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Behaviour of Bamboo Reinforced Slab Panel

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Abstract: This report has been prepared for successfully testing the design and construction of bamboo reinforced slab. The information in this report has been compiled from reports of experiments done by us under the guidance of faculty and expects. Slab panels are made using bamboo reinforcement having good compressive strength.
Nowadays global warming is a big issues for society. Bamboo, low cost, fast growing, and broad distribution of growth, is expected to contribute significantly to earthquake resistant construction and seismic retrofit technology in the developing countries. So bamboo is cost effective, eco-friendly and having good compressive strength. It can be use for light weight structure and temporary structure.
Keywords: Bamboo reinforced slab, Bamboo skeleton, Slump cone test, Load provision, Crack pattern

I. INTRODUCTION

The main purpose of this project is to ensure that a bamboo reinforced concrete slab is suitable and sustainable for light weight structure or temporary structure. Nature's material, bamboo has been widely used for many purposes. Mainly as a strength bearing material. It is used for building shelters from an earlier time. Bamboo has used for scaffolding works, formwork supporting stands and many in building construction works. In the history of Civil Engineering construction, bamboo was a vital material in construction. A study of the feasibility of using bamboo as the reinforcing material in precast concrete elements was conducted at the U. S. Army Engineer Waterways Experiment Station in 1964. , the bamboo is used for construction of houses in hilly and flooded areas but it is also used in other conventional construction.

II. LITERATURE REVIEW

[1] Experimental Investigation of Bamboo Reinforced Concrete Slab, American Journal of Engineering Research (AJER) e-ISSN : 2320-0847 p-ISSN : 2320-0936 Volume-03, Issue-01, pp-128-131 www.ajer.org. are working on replacement of conventional materials of building construction with eco friendly material for sustainable development. Bamboo has been in use of mankind for various purposes since a long time. ISO-22156 for Bamboo Structural Design and ISO-22157 for Determination of physical and mechanical properties of bamboo have been published by International Standards.

[2] Research and Development on Bamboo Reinforced Concrete Structure Masakazu TERAI & Koichi MINAMI Fukuyama University, Japan. Suggests that alternative cheaper reinforcement material with a high tensile strength is bamboo. Recently, in the attention in response to global warming issues and sustainable society, the manufacturing using natural materials has become actively. Bamboo, low cost, fast growing, and broad distribution of growth, is expected to contribute significantly to earthquake-resistant construction and seismic retrofit technology in the developing countries.

The tensile strength filled with cement paste cured *w/c*=80% and 100% significantly increase with aging time. The behavior of pull-out test with bamboo is almost the same as the plain steel bar; however, the bond strength with bamboo was higher than the one with plain steel bar. It can be expected that the bond strength covering with full treatment shows the high value 1.2-1.35MPa. Bamboo reinforced concrete slab.

[3] Maruthupandian.G1* , Saravanan.R2 , Suresh Kumar.S3 , Sivakumar.B.G4 A Study on Bamboo Reinforced Concrete Slabs 1Dept of Mechanical Engg, Akshaya College of Engineering and Technology, Coimbatore- 642109. Proved that the application of Polymers synthesized with synthetic fibers are more advantageous as Compared to conventional construction materials. Generally steel is used in the structural materials. But steel has some disadvantages like its corrodibility, high cost and also fabrication of steel leads to the release of CO2 in the atmosphere. On the other hand, composites have shown its advantages like light weight, recyclability and its cost effectiveness. In his work, woven glass fiber and chopped silk fibers are used to fabricate the hybrid composites. From the results Young's modulus is found to increase with the use of 0.3 wt%, 0.4 wt% of the silk fiber. The Young's modulus decreases when the amount of silk fibers increases beyond 0.4 wt%.

[4] Prof. Dirk E. Hebel1, Felix Heisel and Alireza Javadian, "Engineering Bamboo The new composite reinforcement" Chair of Architecture and Construction Future Cities Laboratory, Singapore ETH Centre Singapore.

