

HOW TO ENHANCE THE ECONOMIC VALUE OF STONE SLURRY WASTES AND CREATE BUSINESS OPPORTUNITIES

A Sustainable Approach



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CDOES, Jaipur 9 April 2021

OVERVIEW : HOW ?

- ☐ **Manufacture hybrid green composites materials from stone, marble and granite waste stream**
- ☐ **Opportunities for Economic, Employment and Environmental Benefits**

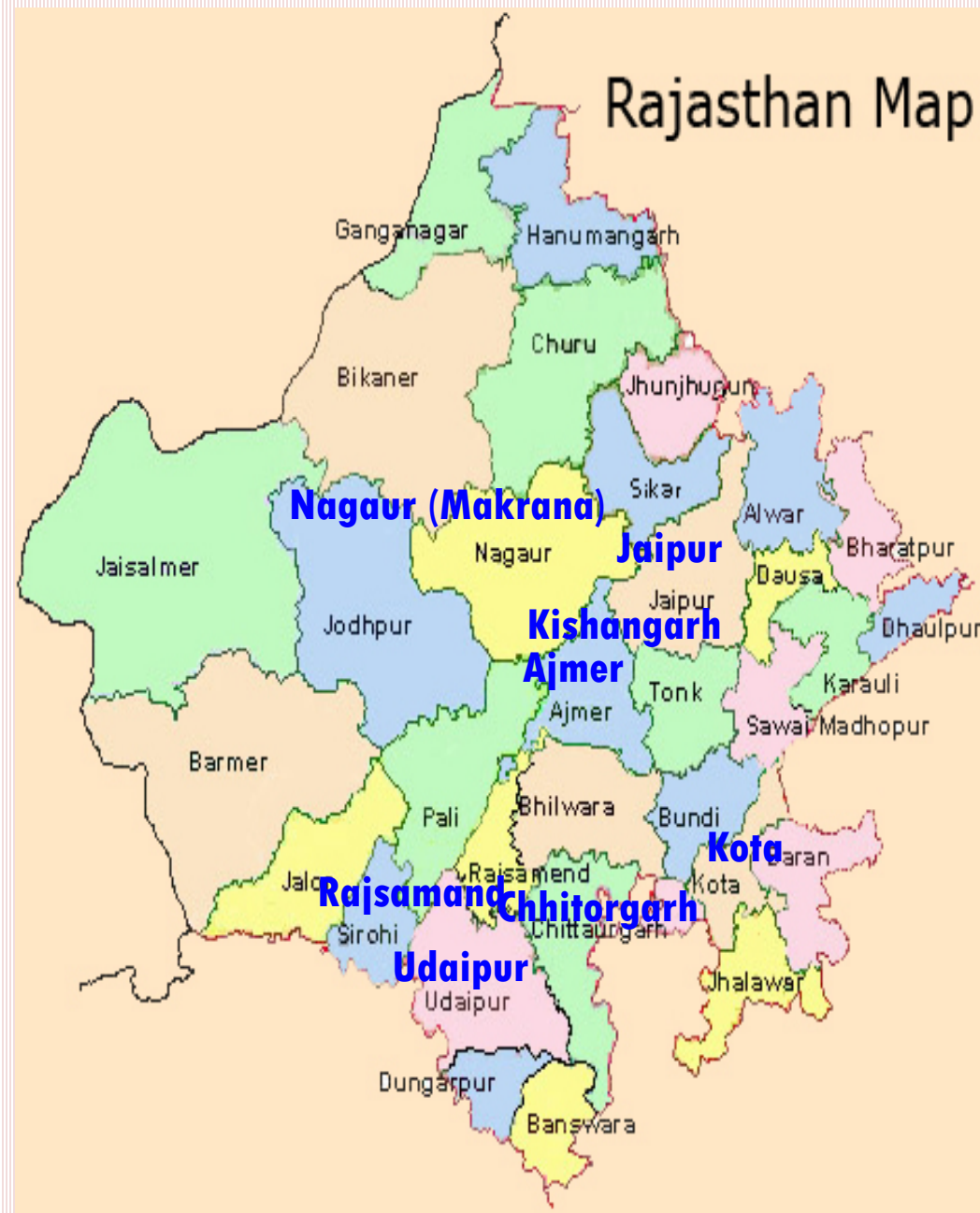
STONE, MARBLE AND GRANITE WASTE STREAM IN RAJASTHAN

CSIR- AMPRI INVESTIGATION

NO	LOCATIONS	DISTRICT
1	(Makrana)	Nagaur
2	Jaipur	Jaipur
3	Kishangarh	Ajmer
4	Rajsamand	Rajsamand
5	Chhitorgarh	Chhitorgarh
6	Udaipur	Udaipur
7	Kota	Kota

Surveyed and sample collected

Rajasthan Map





Marble waste stream: sample collection from Udaipur Rajsamand

S & T INNOVATION



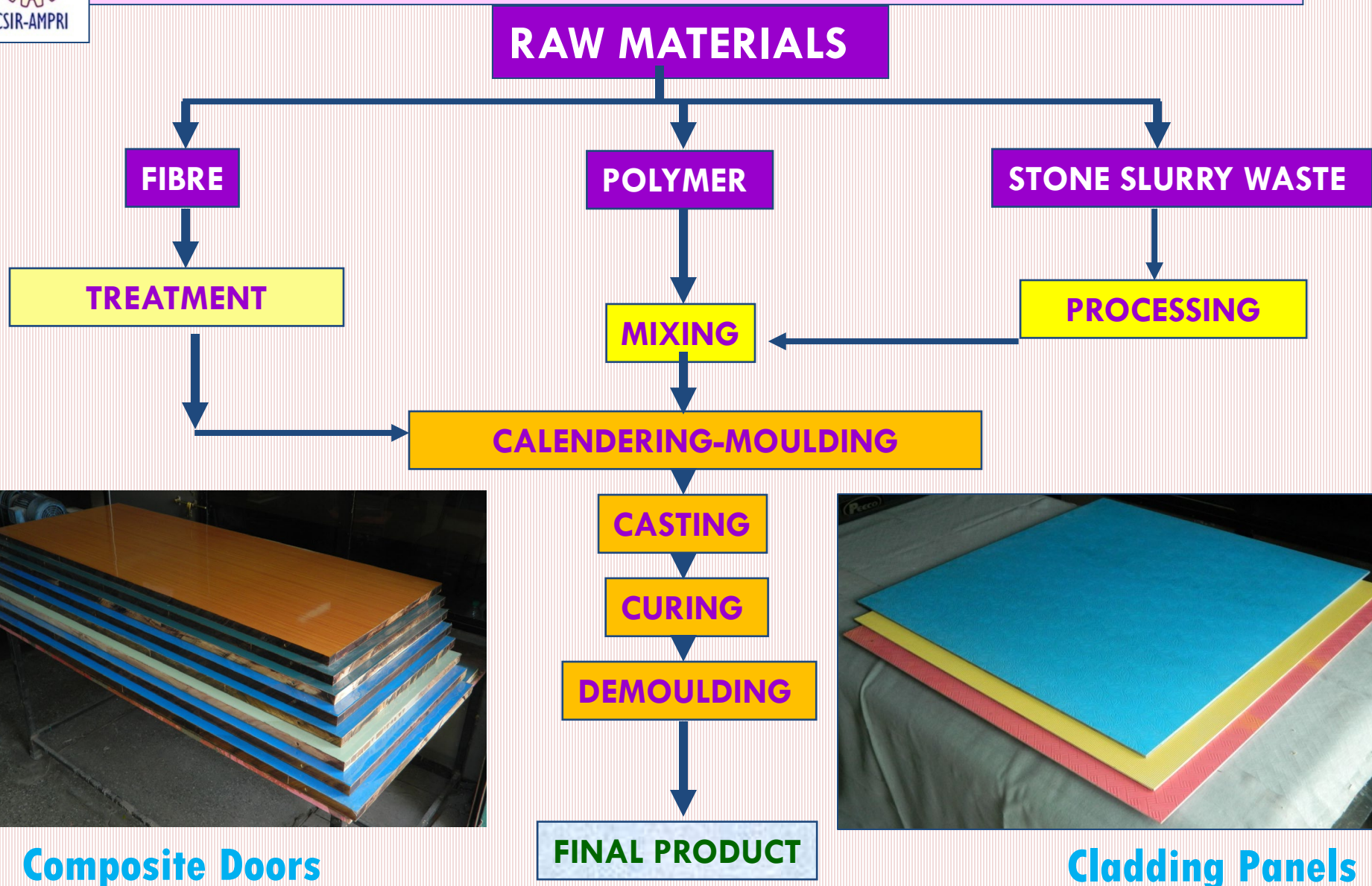
Development of a energy efficient “**Hybrid Green Composite Materials**”

Create opportunity for sustainable manufacturing **from stone, marble & granite wastes stream** for multifunctional applications

