BAMBOO STRUCURES : A PERSPECIVE FOR CLIMATE CHANGE MITIGATION

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WONDER GRASS

After 10 - 12 weeks

Food, Fodder and Medicines

After 10 - 12 months

High Tensile Ropes And Soft Interior for Bio Fuel

After 2 - 3 years

slivers for weaving – mats, baskets etc.

India has the largest area under bamboo cultivation in the world

After 3 - 5 years

structural applications Housing, Vehicle frames, Furniture

After 6 - 7 years

dried & brittle culms for fuel and charcoal

Every ton of steel produces 3 ton of CO_2

Every Ton of Bamboo consumes 1 ton of CO_2

Even a 20% Optimistic replacement of Steel with Bamboo in any type of application will lead to

- Decrease in demand of energy intensive Steel
- Provide a source of employment in a self sustainable manner
- Reduce Global Warming

Bamboo is one of the hardiest plant and it can yield 20 times more timber than other trees in the same area.

While a 60-foot tree cut for market takes about 30-60 years to replace, a 60-foot bamboo takes 50-60 days to replace

Bamboo replaces 30 per cent of its biomass in one year, while a tree forest can only replace 3 to 5 per cent.

Bamboo helps mitigate water pollution due to its high nitrogen consumption, making it a solution for excess nutrient uptake of wastewater from manufacturing, livestock farming and sewage treatment

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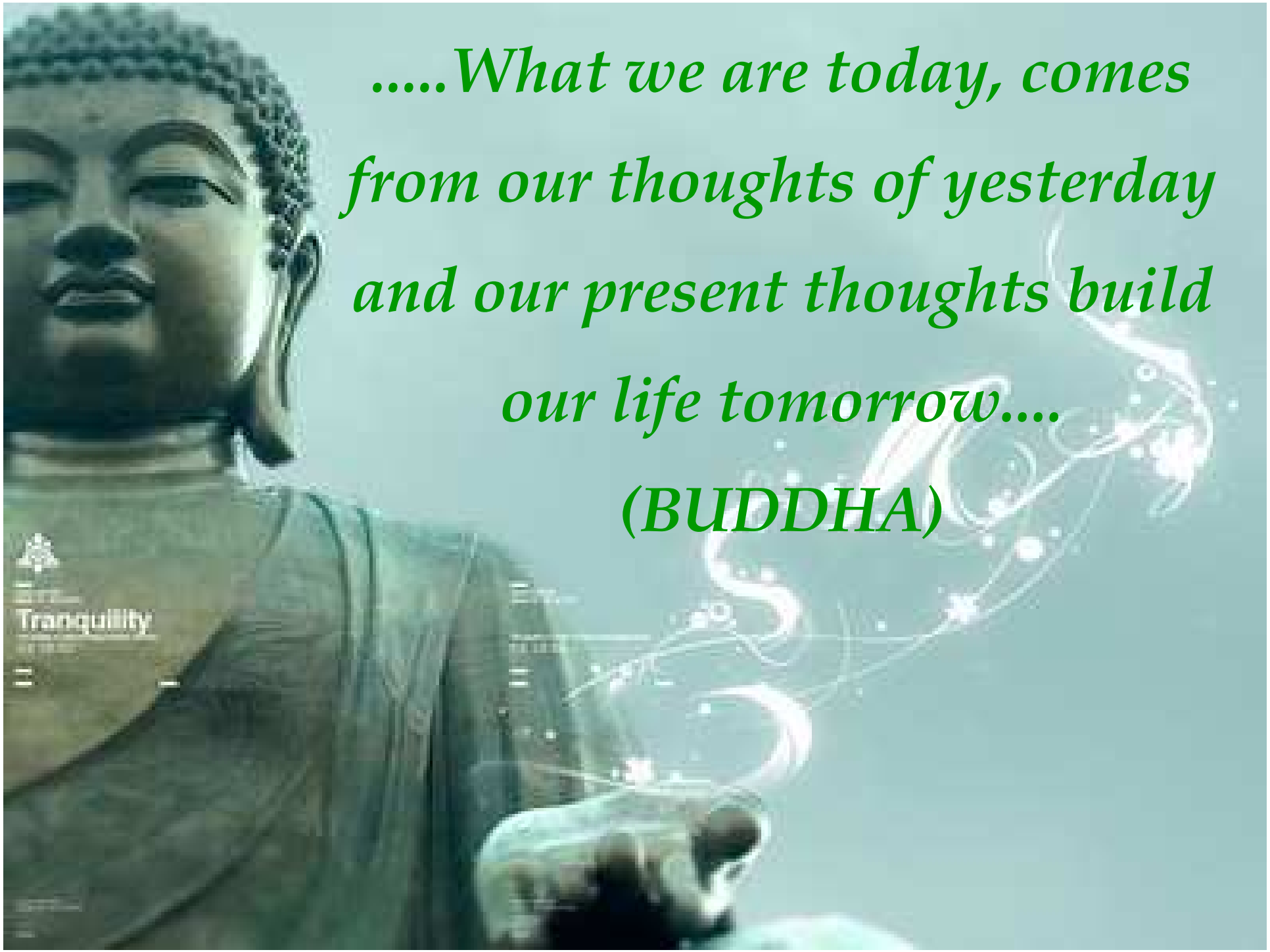
Unlike most tropical hardwood species, which take at least 30 years to mature, bamboo shoots and culms (stems) can be harvested at about three to four years after planting