Bamboo is an incredibly rapidly growing, affordable and widely available natural resource in Africa, which has outstanding constructive qualities. The cultivation and industrially processing of bamboo offers huge potential n the form of composite material products known as Woven Strand Bamboo (WSB). The research group is investigating these possibilities. This paper documents the investigations that were carried out in order to understand the production process of WSB products in accordance to its change of mechanical and physical properties. All tests documented in this paper were completed using 5-year-old Phyllostachys edulis, also known as Moso Bamboo, which was harvested in the Anji area of South China. The WSB material used in the described research activities was prepared in Anji. The tested WSB material represented an average fiber collection from upper, middle and lower sections of the bamboo culm.

III. METHODOLOGY

A. Information of Materials Used for Concrete

1) Ordinary Portland cement (M53 Grade) is used. Which is locally available in market. It is the most suitable cement for infrastructure project because of its high flexural strength.

2) Advantages of cement

a) Excellence resistance to chloride & sulphate attacks.
b) Low risk of cracking.
c) Improved workability.
d) Better compatibility with all type of admixtures.

3) Aggregate

a) Aggregate of 10 mm and 20mm size are used.
b) It consisting sharp, angular, grains particles.
c) It should be free from dust, dirt and organic matters.
d) It is hard and durable.
e) It should not be elongated or flaky but of cubical shape only.

4) River sand

a) Sand used for concrete is fine, free from dust, dirt and organic matter.

5) Water

a) In concrete work the water used for both mixing and curing is free from injurious amounts of deleterious material like acid, alkalies, etc.
b) Potable water is generally used for mixing in proportion 0.37- 0.39 and curing.

B. Preparation of Formwork

1) Formwork is prepared from well finished and smooth plywood of thickness 12 mm.
2) Rectangular box type structure is prepared which is open at top as well as bottom.
3) Size(inner) of formwork is 1000mm x 1000 mm x 70mm.
4) Treaming is done at corner edge of strips to avoid it from wedge action.
5) Joints in formwork are connected with screw which can easily removed at the time of dismoulding and can use further work.

C. Preparation of Bamboo Skeleton

1) Bamboo Treatment

a) Well seasoned bamboo of size 40mm diameter are taken.
b) Split it into four equal parts longitudinally .
c) Primer coat is applied on bamboo and rangoli is spread or coated over the primer coat.

2) Advantages

a) Prevent decay of bamboo .
b) Prevent absorption of water from concrete.
c) Prevent cracking of concrete.
d) Coating of rangoli on bamboo increases roughness and improve bonding of bamboo and concrete.

4) Preparation of reinforcement / skeleton

a) Strips of length 1000mm and width 1/4 are prepared .

b) Bamboo strips having approximate 12 mm diameter and 20mm width is bounded with another strips of diameter 12mm perpendicularly using binding wire making a square mash structure.
c) Spacing between main bamboo are (i)175mm,(ii)125mm

D. Preparation of concrete mix

1) Mix design (1:1.7:2.89)

Total volume of slab panel = 1 x 1 x 0.07 = 0.07 m^3
Weight of slab panel = 2400 x 0.06 = 168 kg
Total weight of slab panels = 3x168 = 504 kg

2) Batching

a) Weigh batching method is used for measuring the materials.
b) Material required for one slab panel (volume=0.07 m3) 1:1:7:2.89

3) Mixing

a) Hand mixing is done on clean solid water tight and thin steel sheet platform to provide ample mixing.
b) Dry mix is prepared.
c) The cement is dumped on the sand and distributed evenly the sand cement is mixed thoroughly with spade, turning the mixture over and over again ,until it is of even color throughout and free from streak.
d) The measured quantity of coarse aggregate is spread out and the sand cement mixture is spread on its top and it is mixed at least three times by shoveling and turning over by twist by center to side again back to center.
e) The hollow is made in a middle of mixed pile. 3 quarter of total quantity of water is added while the material is turned in toward the center with spade.
f) Cur bond admixture is added with 0.3 % by weight of cementaceous material.
g) Remaining water is added slowly, turning the whole mixture over and over again until the uniform colour and consistency is obtained throughout. The platform is washed at the end of day.