हाइब्रिड कम्पोजिट



STONE WASTE COMPOSITES MANUFACTURING PROCESS



HYBRID COMPOSITE MATERIALS FROM STONE, MARBLE AND GRANITE WASTE STREAM

Stone waste composites



Granite waste composites



Marble waste composites



HYBRID COMPOSITE MATERIALS FROM STONE, MARBLE AND GRANITE WASTE STREAM

Stone slurry waste cpmposites



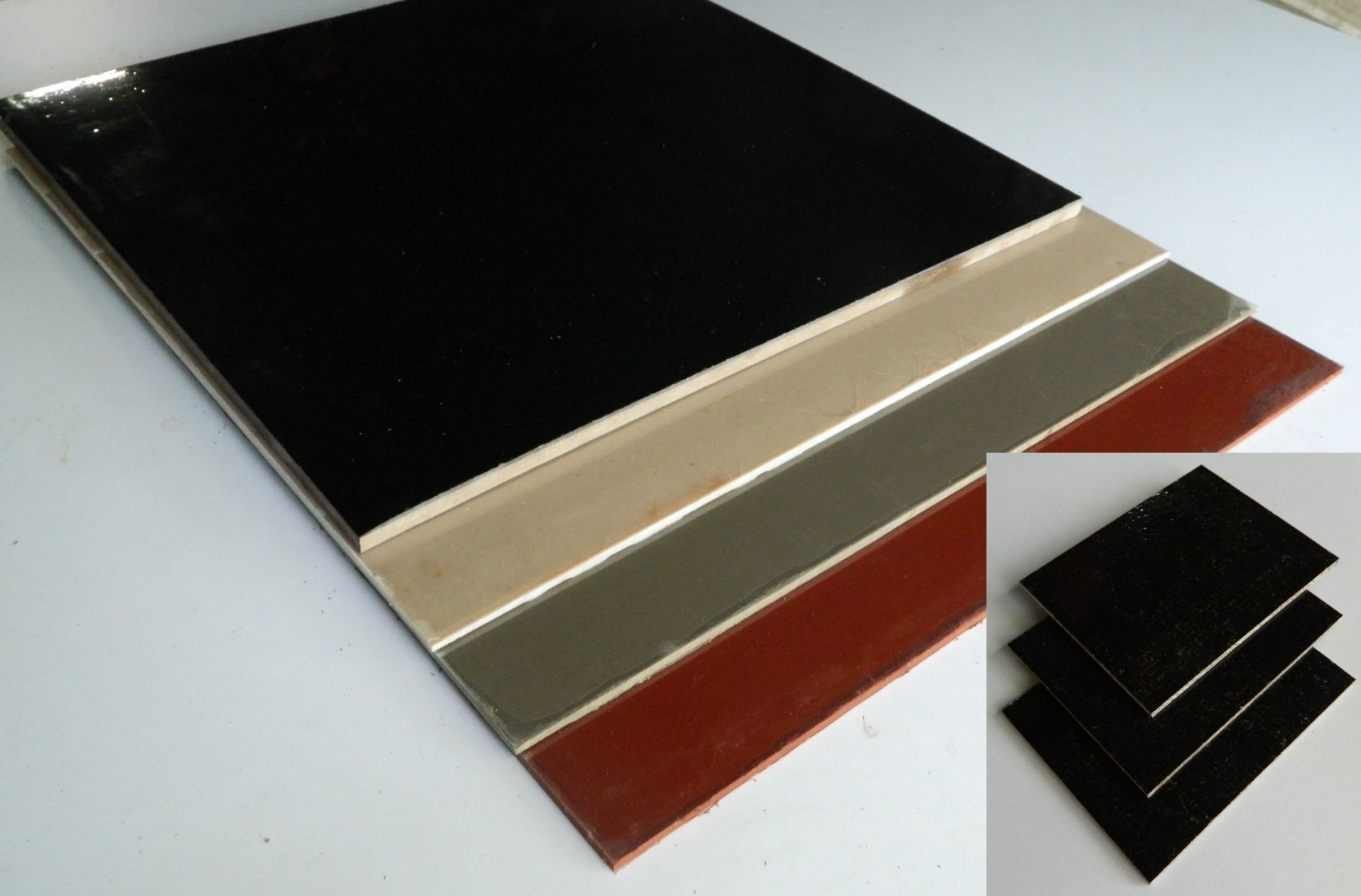
Marble slurry waste composites



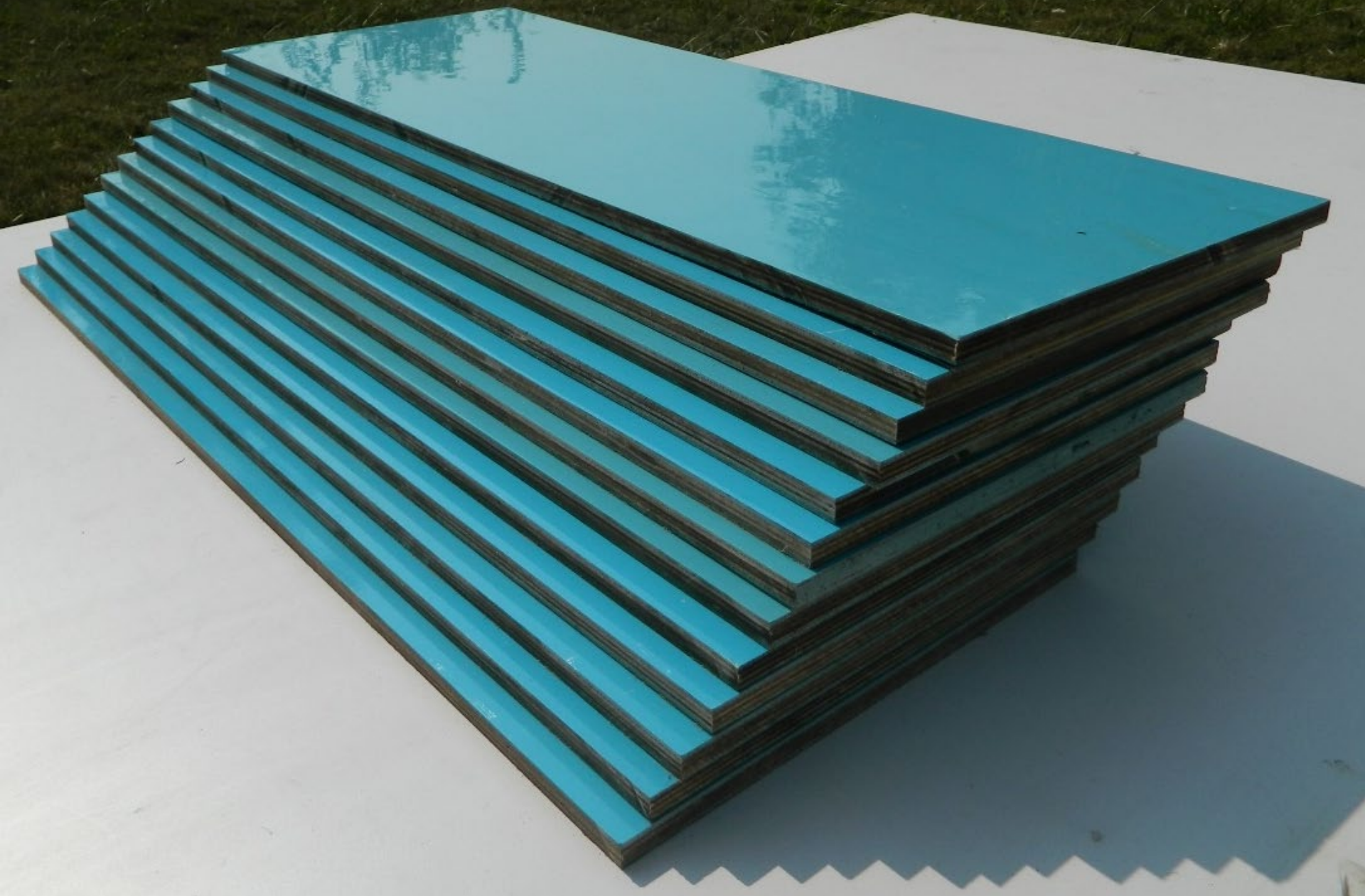
Granite slurry waste composites



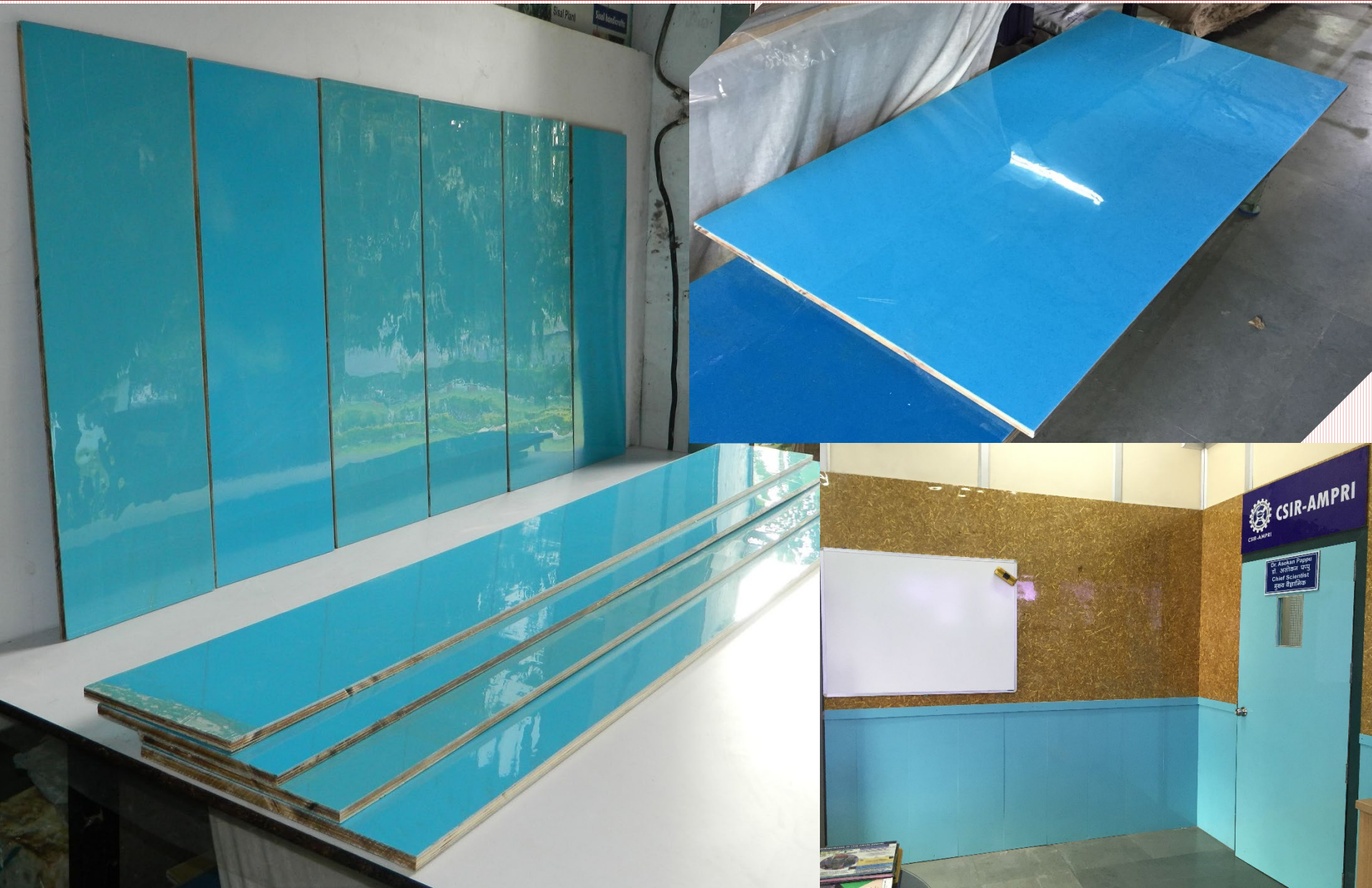
HYBRID COMPOSITE MATERIALS FROM GRANITE, MARBLE AND STONE WASTE STREAM