Ecological Performance

Material	Energy (GJ/m^3)	Stiffness (Gpa)	Strength (Mpa)	Energy/ Stiffness (J/Nm)	Energy/ Strength (kJ/Nm)
Aluminium (Extrusions)	800	70	300	11.4	2.67
Steel (Grade 43 sections)	500	210	275	2.4	1.82
GRP (UD Glass/Polyester)	250	40	300	6.3	0.83
CFRP (UD carbon/Epoxy)	500	125	900	4.0	0.56
Wood (Finnish Birch)	3.8	16	80	0.24	0.048
Bamboo	3.8	25	120	0.15	0.032



.....What we are today, comes from our thoughts of yesterday and our present thoughts build our life tomorrow....

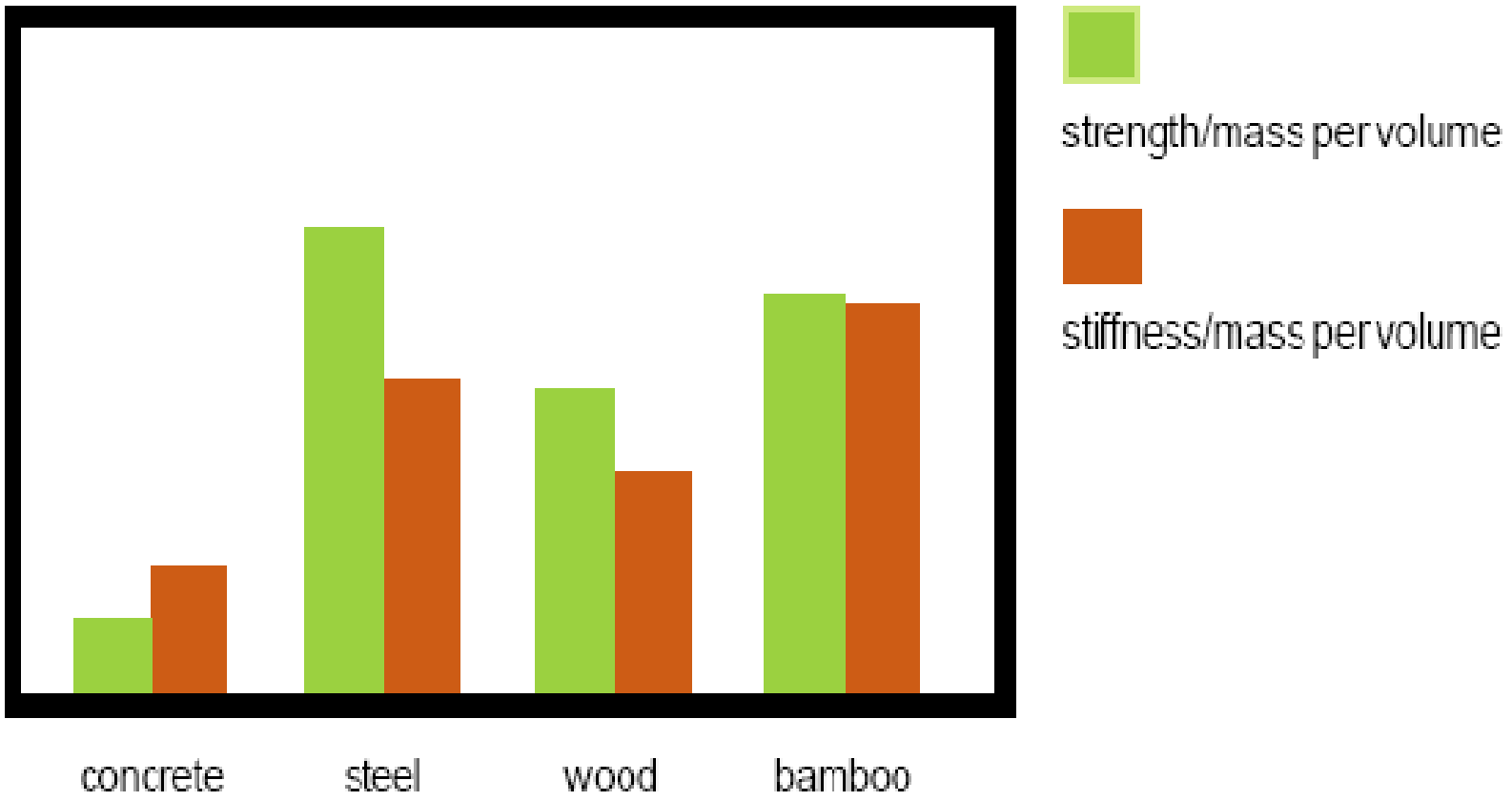
(BUDDHA)

