

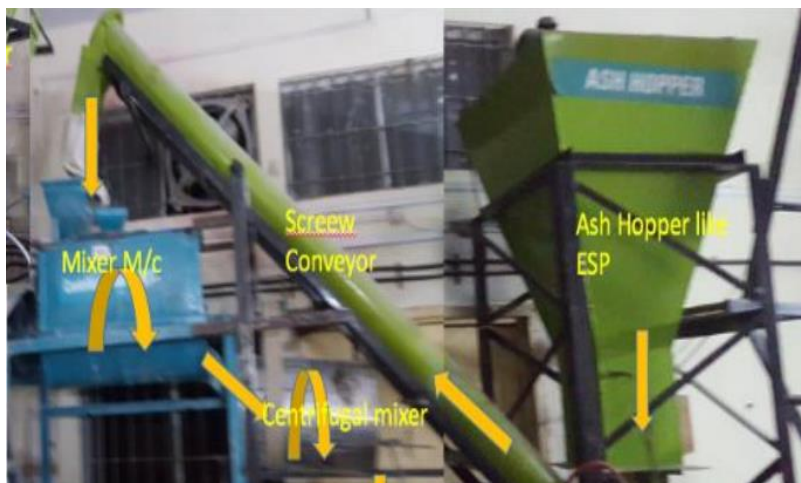


Artificial Geopolymer Fly Ash Fine Aggregate (GFS)

User should check the validity of the Certificate by contacting Member Secretary, BMBA at BMTPC or the Holder of the Certificate

Name and Address of Certificate Holder: **NTPC LTD**,
NTPC Bhawan
Scope Complex Institutional Area,
Lodhi Road,
New Delhi – 110003
Website: www.ntpc.co.in

Performance Appraisal Certificate
PAC No. **1065-M/2023**
Issue No. **01**
Date of Issue: **22.06.2023**




Building Materials & Technology Promotion Council
Ministry of Housing & Urban Affairs
Govt. of India
Core 5 A, First Floor, India Habitat Centre
Lodhi Road, New Delhi -110003

Tel: 011-24636705, Fax: 011-24642849
E-mail: info@bmtpc.org Website: www.bmtpc.org

**Performance Appraisal Certificate
For
Geopolymer Fly Ash Fine Aggregate (GFS)**

**Issued to
M/s NTPC LTD**

STATUS OF PAC

S. No.	Issue No.	Date of Issue	Date of Renewal	Amendment		Valid upto (Date)	Remarks	Signature of Authorized Signatory
				No.	Date			
1	01	22.06.2023				21.06.2024		

PAC No. 1065-M/2023

Issue No. 01

Date of issue: 22.06.2023

CONTENTS

PART 1 CERTIFICATION.....	4
1.1 Certificate Holder	4
1.2 Description of product	4
1.3 Assessment	4
1.4 Uses of Artificial Geopolymer Fly Ash Fine Aggregate.....	5
1.5 Conditions of Certification	5
1.6 Certification	6
PART 2 CERTIFICATE HOLDER’S TECHNICAL SPECIFICATION.....	7
2.1 General.....	7
2.2 Specifications for the product (GFS).....	7
2.3 Manufacturing Process.....	9
2.4 List of Testing Equipments available with the Agency.....	11
2.5 Method of handling of the product at site	13
2.6 Inspections & Testing.....	13
2.7 Services provided by the PAC holder to the customer.....	13
2.8 Responsibility	13
PART 3 BASIS OF ASSESSMENT & BRIEF DESCRIPTION OF ASSESSMENT PROCEDURE	14
3.1 Assessment	14
3.2 Quality Assurance Plan to be adopted by the certificate holder	19
3.3 Data sheet for using GFS.....	19
3.4 Site Inspection.....	19
3.5 Usage of the Product.....	19
PART 4 STANDARD CONDITIONS	20
PART 5 LIST OF APPLICABLE STANDARDS AND CODES	22
Certification	23
PART 6 LIST OF ABBREVIATIONS	24
PERFORMANCE APPRAISAL CERTIFICATION SCHEME – A BRIEF.....	25
ANNEX 1 Quality Assurance Plan for the product	26
ANNEX 2 Product Data Sheet (GFS).....	27

PART 1: CERTIFICATION

1.1 Certificate Holder: NTPC LTD, NTPC Bhawan
Scope Complex Institutional Area
Lodhi Road, New Delhi – 110003
Web Site: www.ntpc.co.in

1.2 Description of product

1.2.1 Name of the Product – Artificial Geopolymer Fly Ash Fine Aggregate (GFS)

1.2.2 Proprietary Name/Brand Name/Trade Name/Trademark: Artificial Geopolymer Fly Ash Fine Aggregate (GFS)

1.2.3 Brief Description

NTPC with VNIT, Nagpur has developed Artificial Geopolymer Fly Ash Fine Aggregate (GFS). For the production of geopolymer fly ash sand (GFS), initially the laboratory scale production was carried out by mixing fly ash in the alkaline activator solution consisting of sodium hydroxide and sodium silicate. After the successful trial production of the GFS at laboratory scale, a pilot plant was setup at VNIT Nagpur from the funding provided by NTPC for the production of GFS at larger scale.