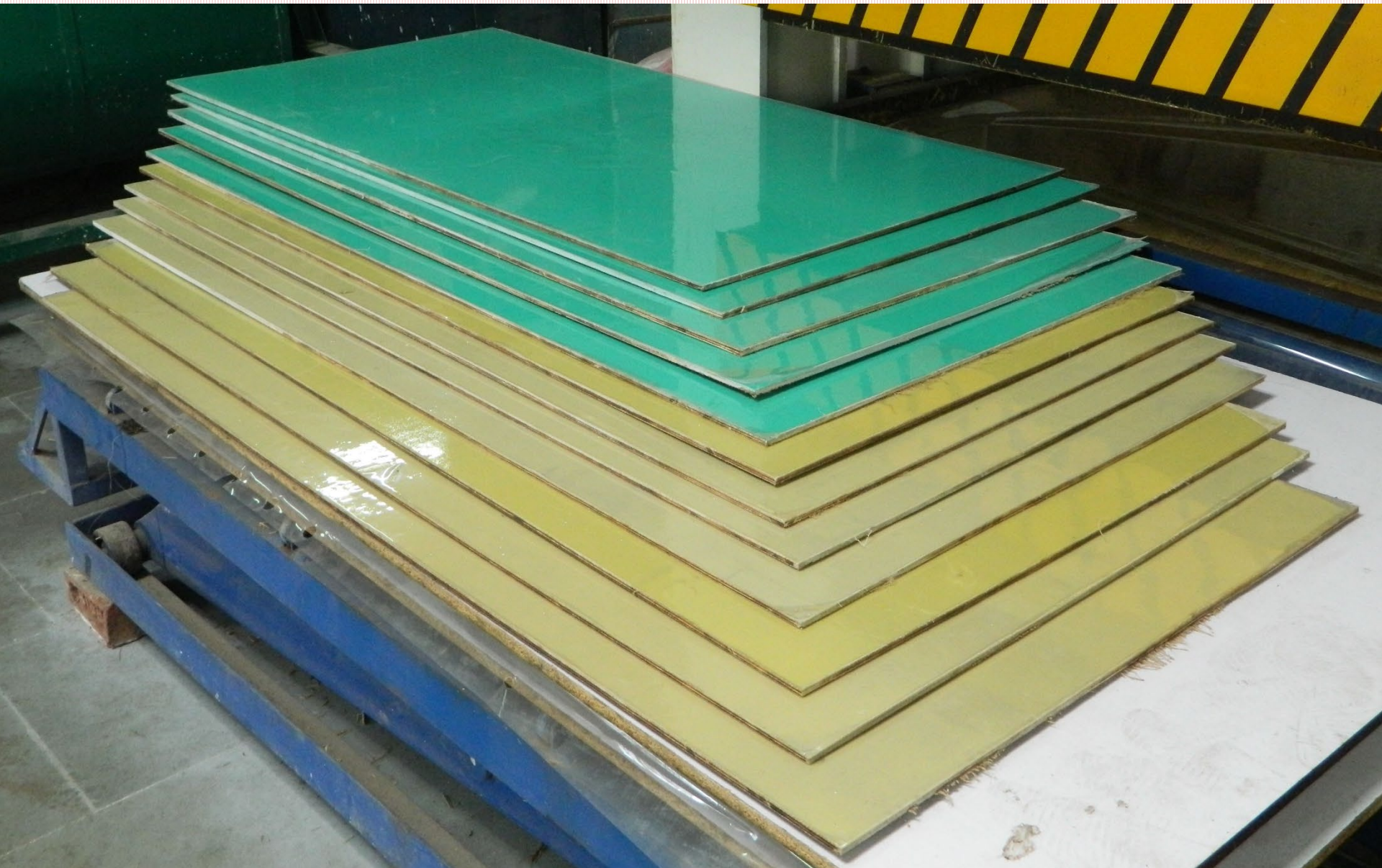
HYBRID COMPOSITE MATERIALS MANUFACTURED USING MARBLE WASTE STREAM



HYBRID COMPOSITE MATERIALS MANUFACTURED USING MARBLE WASTE STREAM



HYBRID COMPOSITE MATERIALS MANUFACTURED USING MARBLE WASTE STREAM



HYBRID COMPOSITE MATERIALS MANUFACTURED USING MARBLE WASTE STREAM



HYBRID COMPOSITE ROOFING SHEETS

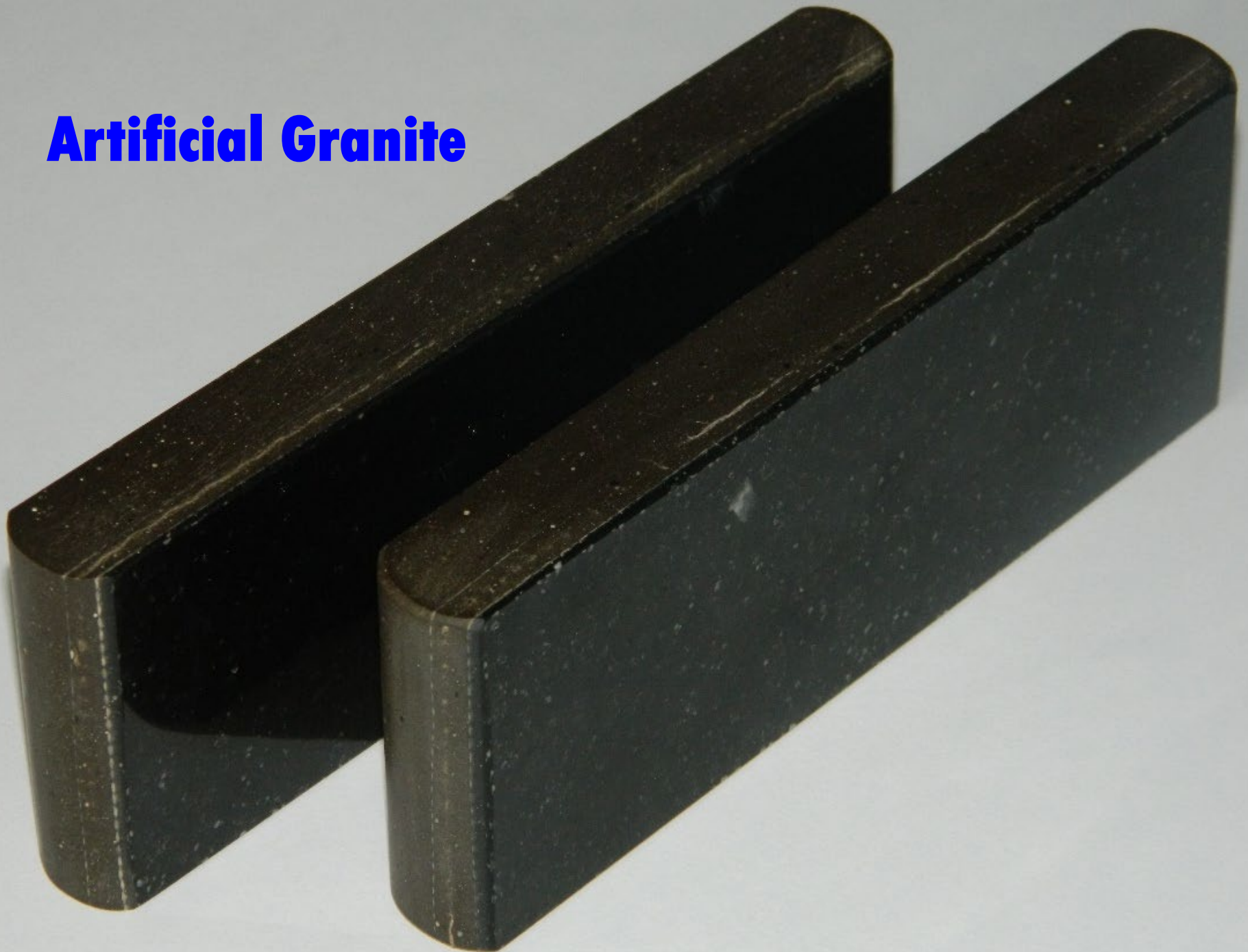


*Hybrid composite **Roofing sheets** made from Stone , Granite & Marble waste*

HYBRID COMPOSITE ARTIFICIAL GRANITE



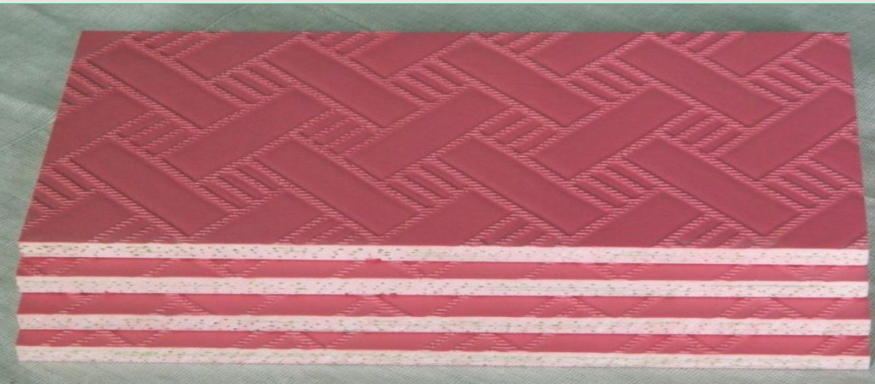
Artificial Granite



HYBRID COMPOSITES

A new class of materials:

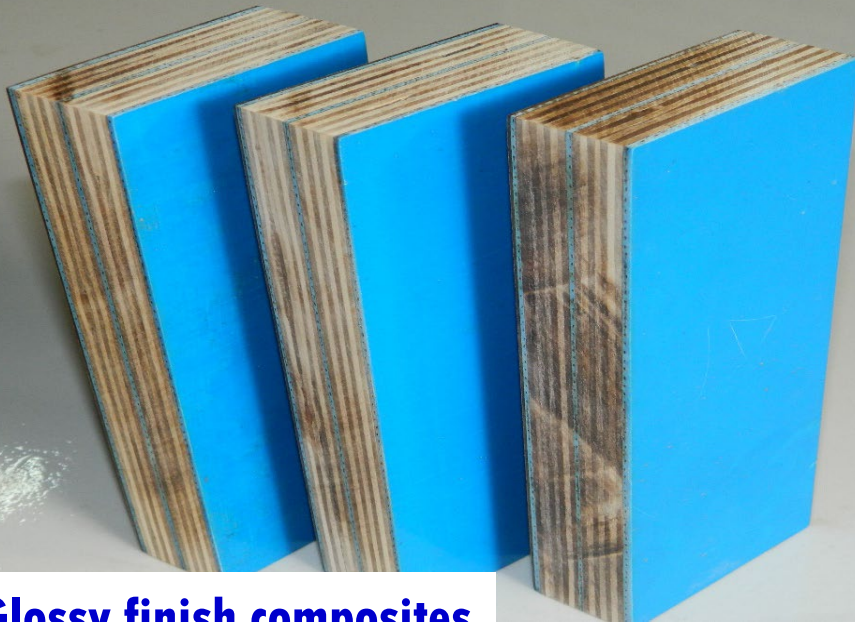
- Varying thickness
- Size, Shape, Design & Colour
- Texture, Surface finish



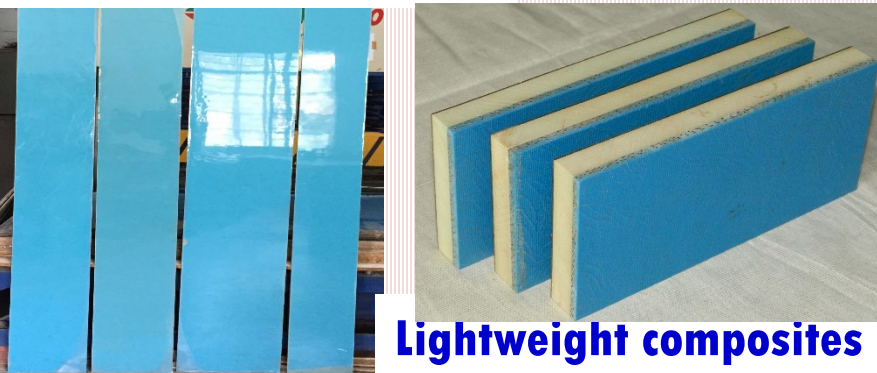
HYBRID COMPOSITES

A new class of materials:

Sandwich composites



Glossy finish composites

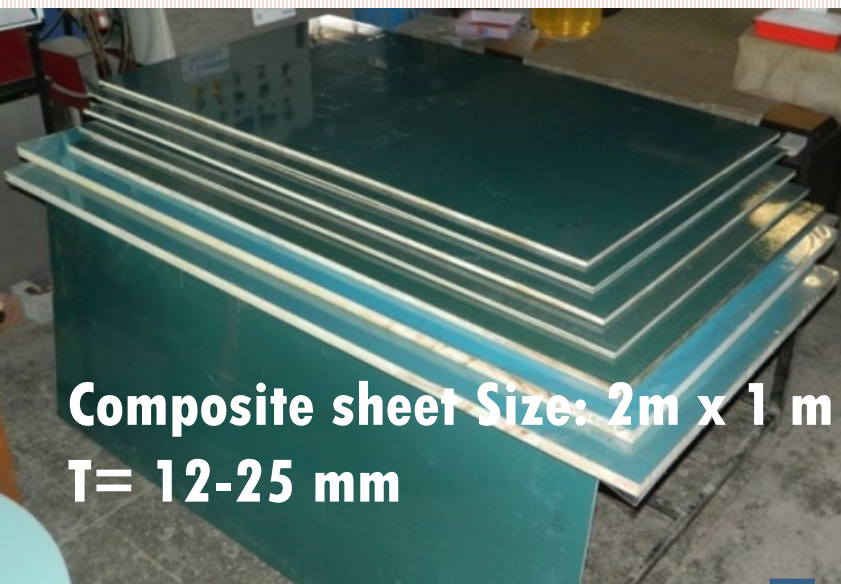


Lightweight composites

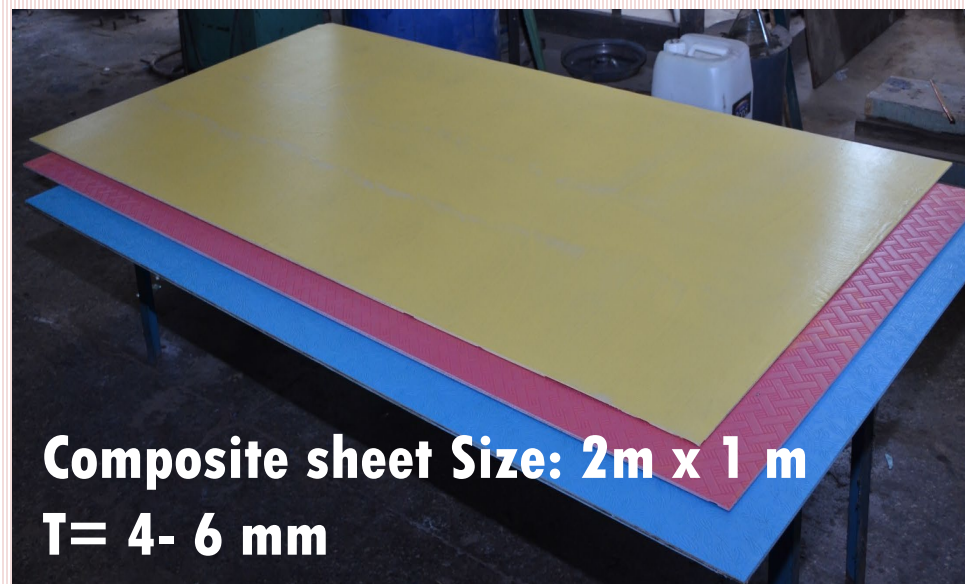
High strength composites



TECHNOLOGY READY FOR COMMERCIALISATION



Composite sheet Size: 2m x 1 m
T= 12-25 mm



Composite sheet Size: 2m x 1 m
T= 4- 6 mm

Applications: an alternative for :

- Wood / Timber
- Synthetic wood (MDF, Particle Board, Ply wood)
- Plastic and FRP / GRP Products

Uniqueness

- Composites are resistance to weather, moisture, corrosion, termite & fungus

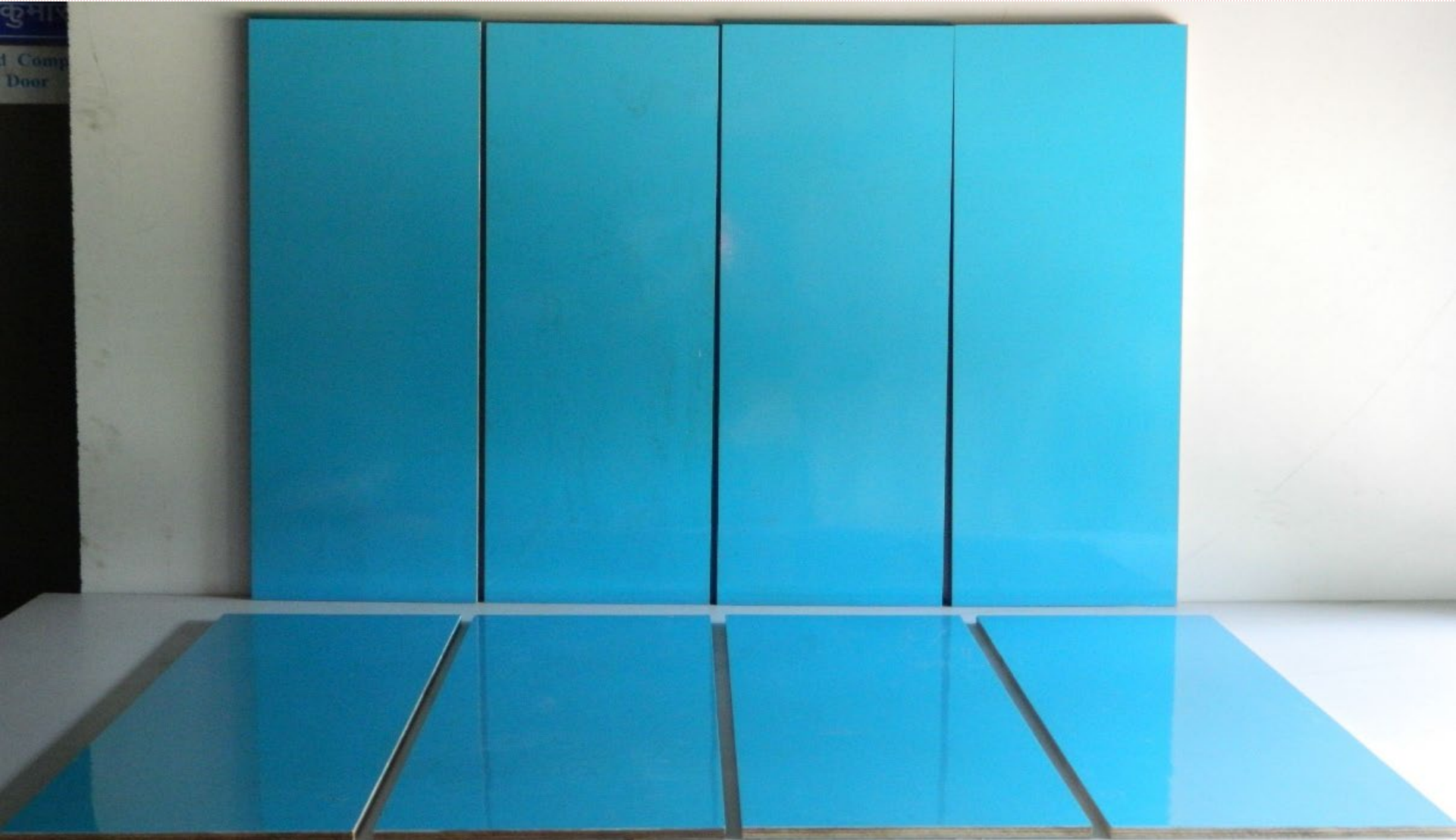
Advantages

- Composites are stronger than timber, synthetic wood & highly durable
- Cost effective & maintenance free products