Bamboo

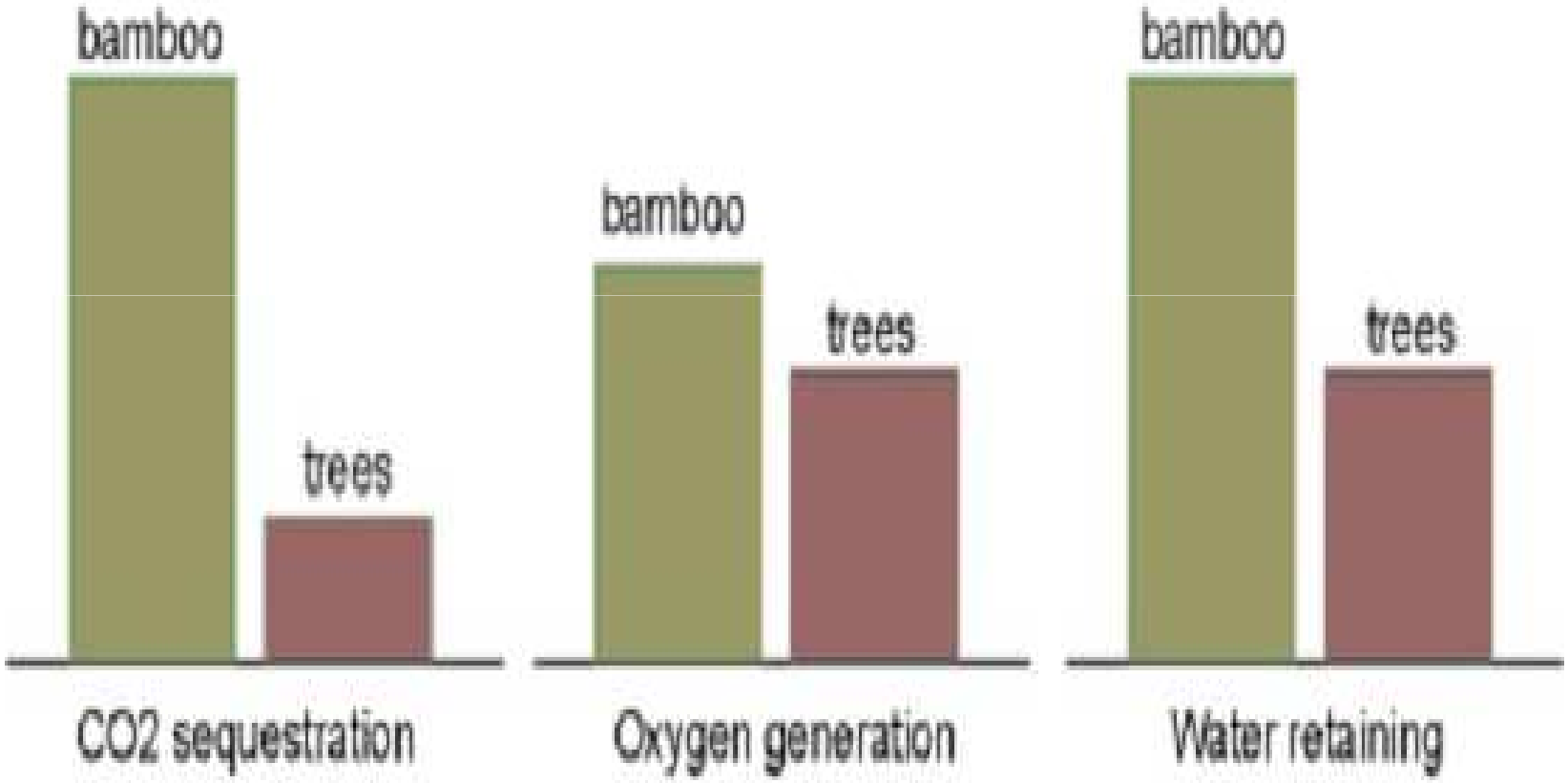
Diameters Ranging from 20 mm to 300 mm

115 species in India and 1200 species world over

Why bamboo


strength/mass per volume
stiffness/mass per volume
concrete
steel
wood
bamboo

Why bamboo


bamboo
trees
CO2 sequestration
bamboo
trees
Oxygen generation
bamboo
trees
Water retaining

Why bamboo

TIMBER:

- **Traditional methods for Timber Houses of 3-5m span**

  require trees of over 30 years old

- **Most Farmers Need Returns in 4 - 6 years**

THE CHALLENGE:

- **How to utilize it for sustainable infrastructure applications..?**

Wood from plantations: Fetches far better return as Timber

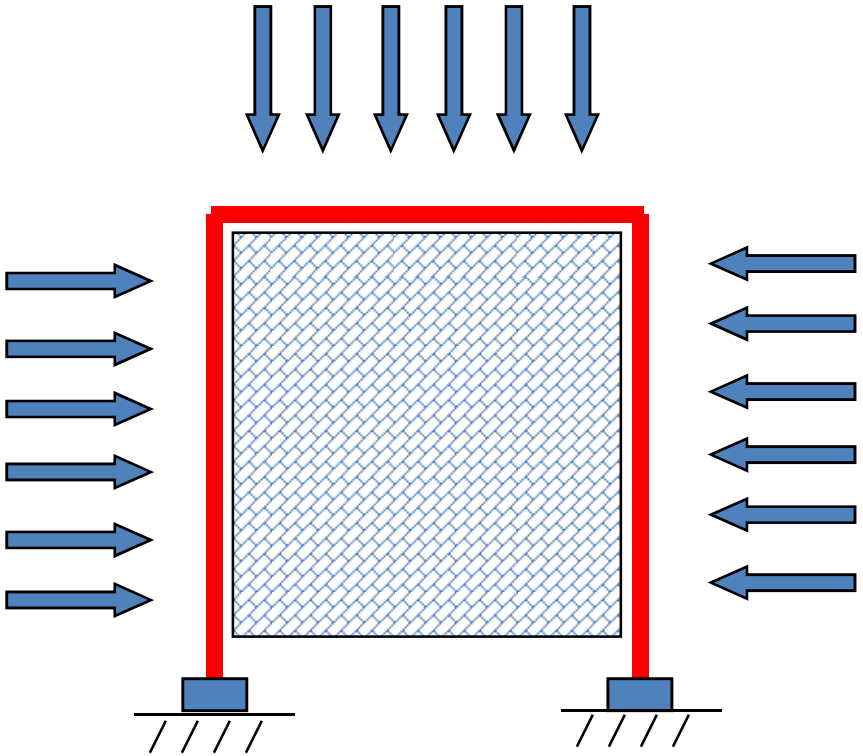
- Timber in housing — 10

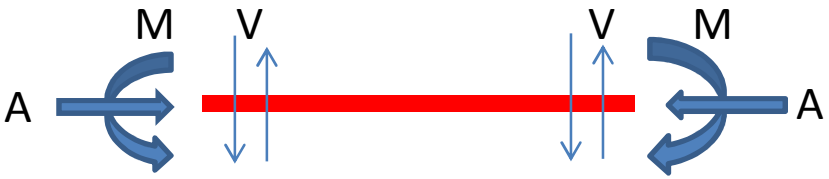
- Fiber pulp and Chips

& saw dust for particle board — 2-3

- As fuel — 1-2

What is a structural main load bearing element (SMLBE) ?