Geopolymer fly ash sand is manufactured by addition of different molar concentration of sodium hydroxide and sodium silicate activator solution to the fly ash particles. The raw materials mixed thoroughly and granulated through a granulator to a desired size as per IS 383: 2016. The fly ash sand granules are then heated at a suitable temperature to provide curing and achieve the desired characteristics.

NTPC is presently in the process of installation of a commercial plant of 10 Ton/Hour (50,000 Ton/Annum) for converting Flyash to sand at Sipat premises for its various applications as replacement of river sand in construction works.

1.3 Assessment

1.3.1 Scope of Assessment

The scope of assessment included suitability of Artificial Geopolymer Fly Ash Fine Aggregate (GFS) in the preparation of cement concrete/Concrete components upto Concrete Grade M25, plastering & mortar work in masonry as replacement of Natural fine aggregate (river sand). The use of GFS in concrete shall be as per Concrete Mix Design.

1.3.2 Basis of Assessment

The assessment of the product is based on the following;

- i. The Testing & Evaluation Report of the Geopolymer Flyash Sand by National Council for Cement and Building Materials (NCCBM), Ballabgarh (February, 2019). The GFS was manufactured & supplied by VNIT, Nagpur.
- ii. Research work conducted at VNIT, Nagpur.
- iii. Quality Assurance Plan adopted by PAC Holder.
- iv. The visit of the Manufacturing Facility at NTPC, Sipat & Interaction with concerned NTPC Officials & VNIT, Nagpur through Video conferencing on March 02, 2023

1.4 Uses of Artificial Geopolymer Fly Ash Fine Aggregate

1.4.1 Uses of the Product

Construction works including plastering, mortar, concrete up to M25 Grade and other works/areas where river sand or crushed stone dust (crushed sand) is used.

1.4.2 Special Aspects of Use/Limitations

- i. The Concrete Mix designer & user agencies shall gain full familiarity with various properties of the product.
- ii. GFS has relatively higher water absorption than natural river sand. Hence wetting the aggregate (to achieve saturated surface dry condition) is necessary before developing concrete using it at construction site.
- iii. As the water absorption of the fine aggregate is high, it needs to be ensured that water used during its manufacturing, curing process and use at construction site is potable, and the amount of chloride content is within permissible limits (as per IS 456: 2000).

1.5 Conditions of Certification

1.5.1 Technical Conditions

- i. Technical Specifications- Raw materials and the finished product shall conform to the requirements of prescribed specifications.
- ii. The Certificate Holder shall provide all required technical details for application of this product to user agencies.
- iii. Quality Assurance- the Certificate holder shall maintain a quality assurance system in accordance with Quality Assurance Plan.

1.5.2 Handling of User Complaints

The Certificate holder shall provide quick redressal to consumer/user complaints which proved reasonable & genuine and within the conditions of warranty provided by it to customer/ purchaser.

As part of PACS Certification, it shall maintain data on such complaints with a view to assess the complaint redressal & suitable preventive measures taken.

1.6 Certification

On the basis of assessment given in Part-3 of this Certificate & subject to the conditions of certification, use & limitations set out in this Certificate and if selected, used & maintained as set out in Part 1 & Part-2 of this Certificate, Geopolymer Fly Ash Fine Aggregate (GFS) is fit for use set out in the Scope of Assessment.

PART 2: CERTIFICATE HOLDER'S TECHNICAL SPECIFICATIONS

2.1 General

The PAC holder shall manufacturer the GFS in accordance with the requirements specified in relevant IS Standards and other codal provisions. In addition, it shall follow its own standards specifying requirement of various materials used in the manufacturing of the product.

2.2 Specifications for the product (GFS)

The NTPC shall only use the raw materials supplied with the relevant documents/ prescribed Quality Assurance Plan. The raw materials shall be subject to agreed controls and tests by the NTPC before acceptance.

2.2.1 Technical specification for Raw Material/Components

Table 1 List of Raw Materials/Components used

S. No.	Raw material/ component	Source	Specification	If quality certified in any form, state
1.	Fly Ash	NTPC Sipat	IS 3812 (Part I)-2013	In-house test certificate
2.	Sodium Hydroxide	Any	IS 376-1986 (Reaffirmed 2010)	MTC
3.	Sodium Silicate	Any	IS 381-1995 (Reaffirmed 1999)	MTC
4.	Additives	Any	IS 9103-1999	MTC
5.	Cement – OPC-43	Ultra Tech	IS 8112-2013	MTC

2.2.2 Performance requirement of the product

Table 2 Performance requirement of the product

S. No.	Performance Characteristics	Requirements, with tolerance, if any	Test Method	Remarks
Chemical Parameters				
1.	Loss on Ignition	NA	IS 383-2016	-
2.	Silica content	NA		-
3.	Iron Oxide	NA		-
4.	Aluminium Oxide	NA		-
5.	Calcium Oxide	NA		-