HYBRID COMPOSITES FOR USE IN ARCHITECTURAL CLADDING



PROPERTIES OF HYBRID GREEN COMPOSITES



HYBRID COMPOSITES

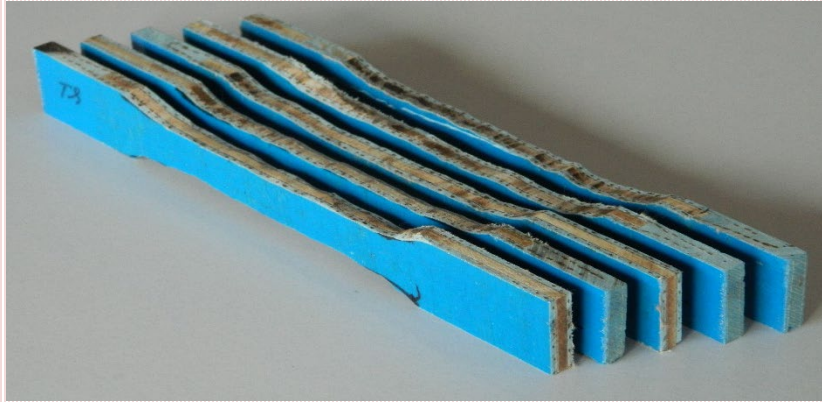
QUALITY COMPARISON WITH MARKET PRODUCTS

S.No	Specification	Hybrid Composite CSIR-AMPRI	Particle board (EG)	MDF Board (EG)	Plywood (EG)
1	Density (gm/cm ³)	0.35 – 2.20	0.5 – 0.6	0.68	0.70
2	Water Absorption (%)	0.00 – 1.5	67.72 – 77.08	87.74	31.40
3	Thickness Swelling (%)	0.00 – 2.75	12.53 – 15.91	18.42	15.19
4	Tensile Strength (MPa)	6.73 – 48.58	4.4 – 9.3	13.33	31.40
5	Tensile Modulus (GPa)	1.40 – 7.05	1.89 – 5.4	2.58	2.94
6	Flexural Strength (MPa)	13.9 – 65.83	11.3 – 51.2	24.23	26.17
7	Flexural Modulus (GPa)	1.2 – 13.07	-	2.23	2.53
8	Impact Strength (kJ/m ²)	1.40 – 30.10	-	2.5	3.10

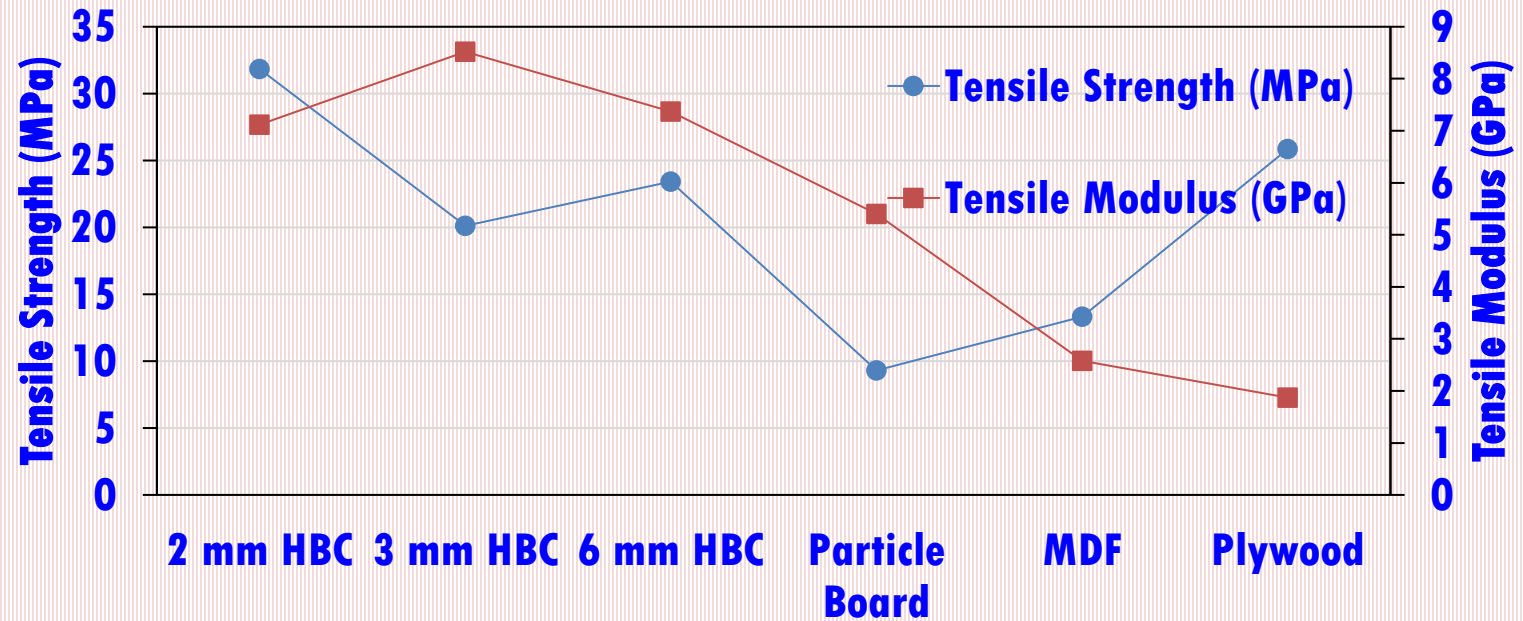
COMPARISON OF PROPERTIES OF MARBLE / GRANITE / STONE WASTE COMPOSITE MATERIALS (Average Values)

	TS	TM	FS	FM	IS	ΔL	WA
Marble Waste	12.85	6.27	48.05	7.12	-	NIL	0.09
Marble+ Jute Fibre	20.59	4.42	48.48	6.31	-	NIL	0.56
Granite Waste	26.74	3.97	44.99	7.89	1500	NIL	0.09
Granite waste + Jute Fibre	38.86	4.52	76.15	9.02	2870	NIL	0.09
Stone Waste	22.00	3.24	55.64	7.75	1387	NIL	0.10
Stone Waste +Jute Fibre	31.33	3.66	52.10	9.17	2384	NIL	0.21