E. Placing

1) Proper oiling is done on formwork before placing the concrete.
2) Slurry type concrete mix is poured into the formwork with proper compaction.
3) For proper compaction, 6 mm diameter tamping rod is used for tamping to avoid honeycombing.
4) Top level plane finished surface is made using trowel.
5) Due to improper compaction honeycombing arises in slab panel.

F. Removal of formwork

1) Formwork is removed after 20 hours of casting of the slab panel.
2) Formwork is removed with proper care so that it could be used for the future.

H. Curing

1) Once the formwork is removed then curing is done for next 28 days.
2) Gunny bag method is used for curing.

I. Testing

1) The wall panel of size (1000 X 1000 X 70 mm) is tested under uniform distributed load.
2) Distribute the load uniformly over entire slab panel .I section of length 1000 mm and of adequate strength are used as support at the four edges so as to make it as simply supported slab.
3) Deflectometer of least count 0.01mm is used for measuring the longitudinal deformation of wall panel.
4) Testing continued until failure occurred in wall panel.

J. Study of crack pattern

1) After applying load on slab panel for considerable time the cracks started to appear.

2) Cracks appears due to improper compaction during casting, temperature effect, use of more fine materials and due to earthquake.
3) By taking suitable measures during and after casting of slab these cracks can be prevented.

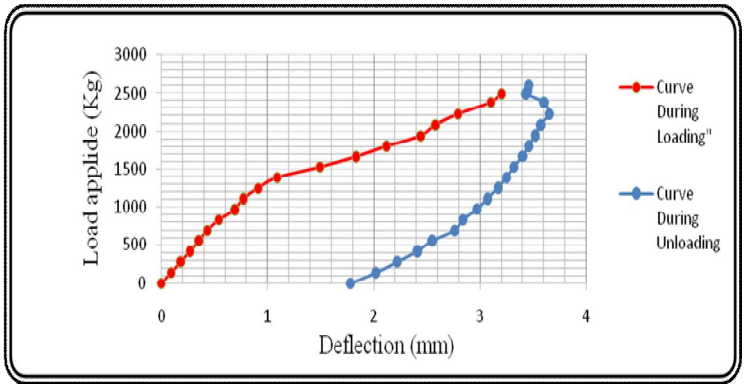
K. Future scope of project

1) Use of bamboo also reduces cost and make it eco-friendly construction.
2) Use of quarter piece of bamboo instead of half piece will reduce cracks.
3) Use of recycled aggregate of size less than 10 mm.
4) Use of light weight materials for construction helps to reduce weight of panels which results into easy handling of panels during slab construction.

IV. EXPERIMENTAL ANALYSIS

Observation Table 4.1: Load Applied and Deflection Of Slab Panal 1 (175mm Spacing)

Sr No.	Type Of Layer	Layer No.	Total Units	Weight Of Each Unit	Total Weight	Cummulative		Dialgauge Reading		Least Count	Deflection	
						Weight	Load	During Loading	During Unloadig		During Loading	During Unloading
				kg	kg	Kg	KN			mm	mm	mm
1	Tile	0	0	0	0	0	0	0	178	0.01	0	1.78
2	Tile	1	20	6.94	138.8	138.8	1.3602	9	202	0.01	0.09	2.02
3	Tile	2	20	6.94	138.8	277.6	2.7205	18	222	0.01	0.18	2.22
4	Tile	3	20	6.94	138.8	416.4	4.0807	27	241	0.01	0.27	2.41
5	Tile	4	20	6.94	138.8	555.2	5.441	35	255	0.01	0.35	2.55
6	Tile	5	20	6.94	138.8	694	6.8012	43	276	0.01	0.43	2.76
7	Tile	6	20	6.94	138.8	832.8	8.1614	54	284	0.01	0.54	2.84
8	Tile	7	20	6.94	138.8	971.6	9.5217	69	297	0.01	0.69	2.97
9	Tile	8	20	6.94	138.8	1110.4	10.882	77	307	0.01	0.77	3.07
10	Tile	9	20	6.94	138.8	1249.2	12.242	91	317	0.01	0.91	3.17
11	Tile	10	20	6.94	138.8	1388	13.602	109	325	0.01	1.09	3.25
12	Tile	11	20	6.94	138.8	1526.8	14.963	149	332	0.01	1.49	3.32
13	Tile	12	20	6.94	138.8	1665.6	16.323	183	340	0.01	1.83	3.4
14	Tile	13	20	6.94	138.8	1804.4	17.683	212	346	0.01	2.12	3.46
15	Tile	14	20	6.94	138.8	1943.2	19.043	244	352	0.01	2.44	3.52
16	Tile	15	20	6.94	138.8	2082	20.404	258	357	0.01	2.58	3.57
17	Tile	16	20	6.94	138.8	2220.8	21.764	279	365	0.01	2.79	3.65
18	Beam	17	8		156.55	2377.35	23.298	310	360	0.01	3.1	3.6
19	Boy1,2	18	2		114	2491.35	24.415	320	343	0.01	3.2	3.43
20	Boy3	19	1		49	2540.35	24.895	328	345	0.01	3.28	3.45
21	Boy4	20	1		59	2599.35	25.474	346	346	0.01	3.46	3.46