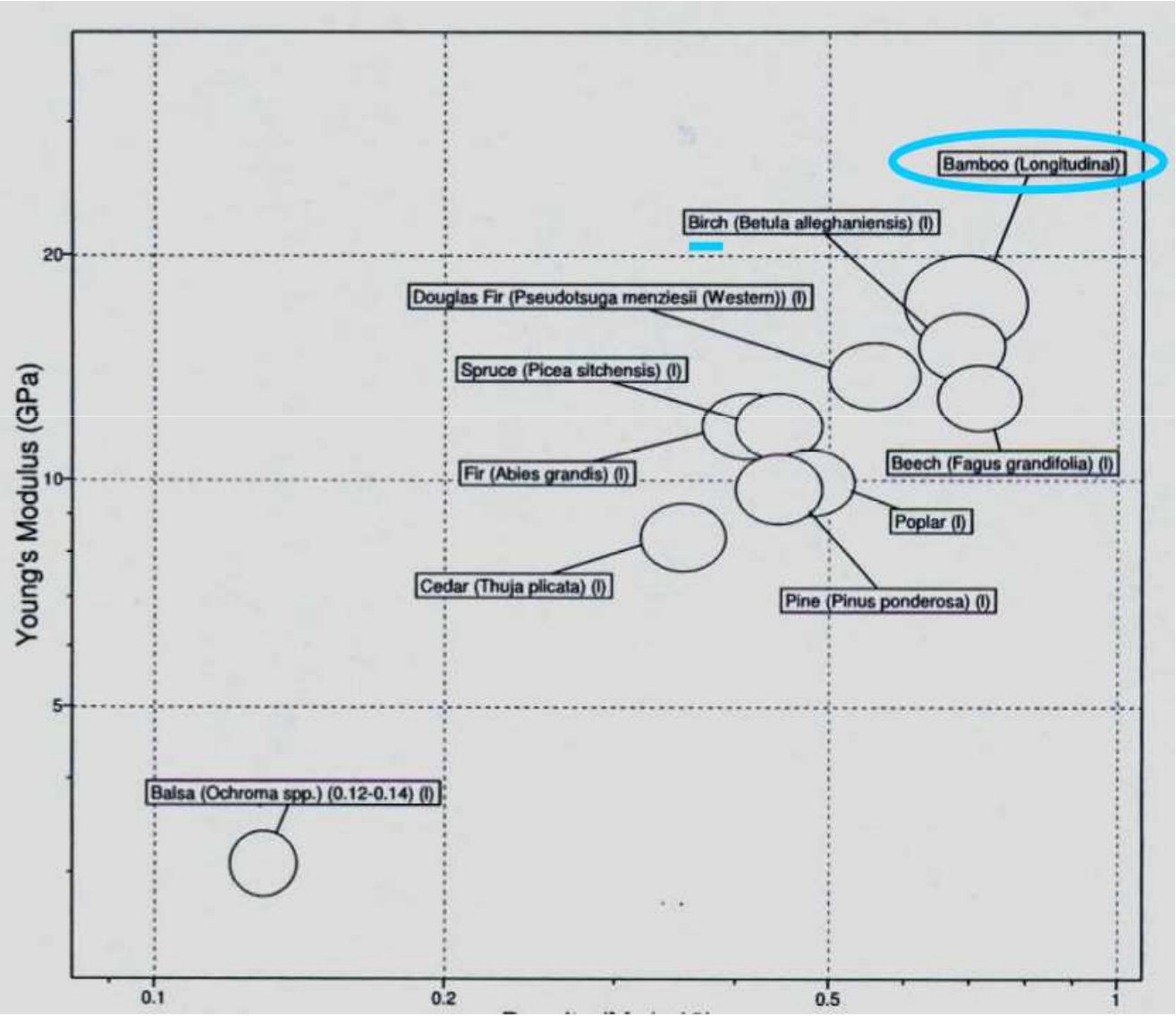




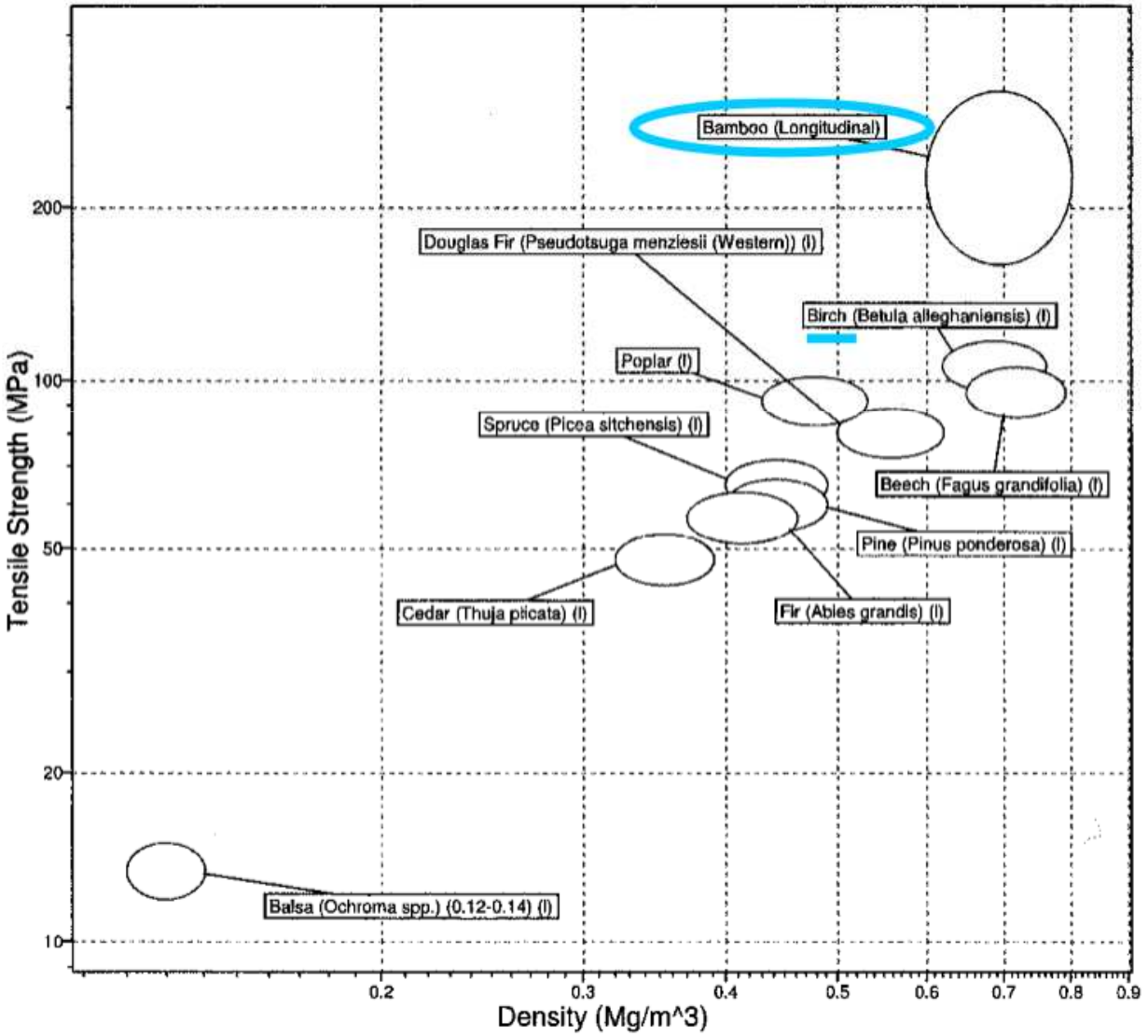
Why bamboo as SMLBE ?