S. No.	Performance Characteristics	Requirements, with tolerance, if any	Test Method	Remarks
6.	Magnesium Oxide	NA		-
7.	Total Sulphate	<0.5		-
8.	Total Alkalis	<4.0		-
9.	Chloride	<0.04		-
Physical Parameters				
10.	Specific Gravity	1.5-1.8	IS 383-2016	
11.	Water absorption	10%-20%		
12.	Material finer than 75 um	<10%		
13.	Organic impurities	Nil		
14.	Sieve analysis	NA		
15.	Total deleterious material	<3%		
16.	Soundness	<10%		
17.	Silt content	<2%	CPWD	
18,	Alkali-aggregate Reactivity	NA	IS 2386 (Part VIII)	
19.	Accelerated Mortar bar Test	<0.03% expansion at 14 days	ASTM C 1260	
20.	Prism bar Test	<0.005% expansion at 30 days	ASTM C 1293	
Durability Studies of Hardened Concrete				
21.	Compressive Strength of concrete			
	At 3 days	>40% of control	IS 516 (Reaffirmed Year : 2018)	
	At 7 days	>55% of control		
	At 28 days	>70% of control		
22.	Rapid Chloride Permeability Test (RCPT)			
	RCPT value at 28 days	<2000	ASTM C 1202	
23.	Compressive Strength of Masonry Mortar			
	Cement : Sand = 1:3			
	7 days	>35% of control	IS 2250-1981	
	28 days	>35% of control		
	Cement : Sand = 1:4			

S. No.	Performance Characteristics	Requirements, with tolerance, if any	Test Method	Remarks
	7 days	>45% of control		
	28 days	>45% of control		
	Cement : Sand = 1:6			
	7 days	>55% of control		
	28 days	>55% of control		

2.2.3 Special feature of the product are

- Geopolymer Fine Flyash Aggregate (GFS) are artificial aggregates made from industrial waste like fly ash.
- The GFS is light in weight and meets the specifications to be used in concrete works.
- The GFS based concrete gains strength with passage of time. The durability characteristics of the concrete in terms of Rapid Chloride penetration, chloride migration & carbonation resistance are much better with use of GFS as replacement of river sand in concrete.
- With the production & use of GFS, already scarce natural resource (river sand) can be conserved.

2.3 Manufacturing Process

Material selection:

Manufacturing process

- For the preparation of artificial geopolymer fly ash light aggregates, fly ash is first heated up to 60°C to remove extra moisture content.
- Then, Optimum geopolymer liquid solution (10M NaOH and $\text{Na}_2\text{SiO}_3/\text{NaOH} = 2$) is to be mixed with fly ash for 10 minutes in the proportion of 3:1 (dry powder: liquid) to produce a dry mix having a workability of 26 sec as per Vee Bee Consistometer Test.
- This mix is sieved through 4.75 mm and 2.36 mm sieve to yield particles of varying size like the shape and size of the natural river sand (NRS). For commercial plant of 10TPH (under installation at NTPC Sipat), the sieving process will be replaced with a commercial grade granulator.
- The sieved particles will then be passed through a heat curing chamber for 1 hr. at 100°C.

- After heating the particles, it is to be kept in ambient temperature for one day.
- Finally, tests such as specific gravity, water absorption, particle size distribution, direct shear test, pH, soundness, alkali aggregate reaction, etc. will be performed on the samples as per the quality assurance plan. The process produces no by-products.
- The development of artificial geopolymer fly ash fine aggregates on a lab-scale is a batch process with a batch size of 5 kg. The production rate is 5 kg of sand per shift of 60 minutes. However, another commercial scale plant of capacity 10 Ton/Hour is envisaged and is under installation at NTPC Sipat premises.



Pictorial representation of installed pilot plant indicating the process flow chart

Manufacturing Machinery

Table 3 List of Manufacturing / Installing Machinery Available with the Agency

S. No.	Date of installation	Name of machine	Make	Capacity	Number of machines	Does the unit have maintenance schedule	Remarks
1.	28.08.2016	Hot Belt Conveyor	Chamunda Engg.	NA	2 nos.	Yes, 3 months	
2.	26.08.2016	Vibro Sifter	Pan BA Engg. Model GMP	NA	1 no.	Yes, 3 months	
3.	15.09.2016	Automatic cement autoclave	AIMIL	NA	1 no.	Yes, 6 months	
4.	10.10.2016	Digi mortar mixer	AIMIL	NA	1 no.	Yes, 6 months	
5.	08.11.2016	Continuous granulator	Clarion Enterprises	NA	1 no.	Yes, 1 month	
6.	10.10.2017	Fabrication and installation of: a. Ash supply hopper b. NaOH+Na ₂ SiO ₃ mixer c. Electrical panel	Yamuna Technologies	NA	1 no. each	Yes, 3 months	

2.4 List of Testing Equipments available with the Agency

Table 4

S. No.	Name of equipment	Make (ID no.)	Range and least count	No.	Calibration frequency	Remarks
1.	Compression testing machine	M/s Rajco:17& M/s PSI Sales	1KN to 2000KN	1 Each	1 year	
2.	Digital Vernier caliper	M/s MITUTOYO	0.01	1	1 year	
3.	Digital Micrometer	M/s MITUTOYO	0.001	1	1 year	
4.	Digital Thermometer	METRAVI	0.10c	1	1 year	
5.	Vibration Machine	M/s AMIL: 011362		1	1 year	
6.	Autoclave	M/s HELCO: 01030	0-4.2kg/cm ² (0.1 kg/cm ²)	1	1 year	
7.	Mortar Mixer	M/s HELCO		1	1 year	
8.	Universal Automatic Compactor	M/s HELCO: 01068		1	1 year	