Load Deflecion Curve During Loading and Unloading

A. Activity : Testing of BRC slab -1

1) ISMB 100 frame of dimension 1 m × 1 m was fabricated for testing of slabs.

2) Red oxide paint is applied to the frame to prevent rusting.

3) The frame of 70 cm high, so that cracks can be observed from below. Also dial gauge was easily placed below the slab.

4) Testing of 1nd slab was scheduled on 27th may 2017. The slab of bamboo reinforcement at 175 mm c/c was tested. Uniformaly distributed Load was applied with the help of paving tiles. Each loading interval was of 20 tiles having load of 138.8 kg. Deflection at center was measured with a magnetic dial gauge. Total load of 25.48 KN/m^2 was applied. Only two , three minor cracks of 0.3 mm width were noticed.

5) The total deflection at center was 3.46 mm at 25.48 KN/m^2 load.

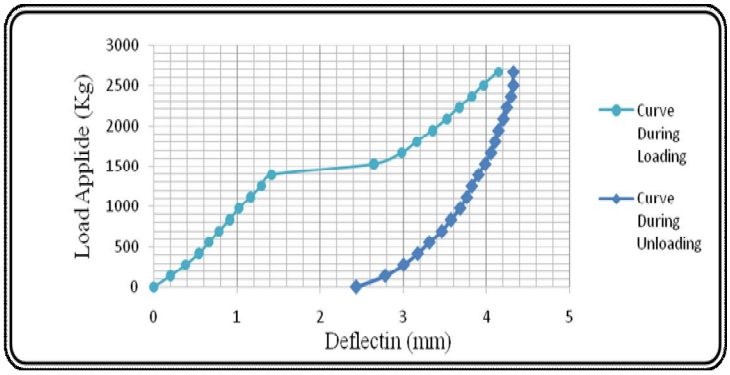
6) Unloading was done at same interval of 138.8 kg.

7) Permanent set was recorded as 1.8 mm.

8) The observations were tabulated and a graph was plotted of deflection v/s load applied.

Observation Table 4.2 : Load Applied and Deflection Of Slab Panel 2 (175mmSpacing)