Bamboo and Wood with same cross sectional Area

Bamboo & other Wood



Bamboo & Other Wood



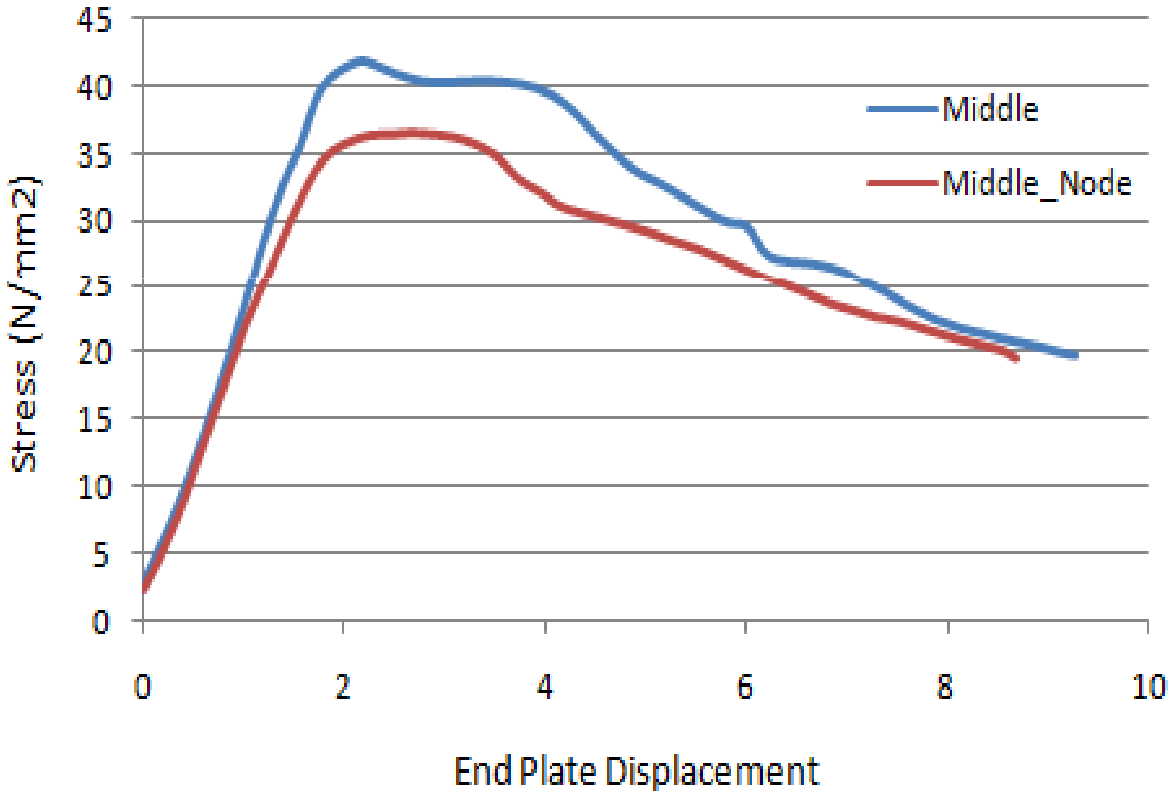
Material properties of *Dendrocalamus strictus* Bamboo

- Allowable compressive stress = 10 MPa (NBC – 2005)
- Modulus of Elasticity = 15000 MPa (NBC – 2005)
- Tensile stress = 150 MPa

Dendrocalamus strictus

45 % of Indian Bamboo

Material Testing

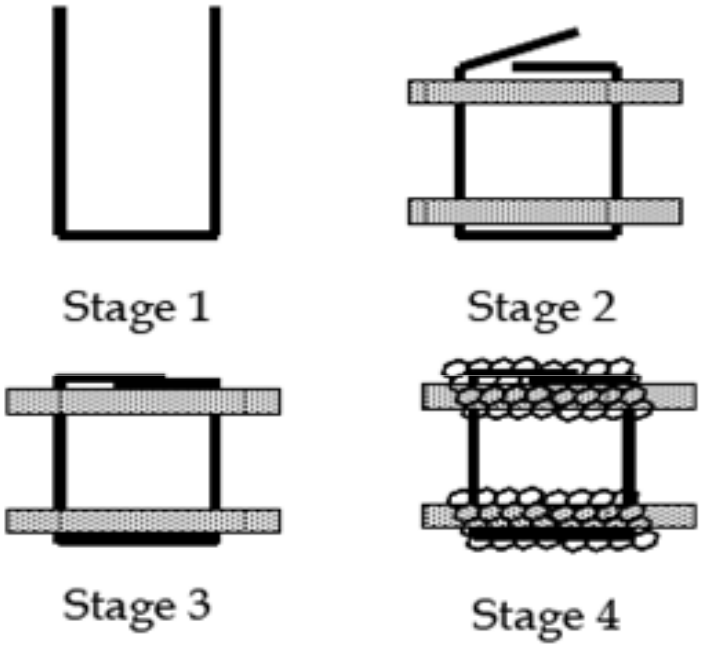


L/d = 2

Where is the Engineering challenge ?