S. No.	Name of equipment	Make (ID no.)	Range and least count	No.	Calibration frequency	Remarks
9.	Hot Air Oven			1	1 year	
10.	Universal Testing Machine	M/s HELCO: H-27182		1	1 year	
11.	Los Angeles Abrasion Testing Machine	M/s HELCO: 01061		1	1 year	
12.	Vicat Needle Apparatus	M/s HELCO: 425		1	1 year	
13.	Sieve Shaker	M/s AMIL: 0111141		1	1 year	
14.	Aggregate Impact Testing Machine	M/s AMIL: 01624		1	1 year	
15.	150 KG Electronic Weighting Balance	OPIRAT:9192	0.010Kg	1	1 year	
16.	20 KG Electronic Weighting Balance	OPIRAT:9193	0.001kg	1	1 year	
17.	0.5 KG Electronic Weighting Balance	Instruments Eng. (Anamed) F0500	0.01Kg	1	1 year	
18.	Cube Mould - 150mm & 70.6mm	M/s HELCO		1 Each	1 year	
19.	Slump test apparatus	M/s HELCO		1	1 year	
20.	I.S Sieve (Brass Frame) with Lid and Pandiya 200mm, 450 mm, 300 mm	M/s AMIL/ Instrumentation / M/s HELCO		5	1 year	
21.	Gauging Trowel	M/s R.H. Agency		1	1 year	
22.	Pycnometer	M/s R.H. Agency		1	1 year	
23.	Shrinkage Bar Mould	M/s R.H. Agency		1	1 year	
24.	Standard Spatula	M/s R.H. Agency		1	1 year	
25.	Le chatelier Flask	M/s AMIL		1	1 year	
26.	Flakiness Gauge	Cyber Techno Chhaya		1	1 year	
27.	Thermometer	Instrumentation	-200 to 1300 degree, 0.1 degree C	1	1 year	
28.	Crushing Value Apparatus	M/s AMIL		1	1 year	

2.5 Method of handling of the product at site

It is to be handled in the same manner as Natural fine aggregate (river sand), no special care as such is required.

2.6 Inspections & Testing

Inspections & testing shall be done at appropriate stages of the manufacturing process. The inspected products shall be stored & packed to ensure that no damage occurs during transportation, as per the industrial norms. As part of quality assurance, regular in-process inspections shall be carried out by the trained personnel of the PAC holder.

2.7 Services provided by the PAC holder to the customer

The PAC holder shall provide pre-sale advisory regarding the product. Customer/user may obtain from the PAC holder details of the advice that may be provided to him.

The PAC holder shall also provide after sales service on customer to customer basis. These include items like pre-finishing, trouble shooting in fixing and usage of the shutters. Users / Customers shall ascertain from the PAC holder the type of services and the conditions, the PAC holder is prepared to provide.

2.8 Responsibility

Specific performance of the GFS is the responsibility of the company as per the requirement of the customer according to the contract with the instructions, supervision and guidance of the PAC holder.

PART 3: BASIS OF ASSESSMENT & BRIEF DESCRIPTION OF ASSESSMENT PROCEDURE

3.1 Assessment

3.1.1 The assessment has been done as per the provisions of the standards listed in Part-5 of this Certificate.

3.1.2 Assessment done for the Product at VNIT, Nagpur both at Laboratory & Pilot Plant Scale

For the production of geopolymer fly ash sand (GFS) initially the laboratory scale -production was carried out by mixing fly ash in the alkaline activator solution consisting of sodium hydroxide and sodium silicate. And after the successful production of the GFS from laboratory scale, a pilot plant was setup at VNIT Nagpur from the funding provided by NTPC for the production of GFS at larger scale.

Geopolymer is a hardened product formed by mixing fly ash in alkaline activator solution to produce Si-O-Al-O bonds, imparting the properties similar to OPC based concrete. This technology was used to develop GFS of two types i.e., 4 molar GFS sand (4MGFS) and 10 Molar GFS (10MGFS). It was produced by varying the molarity of NaOH in the alkaline activator solution. The so produced GFS were tested for physical, chemical, mechanical, mineral and morphological properties. The M-25 grade of concrete that was produced by using GFS as complete replacement to the river sand in the concrete was tested for various concrete properties in comparison to the river sand-based concrete.

The mechanical strength of concrete such as the compressive strength, flexural strength and split tensile strength using 4MGFS as 100% replacement to river sand in concrete at 28 days of curing was 28.94 MPa, 2.35 MPa, and 2.4 MPa respectively and that for river sand concrete was 34.2 MPa, 2.61 MPa and 2.59 MPa respectively. At 90 days of curing the compressive strength, flexural strength and split tensile strength was observed as 42.96 MPa, 3.64 MPa, and 3.306 MPa respectively for 4MGFS concrete and 44.14 MPa, 3.79 MPa and 3.45 MPa respectively for river sand concrete. This shows that 4MGFS concrete gradually gains strength as the number of curing days increases. The compressive strength at 28 days for 4MGFS concrete was 81.75% as compared to the river sand concrete which increased up to 97.32% at 90 days. Similar trend was observed in flexural strength and split tensile strength implying that 4MGFS leads to late strength gain in the concrete.