Sr No.	Type Of Layer	Layer No.	Total Units	Weight Of Each Unit	Total Weight	Cummulative Weight	Cummulative Load	Dialgauge Reading During Loading	Dialgauge Reading During Unloadig	Least Count	Deflection During Loading	Deflection During Unloading
				Kg	Kg	Kg	KN			mm	mm	mm
1	Tile	0	0	0	0	0	0	0	243	0.01	0	2.43
2	Tile	1	20	6.94	138.8	138.8	1.36024	20	278	0.01	0.2	2.78
3	Tile	2	20	6.94	138.8	277.6	2.72048	38	300	0.01	0.38	3
4	Tile	3	20	6.94	138.8	416.4	4.08072	54	317	0.01	0.54	3.17
5	Tile	4	20	6.94	138.8	555.2	5.44096	66	331	0.01	0.66	3.31
6	Tile	5	20	6.94	138.8	694	6.8012	78	346	0.01	0.78	3.46
7	Tile	6	20	6.94	138.8	832.8	8.16144	91	357	0.01	0.91	3.57
8	Tile	7	20	6.94	138.8	971.6	9.52168	102	368	0.01	1.02	3.68
9	Tile	8	20	6.94	138.8	1110.4	10.88192	116	376	0.01	1.16	3.76
10	Tile	9	20	6.94	138.8	1249.2	12.24216	129	382	0.01	1.29	3.82
11	Tile	10	20	6.94	138.8	1388	13.6024	141	390	0.01	1.41	3.9
12	Tile	11	20	6.94	138.8	1526.8	14.96264	264	398	0.01	2.64	3.98
13	Tile	12	20	6.94	138.8	1665.6	16.32288	298	405	0.01	2.98	4.05
14	Tile	13	20	6.94	138.8	1804.4	17.68312	316	410	0.01	3.16	4.1
15	Tile	14	20	6.94	138.8	1943.2	19.04336	335	414	0.01	3.35	4.14
16	Tile	15	20	6.94	138.8	2082	20.4036	352	420	0.01	3.52	4.2
17	Tile	16	20	6.94	138.8	2220.8	21.76384	367	424	0.01	3.67	4.24
18	Tile	17	20	6.94	138.8	2359.6	23.12408	382	429	0.01	3.82	4.29
19	Tile	18	20	6.94	138.8	2498.4	24.48432	396	432	0.01	3.96	4.32
20	Beam	19	8		165.55	2663.95	26.10671	414	432	0.01	4.14	4.32



Load Deflection Curve During Loading and Unloading

B. Activity : Testing of BRC slab -2

1) ISMB 100 frame of dimension 1 m × 1 m was fabricated for testing of slabs.

2) Red oxide paint is applied to the frame to prevent rusting.

3) The frame of 70 cm high, so that cracks can be observed from below. Also dial gauge was easily placed below the slab.

4) Testing of 2nd slab was scheduled on 27th may 2017. The slab of bamboo reinforcement at 175 mm c/c was tested. Uniformly distributed Load was applied with the help of paving tiles. Each loading interval was of 20 tiles having load of 138.8 kg. Deflection at center was measured with a magnetic dial gauge. Total load of 26.106 KN/m^2 was applied. Only two , three minor cracks of 0.3 mm width were noticed.

5) The total deflection at center was 4.32 mm at 26.106 KN/m^2 load.

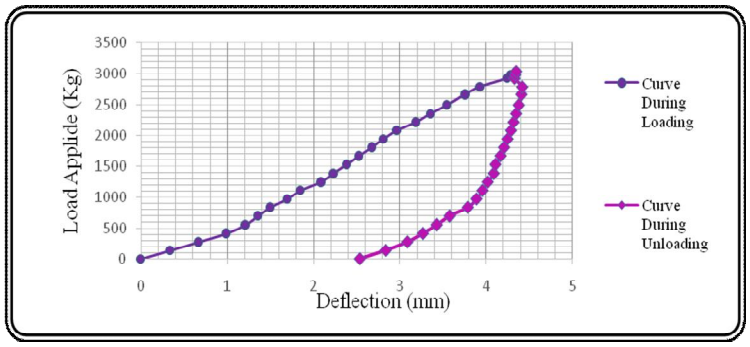
6) Unloading was done at same interval of 138.8 kg.

7) Permanent set was recorded as 2.4 mm.

8) The observations were tabulated and a graph was plotted of deflection v/s load applied.

