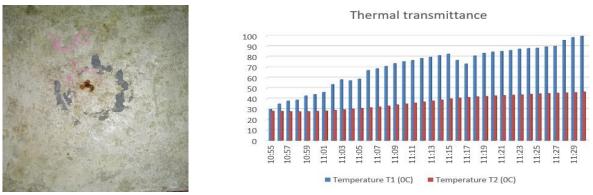


Figure 3-6:(a) Corn Cob sample 4; (b) Thermal transmittance of sample 4

Sample 5: Seven proportion corn cob + 4 cement + 8 lime + 800ml water + 2 M-sand (Figure 3-7).

In this sample, volumetrically 7 proportion of corn cob powder was mixed with 8 proportion of lime powder, 2 proportion of M-sand and 4 proportion of cement was thoroughly mixed till a uniform colour is obtained. Then 800ml of water was added, mixed and casted.

This proportions are casted in the mould of 20cm*20cm*10mm.

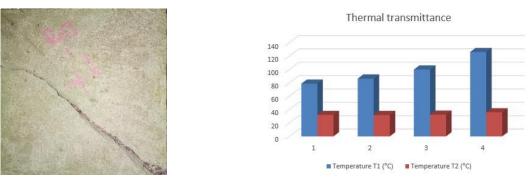


Figure 3-7: (a) Corn Cob sample 5; (b) Thermal transmittance of sample 5

3.1 Comparison of the different samples of materials based on its thermal transmittance

Thermal SI.No Material Heat **Transmittance** transmitted across the material 1 Proportion corn cob powder + 2 cup jaggery +20ml water 20°C 0.328 2 3 Proportion corn cob powder + 9 proportion cement + 500ml water 49.1 °C 0.805 34.7 °C 3 3 Proportion corn cob powder + 6lime + 9 cement + 3 M-sand + 0.56 800ml water 4 Proportion corn cob powder + 4 cement + 8 lime + 600ml water + 51.2 °C 0.83 5 7 Proportion corn cob powder + 4 cement + 8 lime + 800ml water + 57.6 °C 0.94 2 M-sand

Table 3-1. Comparison of the different samples

The comparison in Table 3-1 shows that, the 5th sample (i.e. 7 proportion of corn cob +4 proportion of cement + 8 proportion of lime + 2 proportion of M-sand + 800ml of water) has the very minimum heat transmittance across the material. But the surface of the material is absorbing the heat. Energy rapidly in shorter duration, also the material has very minimum strength hence this material is not preferred for the field applications. All the other samples are providing fairly best results of heat transmittance and can be utilized for the construction of sustainable building in the field.

The different materials can be selected based on the requirements of the locality i.e. the temperature of the area should be considered for the selection of materials.

Highly humid temperature locality requires very less thermal resistance hence the sample 1 and sample2 are sufficient in that location and best results can be obtained. Highly aired regions require high degree of thermal resistance hence sample3 and sample4 are suitable and best results can be obtained.

Application

Reducing the consumption of active energy for thermal comfort with higher efficiency and also good indoor environmental/air quality (IEQ/IAQ).

False ceiling: Corn cob composite material can be used as the material for false ceiling since this material requires least maintenance, less self-weight and mainly it is having very minimum thermal transmittance. (Youngquist, English, & Septler, 1993)

Wall cladding: The corn cob mixed material is mainly best suited for wall cladding. The main purpose of casting this material is wall cladding. The material has all the desirable properties of a wall cladding material like, it has a very high thermal resistivity, high thermal stability, and least thickness hence space is also saved.

Puffed wall: The material can be used in the puffed wall since it resists the heat more than that of the PVC coated puffed wall.

Cavity fill: This material can be used in masonry structures (Rat trap wall) also partition wall.

4 Results & Discussion

The corn cob composite material prepared can be further studied and its thickness could be minimized without any impact on its performance. The corn cob composite material should be enhanced by its strength and durability with further research on the materials.

The sample 5 which is exhibiting unique characteristics (the surface of the material absorbs heat rapidly to maximum extent but transmission of heat across the material is very much minimum) could be further studied and good result of it can obtained.(Table 4-1).

Table 4-1: Transmittance of Different Materials

SI No Material

Sl.No.	Material	Thermal Transmittance (W/m²-K)
1	1 Proportion corn cob powder + 2 cup jaggery +20ml water	0.328
2	3 Proportion corn cob powder + 9 proportion cement + 500ml water	0.805
3	3 Proportion corn cob powder + 6lime + 9 cement + 3 M-sand + 800ml water	0.56
4	4 Proportion corn cob powder + 4 cement + 8 lime + 600ml water + 2 m-sand.	0.83
5	7 Proportion corn cob powder + 4 cement + 8 lime + 800ml water + 2 M-sand	0.94
6	Plain glass sheet 3mm thickness	5.23

7	White Painted glass	5.22
8	Yellow painted glass	5.22
9	Green painted glass	5.22
10	Heat absorbing glass	4.65
11	100 % shaded glass sheet	5.23
12	75% shaded glass sheet	5.23

5 Conclusion

The construction of sustainable building increases the initial cost by 10% generally.

CII-Sorabiji Godrej GBC located in Hyderabad, built up area =20,000 sq. ft. rating achieved – platinum the construction cost is increased by 18%, but it was pay backed within 7 years, providing all kinds of comfort to the users and less environmental impact. Grundfos Pump located in Chennai, built up area =40,000 sq. ft. rating achieved – Gold, the construction cost is increased by 6%, but it was pay backed within 3 years.