1. Development of a joinery to integrate more than two bamboos together
2. Establish reproducibility of technology

Developed Technology



HARITHA IITD BAMCRETE (HIB) TECHNOLOGY

Dendrocalamus strictus

45 % of Indian Bamboo

Scientific Evaluation

(a)

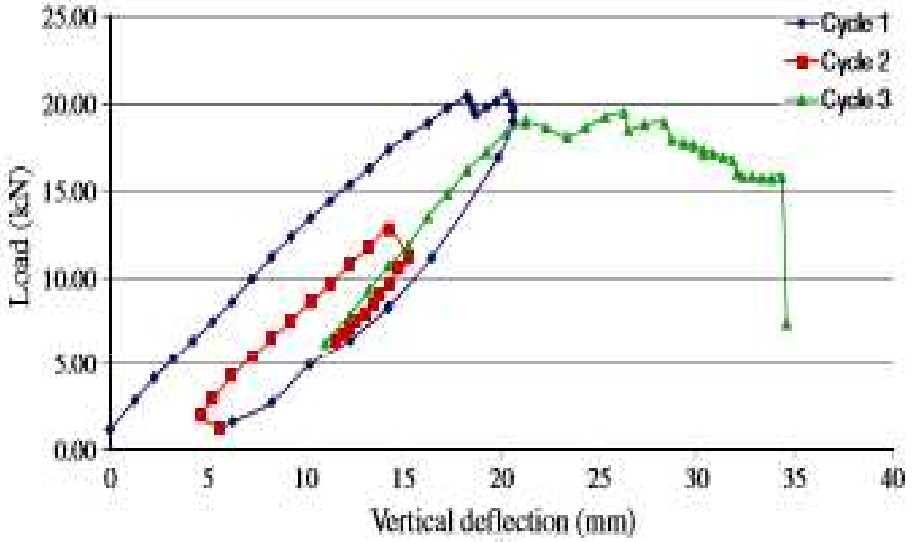
(b)

(c)

45 % of Indian Bamboo

Ultimate Load Test

(a)



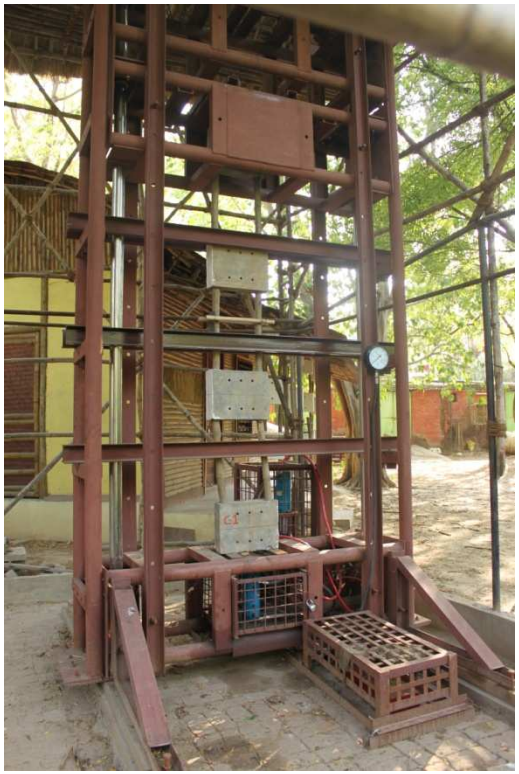
(b)

MAXIMUM LOAD = 2000 kg; Span 4.5 m

Korde C., West R., Gupta A. & Sudhakar P., "Laterally restrained dual bamboo concrete composite arch under uniformly distributed loading", in Special Issue of Sustainable Building Structures, **Journal of Structural Engineering**, ASCE, 2015.