Observation Table 4.3 : Load Applied and Deflection Of Slab Panel 3 (175mmSpacing)

Sr No.	Type Of Layer	Layer No.	Total Units	Weight Of Each Unit	Total Weight	Cummulative Weight	Cummulative Load	Dialgauge Reading During Loading	Dialgauge Reading During Unloadig	Least Count	Deflection During Loading	Deflection During Unloading
				Kg	Kg	Kg	KN			mm	mm	mm
1	Tile	0	0	0	0	0	0	0	254	0.01	0	2.54
2	Tile	1	20	6.94	138.8	138.8	1.36024	34	284	0.01	0.34	2.84
3	Tile	2	20	6.94	138.8	277.6	2.72048	67	309	0.01	0.67	3.09
4	Tile	3	20	6.94	138.8	416.4	4.08072	99	327	0.01	0.99	3.27
5	Tile	4	20	6.94	138.8	555.2	5.44096	121	343	0.01	1.21	3.43
6	Tile	5	20	6.94	138.8	694	6.8012	136	358	0.01	1.36	3.58
7	Tile	6	20	6.94	138.8	832.8	8.16144	150	379	0.01	1.5	3.79
8	Tile	7	20	6.94	138.8	971.6	9.52168	170	389	0.01	1.7	3.89
9	Tile	8	20	6.94	138.8	1110.4	10.88192	185	396	0.01	1.85	3.96
10	Tile	9	20	6.94	138.8	1249.2	12.24216	209	402	0.01	2.09	4.02
11	Tile	10	20	6.94	138.8	1388	13.6024	223	409	0.01	2.23	4.09
12	Tile	11	20	6.94	138.8	1526.8	14.96264	239	411	0.01	2.39	4.11
13	Tile	12	20	6.94	138.8	1665.6	16.32288	253	417	0.01	2.53	4.17
14	Tile	13	20	6.94	138.8	1804.4	17.68312	268	421	0.01	2.68	4.21
15	Tile	14	20	6.94	138.8	1943.2	19.04336	281	425	0.01	2.81	4.25
16	Tile	15	20	6.94	138.8	2082	20.4036	297	429	0.01	2.97	4.29
17	Tile	16	20	6.94	138.8	2220.8	21.76384	319	432	0.01	3.19	4.32
18	Tile	17	20	6.94	138.8	2359.6	23.12408	336	435	0.01	3.36	4.35
19	Tile	18	20	6.94	138.8	2498.4	24.48432	355	438	0.01	3.55	4.38
20	Beam	19	8		165.55	2663.95	26.10671	376	441	0.01	3.76	4.41
21	Iron	20			121.07	2785.015	27.293147	393	442	0.01	3.93	4.42
22	Cube	21			141	2926.015	28.674947	425	433	0.01	4.25	4.33
23	Deepa	22			60	2986.015	29.262947	429	434	0.01	4.29	4.34
24	Piyush	23			54	3040.015	29.792147	435	435	0.01	4.35	4.35



Load Deflection Curve During Loading and Unloading

C. Activity : Testing of BRC slab -3

1) ISMB 100 frame of dimension 1 m × 1 m was fabricated for testing of slabs.

2) Red oxide paint is applied to the frame to prevent rusting.

3) The frame of 70 cm high, so that cracks can be observed from below. Also dial gauge was easily placed below the slab.

4) Testing of 3rd slab was scheduled on 27th may 2017. The slab of bamboo reinforcement at 175 mm c/c was tested. Uniformly distributed Load was applied with the help of paving tiles. Each loading interval was of 20 tiles having load of 138.8 kg. Deflection at center was measured with a magnetic dial gauge. Total load of 29.79 KN/m^2 was applied. Only two , three minor cracks of 0.3 mm width were noticed.

5) The total deflection at center was 4.35 mm at 25.48 KN/m^2 load.

6) Unloading was done at same interval of 138.8 kg.

7) Permanent set was recorded as 2.5 mm.

8) The observations were tabulated and a graph was plotted of deflection v/s load applied.

V. CONCLUSIONS

The compression test is made on bamboo reinforced slabs by applying a gradually uniformly distributed load. The values of load and deflection withstanding capacity are founded and shown in figure.