By adapting the different samples of the corn cob composite materials depending of the temperature zones of the locality, required material (depending upon the value of thermal resistance) can be chosen, which leads to best results. Enormous amount of energy is utilized for thermal comfort in infrastructure like industries, complex, metro transit stations and residency. Hence in order to avoid such impact on environment the best way is adopting passive method of thermal comfort. Huge amount of electricity (70%during operation and maintenance (O&M) phase) is consumed in building for thermal comfort, intern GHG are emitted in this process which are harmful for ozone layer.

6 References

- 1. Adesanya, D. A., & Raheem, A. A. (2010). A study of the permeability and acid attack of corn cob ash blended cements. *Construction and building materials*, 403-409.
- 2. Eisfeld, J.-G. (2003). US Patent No. US6634574B1.
- 3. Foley, K. M., & Hooven, D. I. (2012). Properties and industrial uses of corncabs. AGRIS.
- 4. Pintoa, J., Paivaa, A., Varumd, H., Costaa, A., Cruz, D., Pereiraa, S., . . . Tavares, P. (2011). Corn's cob as a potential ecological thermal insulation material. *Energy and buildings*, 1985-1990.
- 5. Youngquist, J., English, B., & Septler, H. (1993). Agricultural fibres in composition panels. *27th International particle board/composite materials Symposium* (pp. 133-152). Washington DC,US: AGRIS.

Technical Paper -5 Sustainable Planning Approaches: The Need for Child Friendly Urban Environments

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Abstract

The world health organisation recommends 60 minutes of moderate to vigorous intensity of physical activity every day for children. (WHO, 2010). Urban spaces on the contrary are challenged in supporting or encouraging children's outdoor physical activities which have an impact on their health and wellbeing. This paper presents a review of transdisciplinary literature, pointing out the challenges faced in the urban scenario, the influences of the built environment on the development of children and the need to actively confront these challenges to bring child friendliness into the built environment. It illustrates examples of child friendly environments implemented in various urban contexts. The paper also lists out the policy frameworks and the urban design initiatives put forth by the Indian government. It analyses them and stresses on the need for further and in-depth research of child friendly environments in the Indian context for it to make inroads in policy levels.

Key words:

Child friendly environment, urban spaces, child development, Indian policies

1 Introduction:

The World Health Organisation states in its preamble that "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (WHO., 2007). Decision makers and Planners through their policies and design can govern how one interacts with the environment. As a result, the surrounding physical environment has a significant impact on the mental, social and physical health of all citizens including children. Therefore, the authorities have an important responsibility of making space child friendly. And for the making of a child friendly community, integration of access, green spaces and safety become critical. This can help achieve better social interactions helping sustain natural spaces, thereby improving the quality of life and encouraging healthy lifestyles (McAllister, 2008).

1.1 Fundamental rights and Global Initiatives:

In the present moment Children's health and future faces uncertainty and threat from environmental degradation in which the capacity of the environment to fulfil social and ecological demands has been compromised. The United Nations recognised the need to invest in the Child's mental and physical well-being and striving to bring in better living standards, adopted the Convention of Rights of Child (UNCRC) in 1989. As a widely ratified and legally binding instrument, India signing up the agreement in 1992, the articles of UNCRC set out Children's rights and how the governments must strive to provide children's basic needs to help them achieve and perform to the fullest of their capabilities at a city level. (Riggio, 2002). In upholding the basic and fundamental rights, the right to rest, leisure and to engage in play and recreational activities has been underlined by Article 31 in the UNCRC. The member governments have an obligation to support, provision and promote the implementation of recreational and play spaces which become an important constituent contributing to the betterment of Children's mental and physical health. Aligned with the Sustainable Development Goals, the UNCRC calls for a healthy, safe and sustainable environment for every child. In the act of spurring on cities to commit to improve the quality of life of children, UNICEF came up with the Child Friendly Cities Initiative (CFCI) encouraging the local governments to make decisions in the best interests of children to promote a culturally rich environment. (Riggio, 2002), (Malone, 2001). In addition to a dearth of planning children are not involved in decision making in the community level. Empowering children through community engagement can positively influence the measure of physical activities, improving their social, physical and mental health. (Bartlett, 2005).

2 Why focus on Children?

2.1 Play as a natural disposition:

Children are naturally disposed towards play. Children exhibit a playful personality which goes beyond context, situations and tasks. Children primarily participate through play. And it is the right of a child to play. These playful encounters are motivated from within, with self-imposed goals as children assign their own meaning to objects

and behaviours. (Barnett, 1991). Children will play as long as basic survival needs are met. But Children live and play in adult controlled environments. Urban settings are generally not child responsive. There exists a spatial inequality in terms of insufficient play spaces, environmental and physical barriers for a child to play. Children have a right to play and this is subject to spatial justice. A child's right to play is recognised when provisioning for it. This space for play organises, controls and structures a child's play experiences while offering the right kind of situation to support their mental and physical development. In supporting a child's participation through play by effectively managing time and space in the urban set up through making and preserving children's territories, an optimistic approach is developed in making a better city. (Russell, 2020).

2.2 Vulnerability and invisibility

Children have been rendered invisible and powerless in families and societies and their voices have been often neglected or overlooked as a result of age and immaturity. (Unicef, 2011). The most vulnerable period of life is childhood. To fulfil their basic needs children are dependent on others to a high degree which makes them vulnerable. The most notable source that makes them particularly vulnerable is that Children are dependent on the decisions others make for them. While adults are enfranchised and independent, children are a disenfranchised group and hence vulnerable and dependent. (Bagattini, 2019). Developmental vulnerability can arise from the influence of the surrounding environment like access to schools, parks, playgrounds, housing density and recreational opportunities. Children are dependent on the qualities of neighbourhood which has an effect on child health and developmental outcomes over time. Children, who are developmentally susceptible, are at peril in achieving their true capabilities over time. (Woolfenden, 2015) . Supportive mechanisms in a neighbourhood can promote child development in a positive way. (Christian et al, 2017) in their research found that a good amount of home yard space and reduced traffic levels are associated with reduced levels of developmental vulnerability.