The durability properties of concrete like rapid chloride penetration test (RCPT), rapid chloride migration test (RCMT), acid attack test, drying shrinkage and accelerated carbonation tests showed an improvement with the use of 4MGFS in concrete. The chloride penetration (RCPT) of the 4MGFS concrete was observed as 707.8 Coulombs at 90 days curing which is classified as very low penetrability as per ASTM C1202. The value of RCPT for river sand concrete at 90 days of curing was 1184.2 Coulombs which is classified as low penetrability. The 4MGFS concrete showed a better resistance to chloride penetration. Even the results from RCMT showed the same trend with 4MGFS showing $4.16 \times 10^{-12} \text{ m}^2/\text{s}$ chloride migration and river sand showing $6.43 \times 10^{-12} \text{ m}^2/\text{s}$ hence portraying an improved resistance to chloride ion by the use of GFS. The acid attack test on 4MGFS concrete by using HCl was 7.23% whereas for river sand concrete was 8.57%. Even when exposed to H_2SO_4 acid the GFS concrete gave better results with 8.93% for GFS concrete and 8.96% for river sand concrete. A four-fold increase in the carbonation resistance was observed with the use of GFS as compared to the river sand. The drying shrinkage of both the types of concrete was observed similar. These tests conclude that the use of GFS in concrete helps to improve the chloride ion resistance, acid resistance and carbonation resistance of concrete thus improving the durability of the concrete.

The characteristic properties of GFS were also tested for physical, chemical, mechanical and morphological properties such as specific gravity, water absorption, particle size distribution, pH, soundness, alkali aggregate reactivity, chemical composition, mineralogical composition, morphology and mortar making properties of GFS to find the suitability of GFS as compared to river sand. It was observed that GFS exhibited similar results as that of river sand except it had low specific gravity (1.89) and high-water absorption (14.31%). The alkali aggregate reaction and soundness of GFS was well below the specified limits as per IS codes. The compressive strength of GFS mortar was nearly 94% as that of river sand mortar at 28 days and it increased gradually with the increase in the curing duration.

3.1.3 Evaluation of Physical, Chemical, Potential Alkali Aggregate Reaction & Durability Studies of Hardened Concrete properties carried out at NCCBM lab at Ballabgarh

Based on the samples of the Artificial Geopolymer Fly Ash Fine Aggregate (GFS) supplied by VNIT, Nagpur, the following tests were carried out at NCCBM, Ballabgarh (Report dated February 21, 2019).

i) **Physical & Chemical Test results of Geo Polymer Fly Ash Sand (Table 5)**

Physical Test results

S. No.	Test Carried Out	Result Obtained	Permissible Limits as per IS: 383-2016
1	Specific gravity	1.57	2.1-3.2
2	Water absorption %	17.85	5
3	Material finer than 75 micron %	2.4	10.0
4	Soundness, Na ₂ SO ₄ %	5.07	10
5	Organic impurities	Nil	-
6	Clay Lumps %	Nil	1
7	Total deleterious material % (except coal & lignite)	2.4	2
8	Silt by CPWD %	0.9	

Chemical test results

S. No.	Properties	Results obtained	Permissible limits as per IS 383-2016
Chemical analysis %			
1.	Loss of ignition (LOI)	3.12	-
2.	Silica (SiO ₂)	58.52	-
3.	Iron Oxide (Fe ₂ O ₃)	3.55	-
4.	Aluminum Oxide (Al ₂ O ₃)	22.94	-
5.	Calcium Oxide (CaO)	5.24	-
6.	Magnesium Oxide (MgO)	0.99	-
7.	Sulphate (SO ₂)	0.30	0.5 (Max)
8.	Alkalies:		
	Na ₂ O	2.76	-
	K ₂ O	0.94	-
9.	Total Alkalies as Na ₂ O equiv.	3.37	0.3 (Max)
10.	Chloride	0.030	0.040 (Max)

ii) Durability studies of Hardened Concrete

Casting and testing of concrete samples

Mix constituents (Kg /one cubic meter)	M25 with natural fine aggregate (Control Mix)	M25 with 100% replacement of natural fine aggregate with Geopolymer Flyash Sand (Experimental Mix)
Cement (OPC-43 Grade)	320	320
Water	160	160
Fine Aggregate (Natural Sand/Geopolymer Flyash Sand)	833 (Abs. Vol. 0.3157m ³)	499 (Abs. Vol. 0.3166m ³)
Coarse Aggregate		
Fraction-I) 20mm (60%)	632	631
Fraction-II) 10mm (40%)	517	516
Chemical Admixture @ by Wt. of cementitious	2.56 (dosage at rate of 0.8% weight of cementitious)	5.12 (dosage at rate of 1.6% weight of cementitious)
Water – Cementitious Ratio	0.50	0.50
Workability obtained in terms of slump (after 90 mins of retention period)	75-100mm	75-100mm

Compressive strength at 3, 7 and 28 days

S. No.	Age of testing	M25 with natural fine aggregate (Control Mix)	M25 with 100% replacement of natural fine aggregate with Geopolymer Flyash Sand (Experimental Mix)
1.	4 days	19.87	10.27
2.	7 days	24.23	13.49
3.	28 days	36.06	27.01