A. The first crack appeared at a load of 15.00 KN/m^2.

B. The stress strain relationship is linear up to certain limit.

C. Average deflection of slab panel is 2.65mm at the time of first crack developed.

D. it is beneficial for light weight and temporary building.

E. environmental and financial comparison demonstrates that bamboo can compete as Building material

F. Bamboo solution is highly sustainable and cost effective and beautiful construction material for home

G. Bamboo construction require good preparation and accurate calculation.

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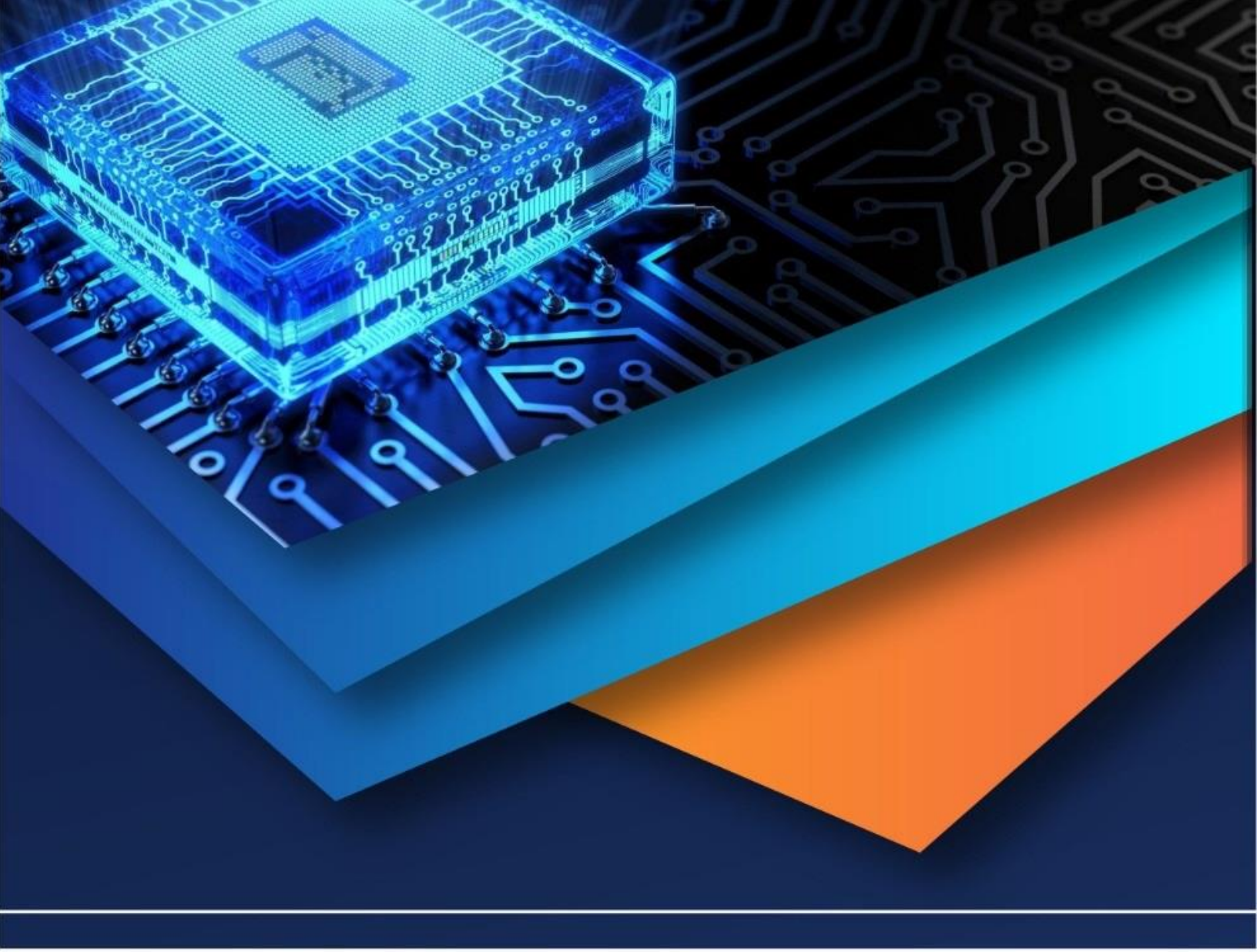
[4] Prof. Dirk E. Hebel1, Felix Heisel and Alireza Javadian, “Engineering Bamboo The new composite reinforcement” Chair of Architecture and Construction Future Cities Laboratory, Singapore ETH Canter Singapore.



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