2.3 Children's Population in the world and in India:

The number of people living in cities and urban areas has increased noticeably in the last century. Populations of many cities have become more than that of small nations. Rapid and uncontrolled growth has crippled the ability of urban authorities to meet basic physical and social needs pertaining to infrastructure. (NIUA, 2017). With a 0.92 rate of urbanisation between 1950 and 2018, an estimated 55 percent of the world's population became urban. (Desa, 2018). The trend is expected to continue where more people are set to be urbanites in the future. This accentuates that the planning and design of urban spaces are critical to achieve efficient functioning of cities. Inclusive planning would be of utmost essence for the wellbeing of all including Children. According to (Unicef, 2011), India holds the largest children and youth population in the world. With 365 million young people and 30 percent of the country's population in the age group of 10-24 years, India is the youngest

nation in the world. (UNFPA, 2018). Children form a large sector of the population living in cities, yet they become a neglected democratic group who are ignored in the planning of our cities. This large sector of the youth population's rights can no longer be neglected. The country needs to invest in its youth for long term benefits. The environmental need of the increasing youth population needs to be taken into consideration when designing the urban spaces. Understanding how children experience urban environments therefore becomes of paramount importance. Many researchers have pointed out the developmental benefits of designing environments that are more suitable to the needs of children. (Korpela, 1989) (Loprinzi et al, 2012) (Chawla, 2015) (Cozens, 2007) (Schweitzer et al, 2004) (Hart, 1979).

3 Middle Childhood

3.1 The age for exploration:

The age range of 6 to 12 years is called middle childhood where the child's world expands to a great degree as they enter school. Increasing physical and motor skills enable children to play games of complex skills like bicycling and other organised games. By age nine they explore the environment and the necessary through bikes to distant points and may use public transportation. (Pollowy, 1977) (Charlesworth et al, 2011). Children are more likely to explore the neighbourhood during the time of middle childhood. (Hillman and Adams, 1992)

3.1.1 Places children go in the neighbourhoods:

In a survey by (Egli et al, 2020) the most commonly named destinations were Parks, playgrounds, fields and courts as it allowed children the affordance of friends, climbing trees etc. followed by eateries. Other destinations like friend's and relative's houses especially the backyard part of the house was important. Nature destinations like the beach, forest offered affordances like climbing and running and were also mentioned. But there is a lot of literature which shows that Children's Independent Mobility children's right to move freely in the environment, walk or cycle and use public transport to reach destinations without adult supervision is challenged in urban areas. (Hillman and M, 1990).

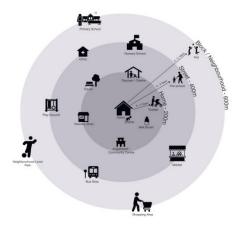


Figure 8: Walking and Access range by age,

Source: (ITCN, 2019)

3.2 Need for a Child centred approach:

But children are rarely in control of their environments as they live in adult centric and adult regulated cities. (Davidson et al, 2012). Cities when designed have neglected children's needs into account. It has become essential to design environments taking into consideration children's needs and interests so as to support and promote children's abilities and strengths and where child friendliness is an overall quality of a city. Child centred approaches through designing for Children shapes liveable environments making the city more human centric. (Katsavounidou, 2021). Though children are recognised as citizens and have their own rights, the arduous search for a childhood city has not been realised. (Karsten, 2002).

4 Associations of built environment and Children's Outdoor activities

4.1 Socialisation and Interaction:

As stated by (Webber, 1964) Interaction is the basic quality of a city and city life and not just place. Children love it when the city allows them free movement through space. (O'brien et al, 2000). Children explore their surrounding physical environment and the planning and design of their neighbourhood can affect them. (Egli et al, 2020). Acting as their immediate physical surroundings, neighbourhoods can significantly influence skills like motor development and social and emotional wellbeing. (Christian et al, 2017). Children have less mobility than adults and spend more time in their immediate surroundings and thus neighbourhood can influence behavioural issues like physical or sedentary activity and diet (Mitchell et al, 2016).

Children like to interact with and explore rich and varied environments and play with interesting materials. Not only does the immediate environment act as a primary medium for learning but allows them to socialise.

Exposure to physical settings leads to understanding social norms and regulates behaviour. Rich and diverse built settings provide opportunities for growth and their exploration is crucial for cognitive, social and physical development (David and Weinstein, 1987).

4.2 Diversity and increased playability:

According to Moore's study the more diverse the physical setting is the more is the interaction between the child and his environment (Moore, 1989). According to (Frost, 1997) there is an association between the degree of playability and the opportunities that the physical environment provides for learning in an exciting and challenging way. Neighbourhood destinations provide room for children to be physically active and to engage in play. Access to destinations like park and playgrounds encourage physical activity in a positive way, while accesses to other destinations like fast food outlets and convenience stores have resulted in an unhealthy diet. (Paquet et al, 2017). An understanding of how Children access and regard their neighbourhood, their likes and dislikes and their uses of destinations would help planners and urban designers build a better environment that can encourage healthy behaviours (Davidson et al, 2012).

4.3 Obesity

(Booth et al, 2005) found that obesity in children are linked to parameters like land use, sprawl and reduced activities like walkability, play and level of deprivation. Interventions required at the neighbourhood level were to focus on elimination of barriers and create accessible neighbourhoods. Accessibility to recreational centres, food stores and human centric neighbourhoods not designed around cars were some of the approaches that were recommended. (Booth et al, 2005).