Rapid Chloride Penetration Test RCPT

S. No.	Age of testing	M25 with natural fine aggregate (Control Mix)	M25 with 100% replacement of natural fine aggregate with Geopolymer Flyash Sand (Experimental Mix)
1.	28 days	1217 coulomb	904 coulomb

Chloride Migration Test – NT Build 492

S. No.	Age of testing	M25 with natural fine aggregate (Control Mix)	M25 with 100% replacement of natural fine aggregate with Geopolymer Flyash Sand (Experimental Mix)
1.	28 days	$6.62 \times 10^{-12} \text{m}^2/\text{s}$	$4.65 \times 10^{-12} \text{m}^2/\text{s}$

Accelerated Chloride Induced Corrosion test

S. No.	Age of testing	M25 with natural fine aggregate (Control Mix)	M25 with 100% replacement of natural fine aggregate with Geopolymer Flyash Sand (Experimental Mix)
1.	28 days	157.10 ohm	166.97 ohm

Accelerated Carbonation method as per ISO 1920 Part 12

S. No.	Age of testing	M25 with natural fine aggregate (Control Mix)	M25 with 100% replacement of natural fine aggregate with Geopolymer Flyash Sand (Experimental Mix)
1.	70 days	8.2 mm	2.1 mm

Drying Shrinkage & Moisture Movement as per IS 1199

S. No.	Age of testing	M25 with natural fine aggregate (Control Mix)	M25 with 100% replacement of natural fine aggregate with Geopolymer Flyash Sand (Experimental Mix)
1.	28 days	0.0162%	0.0163%

Evaluation of compressive strength on Masonry Mortar as per IS: 2250-1981

S. No.	Age of testing	Mortar with natural fine aggregate (Control Mix)	Mortar with 100% replacement of natural fine aggregate with Geopolymer Flyash Sand (Experimental Mix)
Mortar Ratio (Cement & Sand)			1:3
1.	7 days	19.18	7.31
2.	28 days	27.83	10.77
Mortar Ratio (Cement & Sand)			1:4
1.	7 days	12.36	6.74
2.	28 days	27.83	10.67
Mortar Ratio (Cement & Sand)			1:6
1.	7 days	7.74	4.89
2.	28 days	11.68	8.45

3.2 Quality Assurance Plan to be adopted by the certificate holder is enclosed at **Annexure 1**.

3.3 Data sheet for using GFS is attached as **Annexure 2**.

3.4 Site Inspection

The setup of the Agency was visited by the members of TAC & Officers of BMTPC via video conferencing on 2nd March, 2023 & interaction were held with technical personnel of the NTPC & VNIT Faculties. The agency through videos demonstrated the plant set up & manufacturing process of the product.

3.5 Usage of the Product

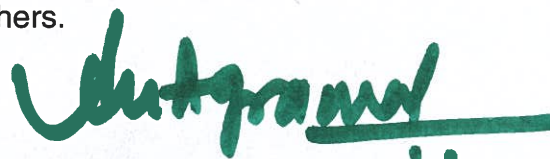
- i. As of now, no such building is constructed. The same is expected to be constructed with Geopolymer fly ash fine aggregate post successful commissioning and production from the 50,000 MTPA plant at NTPC Sipat. The same is expected to be commissioned by March 2023.
- ii. The product has been produced at VNIT, Nagpur Laboratory and one pilot plant set up there.

PART 4: STANDARD CONDITIONS

This certificate holder shall satisfy the following conditions:

- 1 The certificate holder shall continue to have the product reviewed by BMBA.
- 2 The product shall be continued to be manufactured according to and in compliance with the manufacturing specifications and quality assurance measures which applied at the time of issue or revalidation of this certificate. The Scheme of Quality Assurance separately approved shall be followed.
- 3 The quality of the product shall be maintained by the certificate holder.
- 4 The product user should install, use and maintain the product in accordance with the provisions in this Certificate.
- 5 This certificate does not cover uses of the product outside the scope of this appraisal.
- 6 The product is appraised against performance provisions contained in the standards listed in Part-V. Provisions of any subsequent revisions or provisions introduced after the date of the certificate do not apply.
- 7 Where reference is made in this Certificate to any Act of Parliament of India, Rules and Regulations made there under, statutes, specifications, codes of practice, standards etc. of the Bureau of Indian Standards or any other national standards body and the International Organization for Standardization (ISO), manufacturer's company standards, instruction/manual etc., it shall be construed as reference to such publications in the form in which they were in force on the date of grant of this Certificate (and indicated in Part V to this Certificate)
- 8 The certificate holder agrees to inform BMBA of their distributors / licensees whenever appointed by him and agrees to provide to BMBA a six monthly updated list thereof.
- 9 The certificate holder agrees to provide to BMBA feedback on the complaints received, the redressal provided, and the time taken to provide redressal on complaint to complaint basis as soon as redressal is provided. BMBA agrees to provide the certificate holder the user feedback received by it, if any.
- 10 If at any time during the validity period, PAC is unable to fulfill the conditions in his PAC, he should on his own initiative suspend using the PAC and notify Chairman, TAC the date from which he has suspended its use, the reason for suspension and the period by which he will be able to resume. He shall not resume without the prior permission of BMBA. He shall also inform, simultaneously, his agents, licensees, distributors, institutional, government, public sector buyers, other buyers and all those whom he has informed about his holding the PAC. He shall also inform all those who buy his product(s) during the period of suspension. He shall provide to BMBA at the earliest the list of who have been so informed by him.