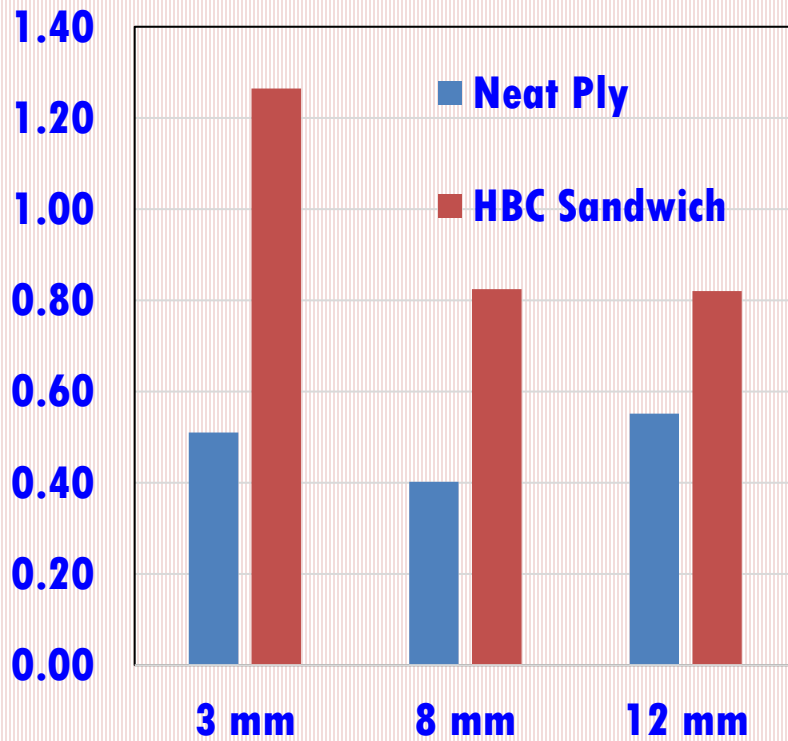
TENSILE PROPERTIES OF HYBRID COMPOSITES AND SYNTHETIC WOOD



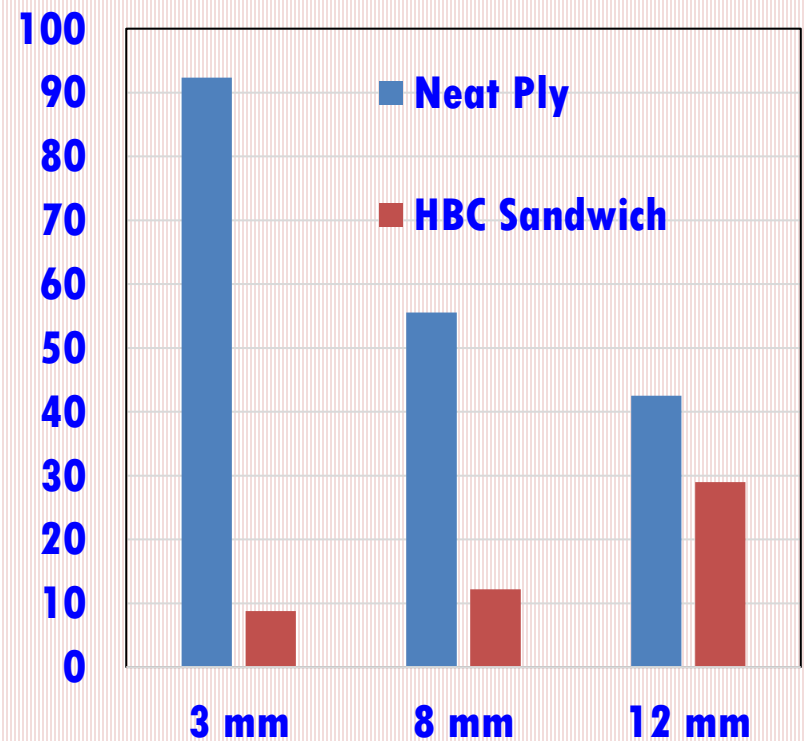
Tensile Strength v/s Tensile Modulus



Density (gm/cm³)



Water Absorption (%)



Neat Plywood v/s Hybrid Sandwich Composites

BIS Testing of Hybrid Composites Samples

Under IS: 303:1989 PLYWOOD FOR GENERAL PURPOSES



CALI-LABS PVT. LTD.
A HOUSE OF CALIBRATION AND TESTING

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Tel : (0755) 2468583 Telefax: (0755) 2461836
e-mail : callilabs@sanchamnet.in; callilabs@gmail.com

TEST REPORT

SERVICE REQUEST No. : CL/TL/1323/2017 Sheet 1 of 2
TEST REPORT No. : 6191/10/2191/2017 Date of Issue : 28.11.2017

REPORT ISSUED To : CSIR - ADVANCED MATERIALS AND PROCESSES RESEARCH INSTITUTE
Hoshangabad Road,
Bhopal - 462 064 (M.P.)

SAMPLE DESCRIPTION : GREEN HYBRID COMPOSITE MATERIAL

TEST METHOD REF. : IS : 303 : 1989 with amendment no. 6

GRADE : MR TYPE : Not Declared
BRAND NAME, IF ANY : Not Declared DECLARED SIZE : Not Declared

QUANTITY & PACKING	BATCH NO. / LOT NO.	DOM
1 No. Green hybrid composite material	Not mentioned	06.10.2017

DATE OF RECEIPT : 26.10.2017
DATE OF START ANALYSIS : 02.11.2017
DATE OF COMPLETION OF ANALYSIS : 27.11.2017

ANY OTHER INFORMATION : Customer requested for all tests on Green hybrid composite material as per IS:303:1989 vide their letter no. AMPRI/BIS/2017-1, dtd. 25th Sep 2017

Clause no.	TEST PARAMETER	REQUIREMENT	RESULTS	TEST METHOD REF.
5.1	Types based on classification by appearance	-	Not Declared	-
5.2	Surface defects	-	Not Applicable	-
8	Dimensions a) Length b) Width c) Thickness, Min/Max, d) Edge straightness % e) Squareness, %	Tolerance on declared value +6mm, -0mm +3mm, -0mm ±10% 0.2% 0.2%	2151 1204 1.81 - 2.35 0.02 0.06	IS:303:1989 (RA 2013)
9.1	The board shall be of Uniform thickness within the tolerance limit	Thickness not specified		IS:303:1989 (RA 2013)
9.2	The faces of board shall be reasonably smooth	The faces of Green hybrid composite material is reasonably smooth		
11.2.1	Water Resistance test (3 cycles of - 3 hr in water at 60±2°C and 8 hr drying at 65±2°C)	Min Pass Standard	Pass Standard	IS:1734 (Pl-5):1983 (RA 2013)

(Analyst)
(Nutan Singh)
(Authorised Signatory)



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e-mail : callilabs@sanchamnet.in; callilabs@gmail.com

SERVICE REQUEST No. : CL/TL/1323/2017 Sheet 2 of 2
TEST REPORT No. : 6192/10/2192/2017 Date of Issue : 28.11.2017

Clause no.	TEST PARAMETER	REQUIREMENT	RESULTS	TEST METHOD REF.
11.3	Moisture Content, %	Min 5%, Max 15%	0.3	IS:1734 (Pl-1):1983 (RA 2013)
11.4	Static Bending strength Modulus of Elasticity, i) Parallel to the face a) Average N/mm ² b) Minimum individual N/mm ² ii) Perpendicular to the face a) Average N/mm ² b) Minimum individual N/mm ²	5000 4500 2500 2200	15942 15115 6311 5982	IS:1734 (Pl-11):1983 (RA 2013)
11.4	Modulus of Rupture, i) Parallel to the face a) Average N/mm ² b) Minimum individual N/mm ² ii) Perpendicular to the face a) Average N/mm ² b) Minimum individual N/mm ²	40 36 20 18	118.08 102.96 114.72 95.76	IS:1734 (Pl-11):1983 (RA 2013)

1 Sample tested as per IS : 303 : 1989 with amendment no. 6 as requested by the customer.
2 This report, in full or in part, shall not be published, advertised, used for any legal action, unless prior permission has been secured from The Director, CALI-LABS PVT.LTD. BHOPAL.
3 The test report pertains to the sample tested.
4 Sample not drawn by us.

(Analyst)
(Nutan Singh)
Authorised Signatory

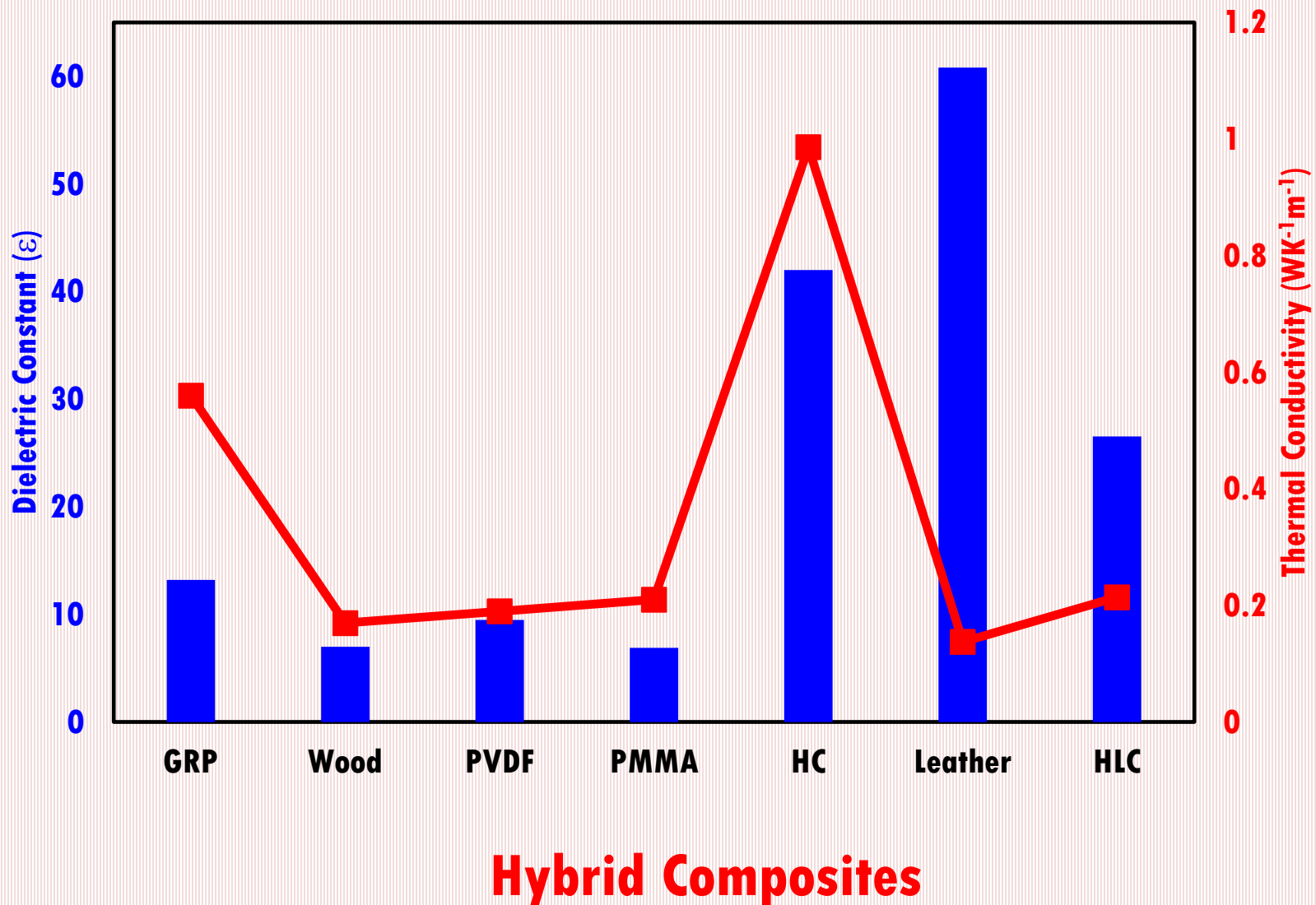
**Moisture Resistant
(MR) Grade**

Salient Features....