4.4 Mental Health and built environment:

Built environment can affect mental health and has an influence on behavioural factors like social relationships, personal control, and restoration from stress and fatigue. Better health is associated with control over surroundings. Feelings of ownership over a territory are associated with a fear of crime and crime levels. Scarcity of safe play spaces, cage children in their homes. These restrictions discourage play opportunities and social interactions with others, and encourage interfamilial conflict. (Evans, 2003)

4.5 Physical activity and the built environment:

The built environment can affect a child's physical level of activity. When walking, biking and play is supported by the built environment, it promotes child development in various ways. Environments achieved through strategically locating schools, parks and sidewalks in a neighbourhood can help children reach the recommended levels of physical activity. Street grids connecting many intersections can provide many route options. Dense communities with higher land use mix and less car dependency, sidewalks that connect streets, green spaces,

and accessible recreational spaces and can be adopted to increase walkability and biking to destinations. (Committee on Environmental Health & Tester, 2009). Repurposing spaces to include play along the way strategies, pop up play spaces, bicycle parking, spaces to socialise can increase possibilities of children's physical activity. (Carroll et al, 2019).

5 Barriers to Children's outdoor activities

5.1 Urbanisation:

Urbanisation has an impact on many aspects of living, especially health in terms of overcrowding, pollution and stress related illness (Godfrey and Julien, 2005) and economy (Narayana, 2010). Urbanisation has affected and limited children's movement at a global level creating so called pattery and overprotected children (Kyttä M., 1997) and the bubble wrap children who fail to have the resilience and skills to use the environment competently and independently (Malone K, 2007). Children's freedom to move about and roam has been decreasing in the urban areas. Factors like traffic, pollution, density and unresponsive environmental conditions which occur as a result of urbanisation have drastically changed the way children move outdoors. (Hillman and Adams, 1992) (Hillman and M, 1990).

5.2 Car dependency:

Increase in car use has decreased the amount of walking and cycling activities by children. Long term car usage can affect the health of children. Increase in car ownership and increase in car use can result in lesser physical activities in children (Mackett et al M. R., 2005) (Mackett et al M. R., 2007). Studies show that an increasing number of children are taken by car to schools. Studies in Europe like Britain, Scandinavia and Italy show the same tendency for both lower and upper grade children. (Mackett et al M. R., 2005). Activities like sports, music and dance classes post school hours where leisure time is institutionalised and organised is an increasing trend while children hardly have time for free play. It was found in a study that the main mode of transport for these activities is the car. Parents who owned a car tended to use the car for transport. The distance at which these activities took place was an important variable influencing the usage of cars as a means of transport. (Hjorthol and Fyhri, 2009).

5.3 Parental perceptions of risk

Parental perception about public spaces not being safe for children increased significantly in the late 1990s. As a result of these concerns, Children's mobility was restricted and their outdoor activities were increasingly being supervised (Malone K, 2007). Safety concerns of parents were influenced by incidences of traffic accidents and strangers' attacks on children. (Hillman and M, 1990). Due to the increase in car ownership and traffic, there were fewer pedestrians (Children and adults) on the streets, making the streetscape abandoned and lonely,

encouraging strangers to carry out anti-social activities. The busier the roads became, the lesser was the play territory for children as parents restricted their independent mobility. (Hillman and M, 1990). Play eventually was centered around home and independent mobility to school diminished by a significant degree. (Bessell, 2015).

5.4 Traffic:

Noisy, crowded and dangerous settings inhibit social interactions. Children who live near traffic prone areas are associated with compromised social networks and lesser play. Their social and motor skills are also affected. Shared green spaces and gathering spaces are known to promote informal contacts and strengthen social support. Walkable human scale neighbourhoods with shared spaces like parks and tree lined streets encourage healthy behaviour and promote social ties. (Sullivan and Chang, 2011).

5.5 Air quality:

Air quality and air pollution have been associated with mental health outcomes. Presences of toxins in the air have neurological and cognitive impacts. According to Global burden of disease 2017, elevated levels of air pollution in addition to causing acute respiratory problems, lead to death, reducing life expectancy. (Balakrishnan et al, 2019). According to UNICEF, almost 300 million children live amidst the most toxic levels of Air pollution which has been violated six or seven times than permissible levels. Air pollution threatens lives and is the cause for death of 6 lakh children every year. Vehicle emissions among other sources tend to be a major factor causing air pollution. Young children breathe faster than adults taking in air more according to their body weight. (UNICEF, 2016,). In India, emerging economies and increasing urbanisation have contributed to a hike in ambient air pollution levels in urban spaces, increasing the risk of respiratory ailments in children.

Violations of permissible limits of suspended particulate matter are common in many cities in India where key pollution sources are vehicular traffic and burning fossil fuels. There is an urgent need for improving the quality of air when planning urban spaces. Policies need to target reduction in air pollution levels to see a significant improvement in children's health (Ghosh and Mukherji, 2014).

6 Theoretical frameworks regarding Child Friendly Environment:

These frameworks broadly follow two approaches.

6.1 Rights based approach:

This focuses on Child rights and urges local governments to promote the rights of children by making decisions in their best interests.