- 11 In granting this Certificate, BMBA takes no position as to:
 - (a) The presence or absence of patent or similar rights relating to the product;
 - (b) The legal right of the Certificate holder to market, install or maintain the product;
 - (c) The nature of individual installations of the product, including methods of workmanship.
- 12 BMTPC and the Board of Agreement of BMTPC (BMBA) take no position relating to the holder of the Performance Appraisal Certificate (PACH) and the users of the Performance Appraisal Certificate (PAC) respecting the patent rights / copy rights asserted relating to the product / system / design / method of installation etc. covered by this PAC. Considerations relating to patent / copy rights are beyond the scope of the Performance Appraisal Certification Scheme (PACS) under which this PAC has been issued. PACH and users of this PAC are expressly advised that determination of the Claim / validity of any such patent rights / copy rights and the risk of infringement of such rights are entirely the responsibility of PACH on the one hand and that of the users on the other.
- 13 It should be noted that any recommendations relating to the safe use of the product which are contained or referred to in this Certificate are the minimum standards required to be met with when the product is installed, used and maintained. They do not purport in any way to restate or cover all the requirements of related Acts such as the Factory Act, or of any other statutory or Common Law duties of care, or of any duty of care which exist at the date of this Certificate or in the future, nor is conformity with the provisions of this Certificate to be taken as satisfying the requirements of related Acts.
- 14 In granting this Certificate, BMTPC and BMBA does not accept responsibility to any person or body for any loss or damage, including personal injury, arising as a direct or indirect result of the use of this product.
- 15 The certificate holder indemnifies BMBA, its officers and officials involved in this assessment against any consequences of actions taken in good faith including contents of this certificate. The responsibility fully rests with the certificate holder and user of the product.
- 16 The responsibility for conformity to conditions specified in this PAC lies with the manufacturer who is granted this PAC. The Board (BMBA) will only consider requests for modification or withdrawal of the PAC.
- 17 The PAC holder shall not use this certificate for legal defense in cases against him or for legal claims he may make from others.



Place: New Delhi
Date of issue: 22/06/2023

Chairman TAC & for and on behalf of Member
Secretary, BMBA

PART 5: LIST OF APPLICABLE STANDARDS AND CODE

List of Standards:

1. IS 383 – 2016, Coarse and Fine Aggregate for Concrete – Specification (Third Revision), 2016, Bureau of Indian Standards, New Delhi.
2. IS 9142 -1979 (Reaffirmed 2002), specification for artificial lightweight aggregates for concrete masonry units, 2002. Bureau of Indian Standards, New Delhi.
3. IS 9142 (Part 2) – 2018, Artificial lightweight aggregate for concrete – Sintered fly ash coarse aggregate, Bureau of Indian Standards, New Delhi.
4. BS 3797-90 Lightweight aggregates for masonry units and structural concrete, 1996, British Standards Institution.

CERTIFICATION

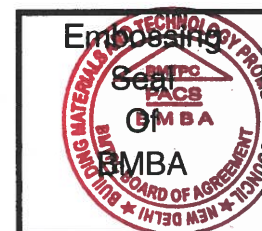
In the opinion of Building Materials & Technology Promotion Council's Board of Agreement (BMBA), **Artificial Geopolymer Fly Ash Fine Aggregate (GFS)** is satisfactory if used as set out above in the text of the Certificate. This Certificate **PAC No. 1065-M/2023** is awarded to **M/s NTPC Ltd., New Delhi.**

The period of validity of this Certificate is for a period of one year i.e. from **22/06/2023 to 21/06/2024** as shown on Page 1 of this PAC. This Certificate consists of pages 1 to 27.



Dr. Shailash Kr. Agrawal
Chairman, TAC

& Member Secretary, BMBA
Building Materials and Technology Promotion Council
Ministry of Housing and Urban Affairs, Govt. of India
Core 5A, 1st Floor, India Habitat Centre
Lodhi Road, New Delhi-110003



On behalf of BMTPC Board of Agreement Chairman, Technical Assessment Committee (TAC) of BMBA & Member Secretary, BMTPC Board of Agreement (BMBA) Under Ministry of Housing and Urban Affairs, Government of India

Place: New Delhi, India

Date: 22/06/2023

PART 6: LIST OF ABBREVIATIONS

BMBA	Board of Agreement of BMTPC
BMTPC	Building Materials and Technology Promotion Council
CPWD	Central Public Works Department
ED	Executive Director of BMTPC
IO	Inspecting Officer
MS	Member Secretary of BMBA
PAC	Performance Appraisal Certificate
PACH	PAC Holder
PACS	Performance Appraisal Certification Scheme
SQA	Scheme of Quality Assurance
TAC	Technical Assessment Committee (of BMBA)

PERFORMANCE APPRAISAL CERTIFICATION SCHEME – A BRIEF

Building Materials & Technology Promotion Council (BMTPC) was set up by the Government of India as a body under the Ministry of Housing & Urban Poverty Alleviation to serve as an apex body to provide inter-disciplinary platform to promote development and use of innovative building materials and technologies laying special emphasis on sustainable growth, environmental friendliness and protection, use of industrial, agricultural, mining and mineral wastes, cost saving, energy saving etc. without diminishing needs of safety, durability and comfort to the occupants of buildings using newly developed materials and technologies.