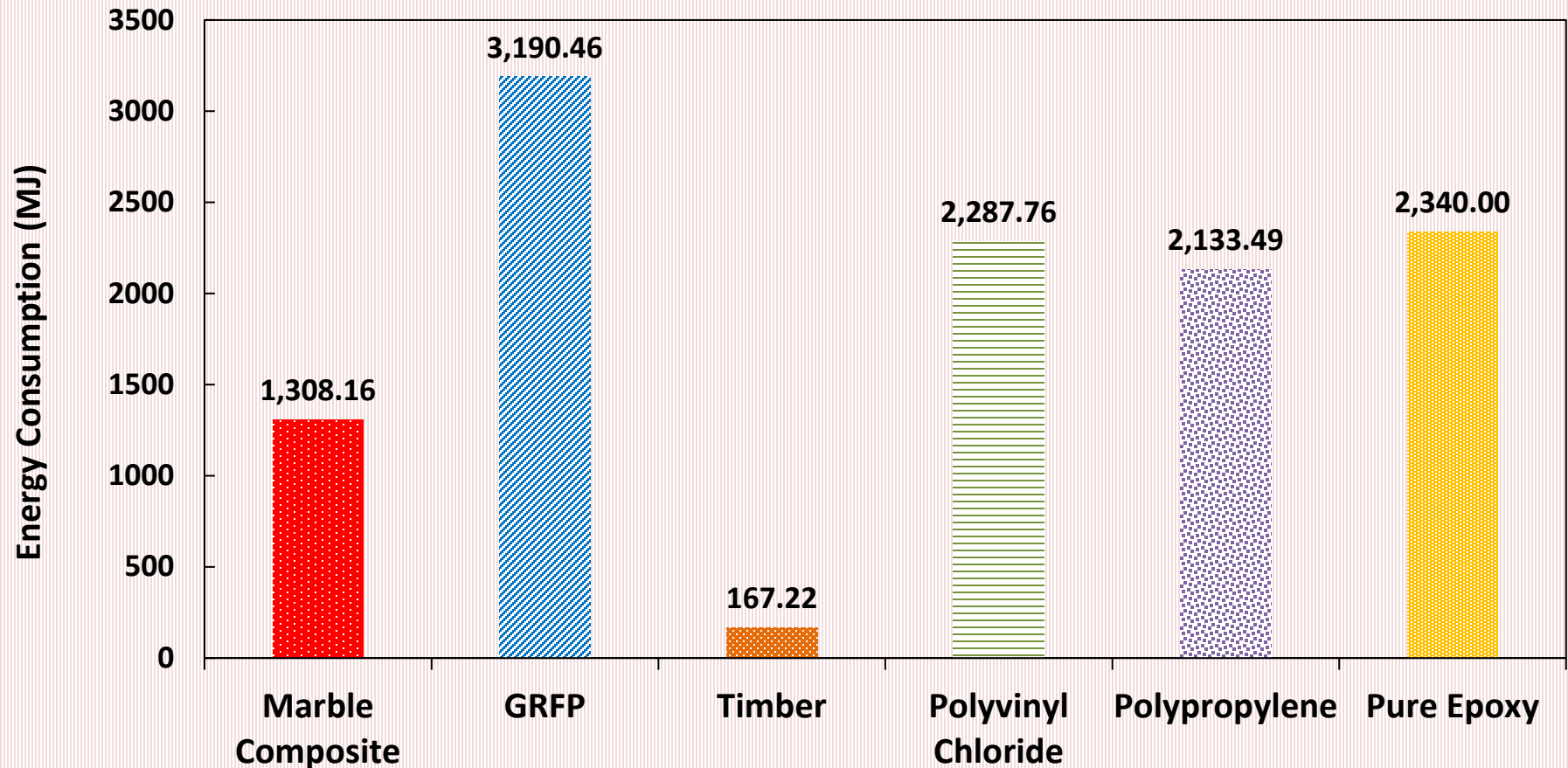
Composites are resistant to Fungus & Termite

BIS 4873-1:2008 Fungi Test & ASTM D-3345 Termites resistance Test

THERMAL INSULATING HYBRID COMPOSITES



ENERGY CONSUMPTION FOR FABRICATION OF STANDARD SHEET (2 M X 1 M X 0.012 M)



IPR Status

Two International Patents (i) A glossy finish sandwich composite and process for preparing the same (Grant No.201811047389, WO 2020/121319 A1) and (ii) High performance glossy finish green hybrid composites with variable density and an improved process for making there of (Publication No. 201811016873, W02019/211862A1) filed.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization

International Bureau

(43) International Publication Date
18 June 2020 (18.06.2020)



(10) International Publication Number
WO 2020/121319 A1

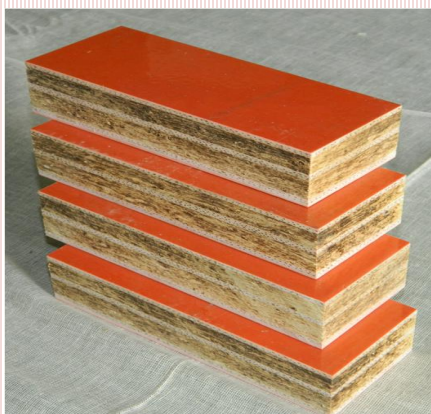
- (51) International Patent Classification:
B29C 70/48 (2006.01) *E04C 2/40* (2006.01)
C08J 11/04 (2006.01) *C08L 75/04* (2006.01)
- (21) International Application Number:
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- (22) International Filing Date:
16 August 2019 (16.08.2019)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
201811047389 14 December 2018 (14.12.2018) IN
- (71) Applicant: **COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH** [IN/IN]; Anusandhan Bhawan, 2 Rafi Marg, New Delhi 110 001 (IN).
- (72) Inventors: **PAPPU, Asokan**; Advanced Materials and Processes Research Institute, Hoshangabad Road, Bhopal 462026 (IN). **GUPTA, Manoj Kumar**; Advanced Materi-

als and Processes Research Institute, Hoshangabad Road, Bhopal 462026 (IN). **MISHRA, Alka**; Advanced Materials and Processes Research Institute, Hoshangabad Road, Bhopal 462026 (IN). **PETERS, Edward**; Advanced Materials and Processes Research Institute, Hoshangabad Road, Bhopal 462026 (IN). **KULSHRESHTI, Ajay**; Advanced Materials and Processes Research Institute, Hoshangabad Road, Bhopal 462026 (IN). **RATHORE, Sanjai Kumar Singh**; Advanced Materials and Processes Research Institute, Hoshangabad Road, Bhopal 462026 (IN). **SRIVASTAVA, Avnish Kumar**; Advanced Materials and Processes Research Institute, Hoshangabad Road, Bhopal 462026 (IN).

(74) Agent: **SINGH, Manisha**; LexOrbis, 709-710 Tolstoy House, 15-17 Tolstoy Marg, New Delhi 110001 (IN).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO,

(54) Title: A GLOSSY FINISH SANDWICH COMPOSITE AND PROCESS FOR PREPARING THE SAME



(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization

International Bureau

(43) International Publication Date
07 November 2019 (07.11.2019)



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- (25) Filing Language: English
- (26) Publication Language: English
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201811016873 04 May 2018 (04.05.2018) IN
- (71) Applicant: **COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH** [IN/IN]; Anusandhan Bhawan, 2 Rafi Marg, New Delhi, DELHI 110 001 (IN).
- (72) Inventors: **ASOKAN, Pappu**; CSIR-Advanced Materials and Processes Research Institute (AMPRI), Habibganj Naka, Bhopal 462026 (IN). **GUPTA, Manoj Kumar**; CSIR-Advanced Materials and Processes Research Institute (AMPRI), Habibganj Naka, Bhopal 462026 (IN). **MISHRA, Alka**; CSIR-Advanced Materials and Processes Research Institute (AMPRI), Habibganj Naka, Bhopal 462026 (IN). **PETERS, Edward**; CSIR-Advanced Materials and Processes Research Institute (AMPRI), Habibganj Naka, Bhopal 462026 (IN). **KULSHRESHTI, Ajay**; CSIR-Advanced Materials and Processes Research Institute (AMPRI), Habibganj Naka, Bhopal 462026 (IN). **RATHORE, Sanjai Kumar Singh**; CSIR-Advanced Materials and Processes Research Institute (AMPRI), Habibganj Naka, Bhopal 462026 (IN). **SRIVASTAVA, Avnish Kumar**; CSIR-Advanced Materials and Processes Research Institute (AMPRI), Habibganj Naka, Bhopal 462026 (IN).

MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, CG, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(iii))
- of inventorship (Rule 4.17(iv))

Published:

- with international search report (Art. 21(3))

(74) Agent: **REMFREY & SAGAR**; Remfry House At The Millennium Plaza, Sector 27, Gurgaon, Haryana 122 009 (IN).