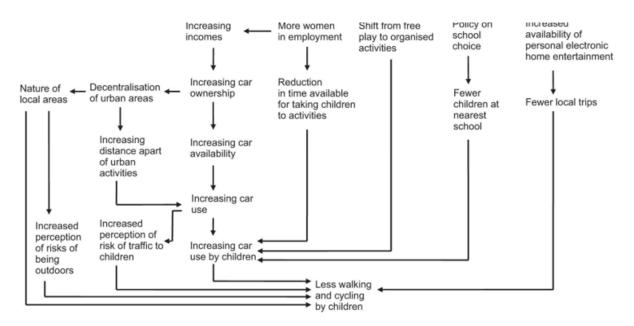


Figure 9 : : Factors contributing to decrease in walking and cycling levels of children Source: (Mackett, 2013)

Article 12 of the United Nations Convention on the Rights of the Child (CRC) made a clear commitment regarding respecting and hearing Children's rights. Following this the 1992 Earth summit's priority areas included children's participation in their living environments and introduced Agenda 21 that focussed on strengthening the role and rights of children. (NIUA ..., 2016). Child friendly Cities Initiative (CFCI) programme of the UNICEF, has driven child's right and promoted Child's participation in a global way, connecting Children's right movements with the Children's environment (UNICEF ..., 2004). Launched in 1996 along with other agendas like Growing up in Cites (UNESCO) and safer cities (UNHABITAT), CFCI came up with Indicators like health, care, protection, education and inclusivity, to be included to achieve a non-discriminating, stimulating and culturally rich environment (Malone K., 2006) (NIUA ..., 2016).

6.2 An approach which is Environment based:

Focusing on physical and social environments, researchers, through academic and theoretical research have tried to understand and define criteria for certain frameworks for the concept of Child friendly Cities. In the project growing up in cities (Chawla L., 1997) providing basic physical and social services, diversity in activity settings, and the ability to move freely without physical dangers were mentioned by children. (Broberg et al, 2013) (Moore, 1989) asserted that variety in environmental resources and opportunities to play and explore are two criteria for child-friendly areas. (Kyttä M. , 2004) came up with the Bullerby model which was based on improving mobility for better development of children and evaluation of child friendliness of the environment by two important criteria: Children's possibility for Independent mobility and realisation of environmental affordances. (Chatterjee, 2006), proposed a theoretical concept on place friendship which is based on the

comprehensive interdisciplinary review of literature on environmental Child friendliness. The six dimensions of place friendship as proposed by Chatterjee are Care and respect, Meaningful exchange with places, Learning and Competence through place experience, Creating and Controlling Territories, Having secret places and Freedom of expression in place. A framework for assessment of Environmental Child Friendliness was developed by Dr. Horelli. Acknowledging how the built environment influences Children's development, the framework included ten normative dimensions which are Housing and dwelling, Basic services, Participation, Safety and security, Family, peers and community, Urban and environmental qualities, Provision and distribution of resources and poverty reduction, Ecology, Sense of belonging and continuity, and Good governance. (Horelli, 2007).

7 Best practices:

The following examples show key findings of how cities have tried to achieve sustainable and inclusive child friendly environments

7.1 City level best practices

7.1.1 Rotterdam:

Rotterdam, a city in the Netherlands, experienced an out migration of middle-class families and realised the need for cities to be attractive to young families and children. As a result, the Government set up a Child Friendly City program in 2007 in which an urban Planning method called "Building Blocks for a Child friendly Program was developed". It aspired to improve the city as a place where families can reside by building up the economy and improving the quality of life for children. The programme identified four building blocks housing, public space, amenities and routes to achieve a family Friendly city. Interventions like better parks, better routes for walking and cycling, wider sidewalks and child participation process resulted in an place that families found attractive to live in. (van den Berg, 2013) (NIUA, 2017).

7.1.2 Gujarat, India:

A community-based initiative started in Ahmedabad, Gujarat, aProCh encourages creation of Child Friendly spaces where a child has many opportunities to explore and play. Main initiatives are addressed are: Street smart: Where the streets block vehicular movement for a day, Moving experience: Where the project partners with other facilities to accommodate spaces for poor children, City on cycles: to promote cycling, Parents of the park where adult take initiatives to engage children with creative activities and City as my Landscape: Where Children are encouraged to design and be visible. (NIUA, 2017) (aProCh, 2021).

7.2 Urban scale initiatives:

7.2.1 Thailand:

"The walking Neighbourhood" in Thailand where the Child as a guide takes participants around curated spaces in the city. Thailand's strategy on Child Friendly Local Governance provides directions to local governments and urban authorities on how to address issues on child rights. Indicators are provided to realise a child Friendly city.

7.2.2 Global Design Guidelines and indicators:

Worldwide, a number of organisations have come out with design guidelines and indicators of Child friendly cities. One of them is The National Association of City Transportation Officials - NACTO which has come out with guidelines on 'Designing Streets for Kids'. Capturing global policies, programs and best practices, the guide promotes enjoyable and safe streets for both Children and caregivers. (NACTO, 2020).



Figure 10 : Ten actions to improve streets for children Source: (NACTO, 2020).

7.2.3 Indian Initiatives:

In Karnataka an Indian NGO "The Concerned for Working Children" came up with India's first "Children Ward Sabha" which allowed school, working and migrant children a platform to express their issues to urban and local administrators. In Orissa a campaign titled "Humara Bachpan" encourages healthy environments which are not only safe but also creates platforms for children to vocalise their issues.

8 Policy framework in Indian context

Though Children are a significant part of the population, they form an under-represented part of our demographics. Until recently the concept of children as stakeholders and contributors to society has been grossly underestimated.

8.1 National level policies

8.1.1 National Policy for Children 1974 -

The Government of India declared Children as the 'nation's supremely important asset' while drafting the National Policy for Children in 1974. The policy committed to secure the rights of Children and endeavours to place the programmes for children in a prominent way in all national plans.

8.1.2 National Policy for Children 2003 –

This policy promotes multi sectoral, sustainable, Inclusive and long-term approach, which is essential for children' safety and their healthy development.

8.1.3 National Charter for children 2013 -

(GoI., 2013). Trying to ensure the healthy growth of children and their development the charter also protects them from all forms of abuse and violence.

8.1.4 National Plan of action for children 2005, 2016:

This plan promotes Survival, Health and development, protection and participation (Gol ..., 2005) (Gol ..., 2016).