During the years Government, public and private sector organizations independently or under the aegis of BMTPC have developed several new materials and technologies. With liberalization of the economy several such materials and technologies are being imported.

However, benefits of such developments have not been realized in full measure as understandably the ultimate users are reluctant to put them to full use for want of information and data to enable them to make informed choice.

In order to help the user in this regard and derive the envisaged social and economic benefits the Ministry of Housing & Urban Poverty Alleviation has instituted a scheme called Performance Appraisal Certification Scheme (PACS) under which a Performance Appraisal Certificate (PAC) is issued covering new materials and technologies. PAC provides after due investigation, tests and assessments, amongst other things information to the user to make informed choice.

To make the PACS transparent and authentic it is administered through a Technical Assessment Committee (TAC) and the BMTPC Board of Agreement (BMBA) in which scientific, technological, academic, professional organizations and industry interests are represented.

The Government of India has vested the authority for the operation of the Scheme with BMTPC through Gazette Notification No. 1-16011/5/99 H-II in the Gazette of India No. 49 dated 4th December, 1999.

Builders and construction agencies in the Government, public and private sectors can help serve the economic, development and environmental causes for which the people and Government stand committed by giving preference to materials and technologies which have earned Performance Appraisal Certificates.

Further information on PACS can be obtained from the website: www.bmtpc.org

Annexure 1

Quality Assurance Plan for the product

S. No.	Performance Characteristics	Requirements, with tolerance, if any	Test Method	Frequency	
				Inhouse	External NABL accredited lab
1	Practical size distribution	NA	IS: 383 - 2016	Each Batch	Every six months
2	Silt content %	2 Max	IS: 2386 Part-2/CPWD	Each Batch	Every six months
3	Deleterious materials & organic impurities %	3 Max	IS: 383 - 2016	Each Batch	Every six months
4	Specific Gravity	1.5 to 1.8	IS: 383 - 2016	Each Batch	Every six months
5	Water Absorption %	10 - 20	IS: 383 - 2016	Each Batch	Every six months

Annexure 2

Product Data Sheet

Edition 1, 2021

Geopolymer Fly Ash Sand (GFS)

Complies with IS 383: 2016 standards

Product Details

GFS is lightweight manufactured fine aggregate produced by mixing fly ash in the alkaline activator solution consisting of sodium hydroxide and sodium silicate. The so produced GFS are tested for physical, chemical, mechanical, mineral and morphological properties and confirm to relevant IS code standards. Owing to the lower specific gravity of GFS, its consumption is also lower in concrete leading to reduced overall cost of concreting.

Salient Features

Following are the salient features of GFS:

- ❖ Promotes usage of waste materials like fly ash.
- ❖ Can be used as partial/ complete replacement to conventional river sand or crushed sand.
- ❖ Very low soundness and alkali aggregate reaction.
- ❖ Acceptable water absorption of GFS.
- ❖ Environment friendly alternative as it reduced the dependency on river sand.
- ❖ Improves the long-term durability of the concrete.
- ❖ Normal set without retardation, even when overdosed.
- ❖ Promotes strength gain in concrete.
- ❖ Reduced overall cost of concreting.
- ❖ Acceptable impact and abrasion resistance, comparable to river sand.

Recommended Uses

GFS can be used as partial/ complete replacement of traditional river sand or crushed sand for following works:

- ❖ RCC works up to M30
- ❖ Road Work-- PQC & DLC
- ❖ Precast Concrete Components
- ❖ Land reclamation
- ❖ Back filling material
- ❖ Overburden for mine filling
- ❖ Dams & other irrigation works
- ❖ Mortar – plastering and joining
- ❖ Pavers and Bricks

Dosages

The dosage of GFS is similar to that of river sand/ crushed sand in concrete/ mortar works. However, the same is decided as per the volume. Owing to the lower specific weight, the actual weight of GFS is comparatively lower than that of river sand in the mix.

Properties & Handling Precautions

- | | |
|-------------------------|-------------------------------------|
| • Type | - Granules |
| • Color | - Grey |
| • Specific Gravity | - 1.5 – 2.0 |
| • pH | - 9.5 – 12 |
| • Mechanical properties | - Complies with IS 383: 2016 |
| • Shelf Life | - 1 year from date of manufacturing |
| • Packaging | - Truck load |

GFS is generally quite harmless, provided certain precautions are taken for handling. Wear protective clothing, gloves, shoes, glass etc. In the event of contamination, wash thoroughly with water. If the eye or mouth is affected, wash with clean water and obtain medical attention.

Important Note

The technical information and application advice given in this data sheet is based on present state of our experience and is correct to the best of our knowledge. However, since success of application of our products is dependent on number of factors, we can only be responsible for quality of our products at the time of our dispatch. Certain changes are possible in the product data sheet as we are constantly endeavoring to improve it through our R&D. Hence, in the event of any doubt on critical parameter, it is advisable to seek clarification from our technical personnel.

Safety Precautions



Skin, Eye, & Metal
Corrosives