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(54) Title: HIGH PERFORMANCE GLOSSY FINISH GREEN HYBRID COMPOSITES WITH VARIABLE DENSITY AND AN IMPROVED PROCESS FOR MAKING THEREOF



Applications: Furnitures



Applications

Souvenirs



Writing pad / clip boards

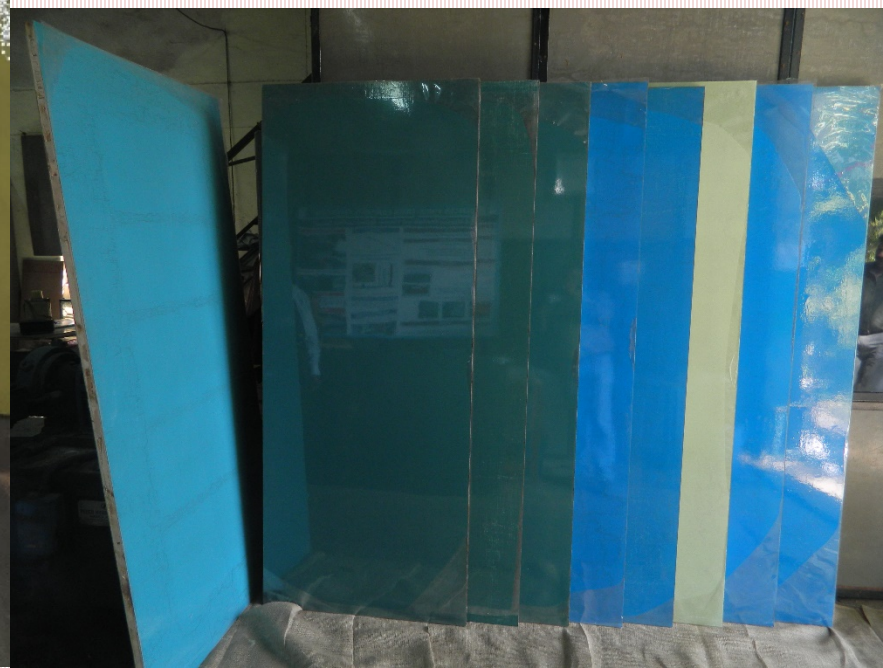


Applications

Architectural cladding panels



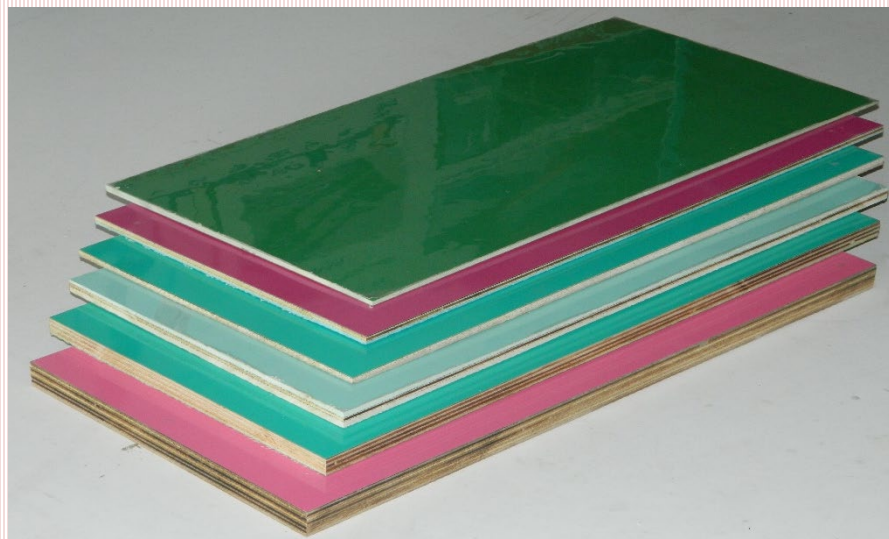
Applications



INDICATIVE COST

DOOR size : 2x1 m (25-30 mm t)	Cost Rs.
AMPRI Door : Fire retardant, water & termite resistant Grade	6500 /-
Commercial Doors	
i) Teak wood	16000 /-
ii) MDF with lamination	7500/-
iii) GRP Solid door	18600/-

Panels (Price psf)	Cost Rs.
AMPRI Panel products	
High strength, Fire retardant, water & termite resistant 4-12 mmt	40-100/-
Commercially available products	
i) Ply 4 -12 mmt	50- 100/-
ii) MDF 12-18 mmt	40-80/-
iii) PVC 25mmt	110/-
iv) Teak (30mmt)	225/-



ECONOMICS ANALYSIS : HYBRID GREEN COMPOSITES (₹)

Thickness (mm)	CSIR-AMPRI *	MDF #	Plywood #	Particle Board
4	45	17	56	-
8	75	39	80	45
12	100	55	102	65
18	140	72	140	82
25	185	120	232	114

* Four times stronger than MDF, Plywood, Particleboard. Resistance to Termite, Fungus, Water

Non-Laminated (Market products) Rate: per sq. ft.

BUSINESS PLAN AND ECONOMIC BENEFITS

Major Machinery

- Stone wastes particulates & fibres handling system, Drying / curing oven
- Polymer matrix mixing, impregnation & calendaring system
- Hydraulic press / Compression moulding machine, Cutting Machine

Techno-Economics

Prices ~ 30% cheaper than teak wood & ~ 4 times stronger than teak wood. About 10 % cheaper than synthetic wood (MDF, particle board, ply wood...) and the quality is manifold better than that of synthetic wood.



PROJECT COST FOR COMMERCIAL SCALE MANUFACTURING

Hybrid composite panels/ sheets from stone / marble / granite wastes – indicative

Investment vs Production Capacity

About Rs. 3.5 crore

About 250 composite panels (Size ~ 2m x1m, thickness ~ 4 mm) per shift per day.

➤ 3 mm panels to 35mm door can be made.

Land, Electricity & Water

About 10000 square feet land needed

40-70 KW power

Water: Nil



BUSINESS MODEL

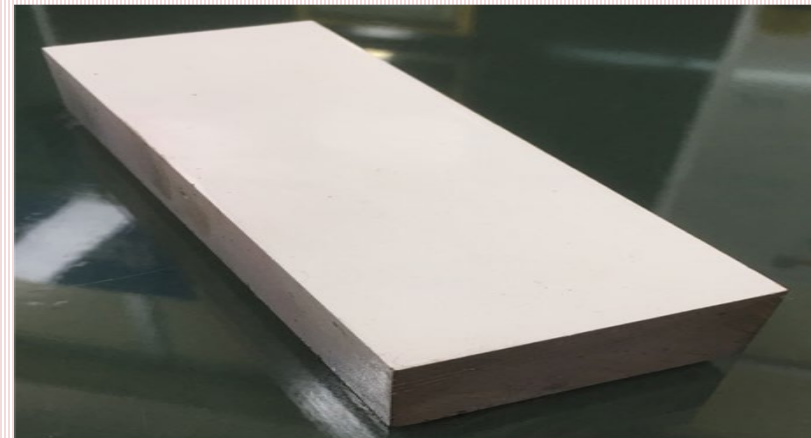
PROJECT COST FOR COMMERCIAL SCALE MANUFACTURING **ARTIFICIAL STONE/ MARBLE / GRANITE (SLAB) – INDICATIVE**

Production Capacity 950 slab per day

Stone Waste Consumption: About 60 tons per day

Solid slab / panels

Nb	Parameter	Value
1	CAPEX	~ Rs. 18 Crore
2	OPEX	~ Rs. 32 Lakhs
3	Land Requirement	~ 50000 sqf
4	Electric Requirement	~ 850 hp (635 KW)
5	Water Requirement	Usually no water required



Slab Size: 2 meter x 1 meter of 15 mm thickness* (~21 sqf)

*Varying thickness can be made from 3mm to 30 mm

Cost of each Slab @ Rs.189 /sqf

Total Weight: 57 kg (size ~21 sqf)

Profit Per day

(Selling price – Production cost): 11,63,925 Per day

BUSINESS MODEL Sandwich panels

PROJECT COST FOR COMMERCIAL SCALE MANUFACTURING **ARTIFICIAL STONE/ MARBLE / GRANITE (SLAB) – INDICATIVE**

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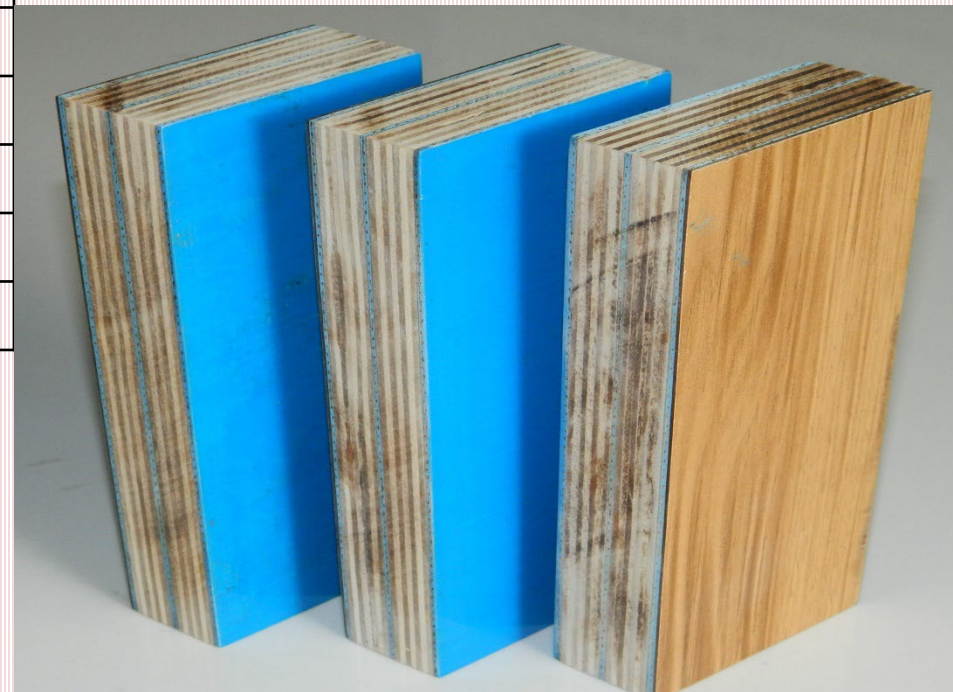
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STONE / MARBLE/ GRANITE WASTE RECYCLING OPPORTUNITY

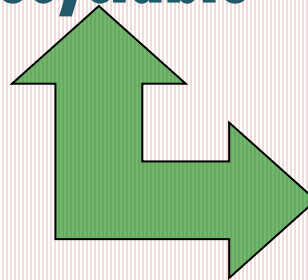
Technically feasible



**Environmental friendly,
Energy saving
processes/products**

Economically viable

**Socially acceptable /
Recyclable**



WASTE TO WEALTH...

Simple process, address multiple issues, multifunctional applications

OPPORTUNITIES

- Create start-up, entrepreneurship & employment thus enhance the economy
- Contribute to Atmanirbhar Bharat
- Technology is ready for commercialization

CREATE URBAN & RURAL EMPLOYMENT FROM STONE WASTE STREAM

CONCLUSION

निष्कर्ष

“ Your understanding & involvement will accelerate to realize the benefits of this research outcome

for

Entrepreneurship & New business creation

on

Stone, Marble and Granite waste utilization in making new class of green composite materials”.

Thanks

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