8.1.5 National Policy for Children (2013)

According to this policy, anyone under 18 years of age is regarded as a child. The policy realises that children have needs different from others. It also realises the need to provide equal opportunities for the development of children and calls for collective action across levels and sectors of governance to achieve children's needs. (GoI., 2013).

8.2 Urban Development Programmes in India:

Child friendly Smart Cities Initiative (CFSC) 2014: The guidelines for this Mission look at Urban Planning and Urban Policy to design a city, involving children. Some of its features include Creation of destinations which are walkable, preserved open spaces that could also be developed, housing and Inclusivity. (NIUA, 2017). Atal Mission for Urban Rejuvenation and Transformation (AMRUT) aims to develop basic Infrastructure in 500 cities. It also endeavours to create green spaces, parks and recreation centres which can be upgraded, especially for children (GoI, 2015). Swachh Bharat Clean India Mission: Aims at improving sanitation facilities at City level and State. (NIUA, 2017). Hriday: This looks at Heritage conservation linking it with the city's infrastructure. Pradhan

Mantri Awas Yojana (PMAY): Looks at projects like Affordable housing and basic Infrastructure. National Urban Livelihood Mission (NULM) has guidelines to provide shelter with essential services to the urban homeless. Infant, Toddler, Caregiver-friendly Neighbourhood (ITCN, 2019) has come up with many parameters to achieve ITC friendly neighbourhoods which include Policy frameworks, Design Guidelines, Policy workbook and Evaluation and Monitoring metrics. Design guidelines have been provided for tot lots, streets, playground, home zones and the neighbourhood. (NIUA., 2018). The Nurturing Neighbourhood Challenge, 2020 an initiative of the smart cities mission, encourages designing neighbourhood-level improvements promoting health and well-being of the young and their caregivers. (MoHUA, 2020).

9 Discussion:

In the policies that were released initially, the aspects of the built environment have gone unobserved with regard to health and development of a child. Children were considered part of the homogeneous group and their voices were not taken into account. The recognition of their needs and rights was broadly confined to the health, education and nutrition sectors. They lived in an environment created and maintained by adults and decisions were made for them. But of late the influences of the physical surroundings on the developmental outcomes have been recognised and there is an effort in policies to issue guidelines on the same. There have been efforts to achieve Child Friendly Governance in our country. But these processes are in a nascent stage. Through urban development programs like Child Friendly Smart Cities (CFSC), AMRUT and PMAY there is an emerging understanding as to how built environments are instrumental in shaping childhood developmental outcomes. (NIUA., 2018). There is a promise of ideas and mechanisms cities are employing to make children an integral part of urban development.

Parallelly there is a burgeoning need for data on the parameters related to the issues of children in Indian cities. And there is a dearth of research that needs to be undertaken to understand aspects regarding quality of life in the Indian context. Different influence variables need to be assessed. Gathering and assessing comparative information of child friendly parameters across cities in India could throw up meaningful insights. Longitudinal and cross-sectional studies can establish cause effect relationships. Effective research can have an impact on a paradigm shift in urban strategies across the country. The insights found could be used as a tool for policy making which can support the development of local urban strategies. (NIUA ..., 2016) (NIUA 2016). Partnership at various levels including involvement and coordination of various actors and sectors for comprehensive research can lead to positive outcomes.

10 References

- [1]. (n.d.).
- [2]. aProCh. (2021, Dec 5). aProCh: A Protagonist in Every CHild, Design for Change." n.d. aProCh: A Protagonist in Every CHild, Design for Change. Accessed December 5, 2021. Retrieved from aProCh: A Protagonist in Every CHild, Design for Change.: http://aproch.org/.
- [3]. Bagattini, A. (2019). Children's well-being and vulnerability. Ethics and Social Welfare, 13(3), 211–215.
- [4]. Balakrishnan et al, B. K. (2019). The impact of air pollution on deaths, disease burden, and life expectancy across the states of India: . . the Global Burden of Disease Study, 2017.
- [5]. Barnett, L. (1991). The playful child: Measurement of a disposition to play. 4, 51–74. *Play & Culture*, 4, 51–74
- [6]. Bartlett, S. (2005). Integrating Children's Rights into Municipal Action: A Review of Progress and Lessons Learned. *Children, Youth and Environments,*, 15(2), 18–40.
- [7]. Bessell, S. (2015). Perceptions of risk and safety in public spaces: towards a child standpoint. , . *Risk, Protection, Provision and Policy*, 223–240.
- [8]. Booth et al, B. K. (2005). Obesity and the Built Environment. https://doi.org/10.1016/j.jada.2005.02.045. *In Journal of the American Dietetic Association*, (Vol. 105, Issue 5, pp. 110–117).
- [9]. Broberg et al, B. A. (2013). Child-friendly urban structures: Bullerby revisited.https://doi.org/10.1016/j.jenvp.2013.06.001. *In Journal of Environmental Psychology*, (Vol. 35, pp. 110–120).
- [10]. Carroll et al, C. P.-D. (2019). A Prefigurative Politics of Play in Public Places: Children Claim Their Democratic Right to the City Through Play. https://doi.org/10.1177/1206331218797546. *In Space and Culture*, (Vol. 22, Issue 3, pp. 294–307).
- [11]. Charlesworth et al, C. L. (2011). Middle childhood. Dimensions of. https://us.corwin.com/sites/default/files/upm-binaries/16297_Chapter_5.pdf. Hutchison (Ed.).
- [12]. Chatterjee, S. (2006). Children's Friendship with Place: An Exploration of Environmental Child Friendliness of Children's Environments in Cities. . North Carolina State University.
- [13]. Chawla L. (1997). Growing up in cities: a report on research under way. https://doi.org/10.1177/095624789700900212. *In Environment and Urbanization*, (Vol. 9, Issue 2, pp. 247–252). [14]. Chawla, L. (2015). Benefits of Nature Contact for Children. Journal of Planning Literature, 30(4), 433–452.

- [15]. Christian et al, C. H. (2017). "Relationship between the Neighbourhood Built Environment and Early Child Development.". *Health & Place*, 48 (November): 90–101.
- [16]. Committee on Environmental Health & Tester, J. M. (2009). The built environment: designing communities to promote physical activity in children. *Pediatrics*, 123(6), 1591–1598.
- [17]. Cozens, P. (2007). Public health and the potential benefits of Crime Prevention Through Environmental Design. *New South Wales Public Health Bulletin*, 18(11-12), 232–237.
- [18]. David and Weinstein, D. T. (1987). The built environment and children's development. In Spaces for Children . *In Spaces for Children*, (pp. 3–18). Springer US.
- [19]. Davidson et al, D. D. (2012). Emotion, Place and Culture. . Ashgate Publishing, Ltd.
- [20]. Desa, U. N. (2018). World urbanization prospects 2018. . United Nations Department for Economic and Social Affiars.
- [21]. Egli et al, E. V. (2020). Understanding children's neighbourhood destinations: presenting the Kids-PoND framework. , . *Children's Geographies*, 18(4), 420–434.
- [22]. Evans, G. W. (2003). The built environment and mental health. *Journal of Urban Health: Bulletin of the New York Academy of Medicine*, , 80(4), 536–555.
- [23]. Frost, J. L. (1997). *CHILD DEVELOPMENT AND PLAYGROUNDS*. REPORT NO PUB DATE NOTE AVAILABLE FROM. https://files.eric.ed.gov/fulltext/ED291748.pdf#page=11.
- [24]. Ghosh and Mukherji, G. A. (2014). Air Pollution and Respiratory Ailments among Children in Urban India: Exploring Causality. *Economic Development and Cultural Change*, , 63(1), 191–222.
- [25]. Godfrey and Julien, G. R. (2005). Urbanisation and health. Clinical Medicine, 5(2), 137–141.
- [26]. Gol. (2015). http://www.amrut.gov.in/. Retrieved from http://www.amrut.gov.in/.
- [27]. Gol, .. (2005). National Plan of Action for Children 2005. Government of India, Ministry of Human Resource Development, Department of Women and Child Development. Gol.,.
- [28]. Gol, .. (2016). National Plan of Action for Children—Safe Children Happy Childhood. Ministry of Women and Child Development New Delhi. New Delhi.: Gol.
- [29]. Gol. (2013). "National Policy For Children 2013.". Gol.
- [30]. Hart, R. (1979). "Children's Experience of Place" 518. https://psycnet.apa.org/fulltext/1980-51458-000.pdf.
- [31]. Hillman and Adams, H. M. (1992). "Children's Freedom and Safety." . Children's Environments,, 10-22.
- [32]. Hillman and M. (1990). "One False Move: A Study of Children's Independent Mobility.". Policy Studies Institute XLV. https://ci.nii.ac.jp/naid/10004535145/.
- [33]. Hjorthol and Fyhri, H. R. (2009). Do organized leisure activities for children encourage car-use? *Transportation Research Part A: Policy and Practice*, 43(2), 209–218.

- [34]. Horelli, L. (2007). "Constructing a Theoretical Framework for Environmental Child-Friendliness." Edited by Horelli, Liisa. "Constructing a theoretical framework for environmental child-friendliness.". *Children Youth and Environments*, 17. 4 (2007): 26.
- [35]. ITCN. (2019). Infant, Toddler, Caregiver-Friendly Neighbourhood, Policy framework, (a). NIUA. BVLF. https://smartnet.niua.org/cfn.
- [36]. Karsten, L. (2002). Mapping Childhood in Amsterdam: the spatial and social construction of children's domains in the city. Tijdschrift Voor Economische En Sociale Geografie = Journal of Economic and Social Geography = Revue de Geographie Economique et Humaine =Zeitschrift Fur Okonomische Und SozialeGeographie = Revista de Geografia Economica Y Social, 93(3), 231–241.
- [37]. Katsavounidou, G. (2021). Child, play, and urban space: a historical overview and a holistic paradigm for child-centered urbanism. . *Journal of Urbanism: International Research on Placemaking and Urban Sustainability*, 1–17.
- [38]. Korpela, K. M. (1989). "Place-Identity as a Product of Environmental Self-Regulation." . . *Journal of Environmental Psychology*, https://doi.org/10.1016/s0272-4944(89)80038-6.
- [39]. Kyttä, M. (1997). Children's independent mobility in urban, small town, and rural environments. . *Growing up in a Changing Urban Landscape*, , 41, 52.
- [40]. Kyttä, M. (2004). "The Extent of Children's Independent Mobility and the Number of Actualized Affordances as Criteria for Child-Friendly Environments." https://doi.org/10.1016/s0272-4944(03)00073-2. *Journal of Environmental Psychology*.
- [41]. Loprinzi et al, L. P. (2012). Benefits and environmental determinants of physical activity in children and adolescents. ,. *Obesity Facts*, 5(4), 597–610.
- [42]. Mackett et al, M. R. (2005). The therapeutic value of children's everyday travel. *Transportation Research Part A: Policy and Practice*, 39(2-3), 205–219.
- [43]. Mackett et al, M. R. (2007). Final report on "children"s activities, perceptions and behaviour in the local environment (CAPABLE)'. London.: University College.
- [44]. Mackett, R. L. (2013). Children's travel behaviour and its health implications. . Transport policy,, 26, 66-72.
- [45]. Malone K. (2007). The bubble-wrap generation: children growing up in walled gardens. *Environmental Education Research*, 13(4), 513–527.
- [46]. Malone K. (2006). "United Nations: A Key Player in a Global Movement for Child Friendly Cities." In Creating Child Friendly Cities, edited by K. Malone, 25–44. Routledge. *In Creating Child Friendly Cities, edited by K. Malone, 25–44. Routledge.*, 25–44.
- [47]. Malone, K. (2001). Children, Youth and Sustainable Cities. . *In Local Environment* . https://doi.org/10.1080/13549830120024215, Vol. 6, Issue 1, pp. 5–12.

- [48]. McAllister, C. (2008). Child friendly cities and land use planning: Implications for children's health. . *Environments*, 35(3), 45.
- [49]. Mitchell et al, M. C. (2016). Built Environment Influences of Children's Physical Activity: Examining Differences by Neighbourhood Size and Sex. https://doi.org/10.3390/ijerph13010130. *International Journal of Environmental Research and Public Health*, 13(1).
- [50]. MoHUA. (2020). Nurturing Neighbourhoods Challenge. (2020, November). https://smartcities.gov.in/Nurturing_Neighbourhoods_Challenge. MoHUA.
- [51]. Moore, R. (1989). Before and after asphalt: Diversity as an ecological measure of quality in children's outdoor environments. The Ecological Context of Children's Play. Norwood, NJ: : Ablex Publishers.
- [52]. NACTO. (2020). Designing Streets for Kids. Island Press.
- [53]. Narayana, M. R. (2010). Impact of Economic Globalization on Urbanization: A Comparative Analysis of Indian and Select Global Experiences. *India Quarterly*, 66(1), 91–116.
- [54]. NIUA. (2017). Compendium of Best Practices of Child Friendly Cities,. Retrieved from National Institute of Urban Affairs (NIUA):

https://issuu.com/bernardvanleerfoundation/docs/compendium_of_best_practices_of_chi

- [55]. NIUA, ... (2016). Indicators for CHIId friendly Local Development (I CHILD) Delhi, India. https://bernardvanleer.org/app/uploads/2017/10/Indicators_for_CHIId_friendly_Local_Development-I CHILD.pdf. Delhi, India: NIUA, BVLF.
- [56]. NIUA. (2018). "CHILDREN' IN THE URBAN VISION OF INDIA, 2019" Delhi, India. NIUA. https://smartnet.niua.org/sites/default/files/resources/children_in_the_urban_vision_of_india.pdf. Delhi, India.: NIUA.
- [57]. O'brien et al, O. M. (2000). Children's Independent Spatial Mobility in the Urban Public Realm. *Childhood*, 7(3), 257–277.
- [58]. Paquet et al, P. C. (2017). The moderating role of food cue sensitivity in the behavioral response of children to their neighborhood food environment: a cross-sectional study. *The International Journal of Behavioral Nutrition and Physical Activity*, , 14(1), 86.
- [59]. Pollowy, A.-M. (1977). "The Urban Nest.". https://eric.ed.gov/?id=ED166330.
- [60]. Riggio, E. (2002). Child friendly cities: good governance in the best interests of the child. . . *In Environment and Urbanization.* https://doi.org/10.1177/095624780201400204, Vol. 14, Issue 2, pp. 45–58.
- [61]. Russell, W. (2020). Children's Right to the Good City. . Urban Design International, 156, 16–18.
- [62]. Schweitzer et al, S. M. (2004). Healing spaces: elements of environmental design that make an impact on health. *Journal of Alternative and Complementary Medicine*, 10 Suppl 1, S71–S83.

- [63]. Sullivan and Chang, S. W.-Y. (2011). Mental Health and the Built Environment.https://doi.org/10.5822/978-1-61091-036-1_7. *In Making Healthy Places*, (pp. 106–116).
- [64]. UNFPA. (2018). "UNFPA India, India Country Office at a Glance.". Retrieved from UNFPA: Https://india.unfpa.org/sites/default/files/pub-pdf/UNFPA%20Profile_combined.pdf. 2018.
- [65]. UNICEF. (2016,). Pollution: 300 million children breathing toxic air UNICEF report. 2016, October 31: https://www.unicef.org/press-releases/pollution-300-million-children-breathing-toxic-air-unicef-report. UNICEF.
- [66]. UNICEF, .. (2004). Building child friendly cities: A framework for action. UNICEF Innocenti Research Centre. UNICEF Innocenti Research Centre.
- [67]. Unicef, a. O. (2011). "Every Child's Right to Be Heard: A Resource Guide on the Un Committee on the Rights of the Child General Comment No. 12." Recuperado de Https://www. Unicef. org/french/adolescence/files/Every_Childs_Right_to_be_Heard. Pdf. Unicef.
- [68]. van den Berg, M. (2013). City Children and Genderfied Neighbourhoods: The New Generation as Urban Regeneration Strategy. https://doi.org/10.1111/j.1468-2427.2012. *In International Journal of Urban and Regional Research*, (Vol. 37, Issue 2, pp. 523–536).
- [69]. Webber, M. M. (1964). The Urban Place and the Nonplace Urban Realm. . In Explorations into Urban Structure. https://doi.org/10.9783/9781512808063-005.
- [70]. WHO. (2010). Prevalence of insufficient physical activity. Global Health Observatory (GHO) Data. WHO.
- [71]. WHO. (2007). Constitution of the World Health Organization: Basic Documents. 46th ed. Geneva, Switzerland. World Health Organization.
- [72]. Woolfenden, S. K. (2015). "Developmental Vulnerability--Don't Investigate without a Model in Mind.". *Child: Care, Health and Development*, 41 (3): 337–45.