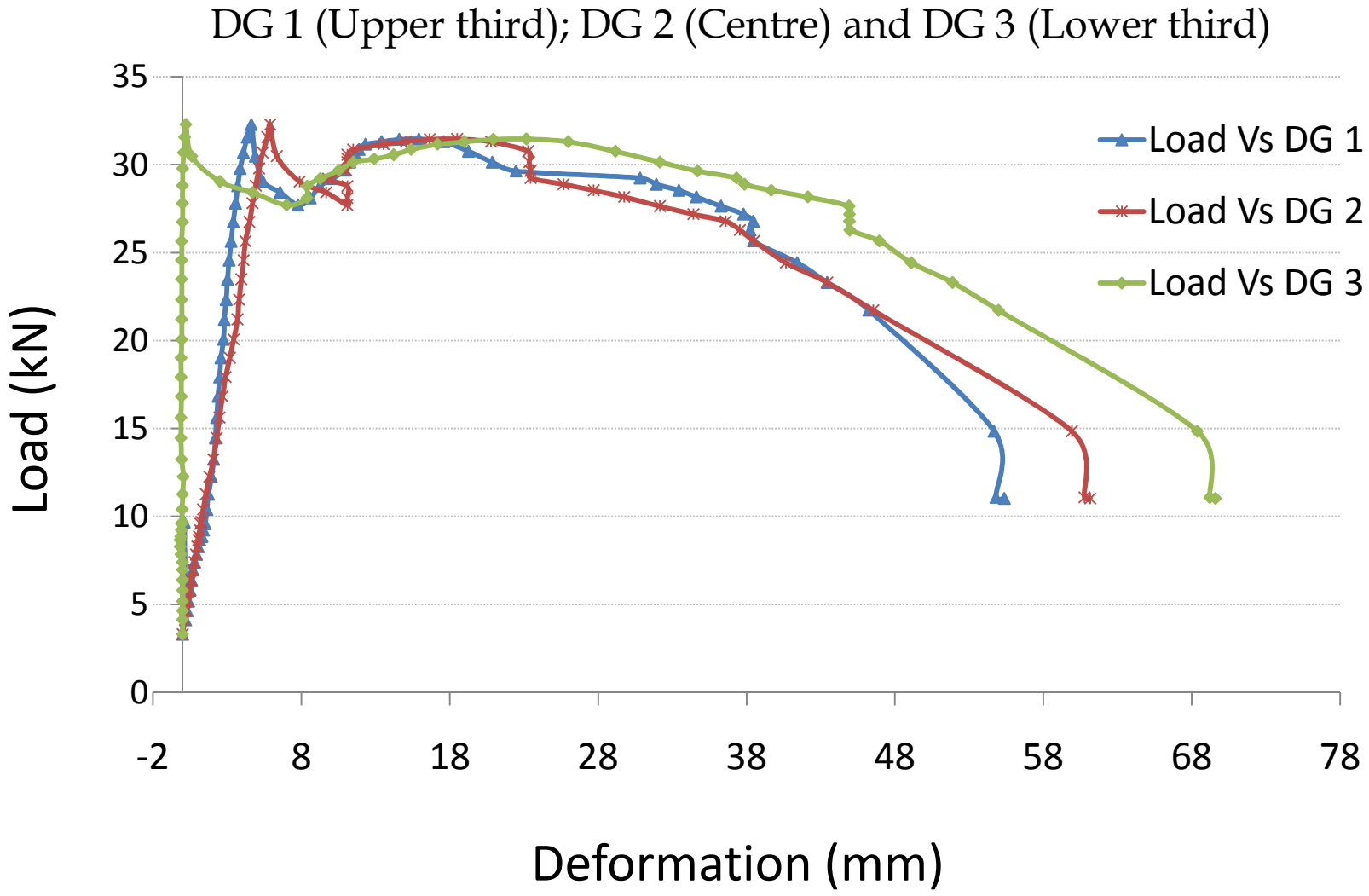
FAILURE PATTERNS – FRESH ARCHES

Laterally Restrained Testing

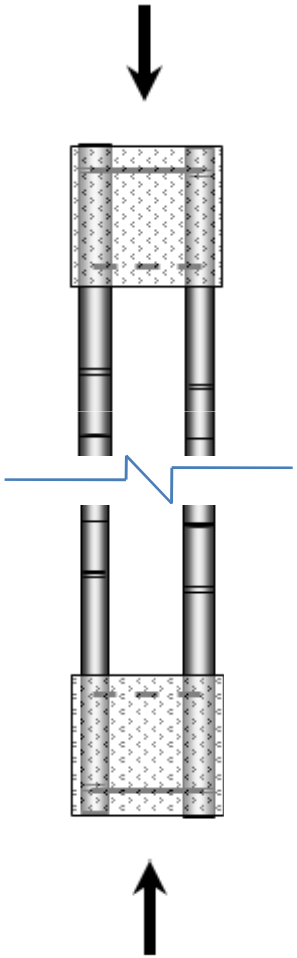


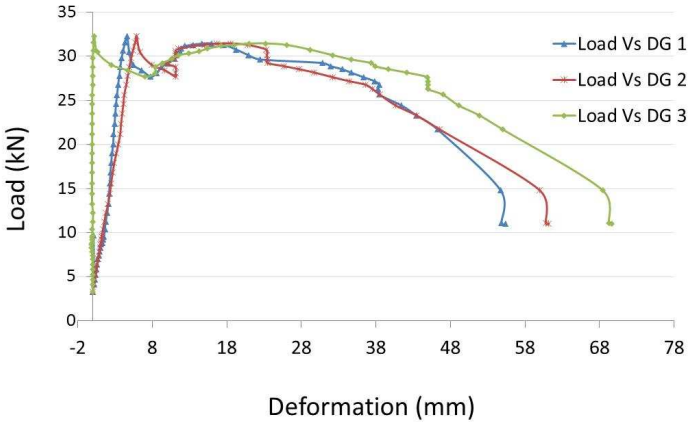
Column Test Equipment Developed for Testing

Bamcrete Column under Laterally Restrained Pure Axial Loading



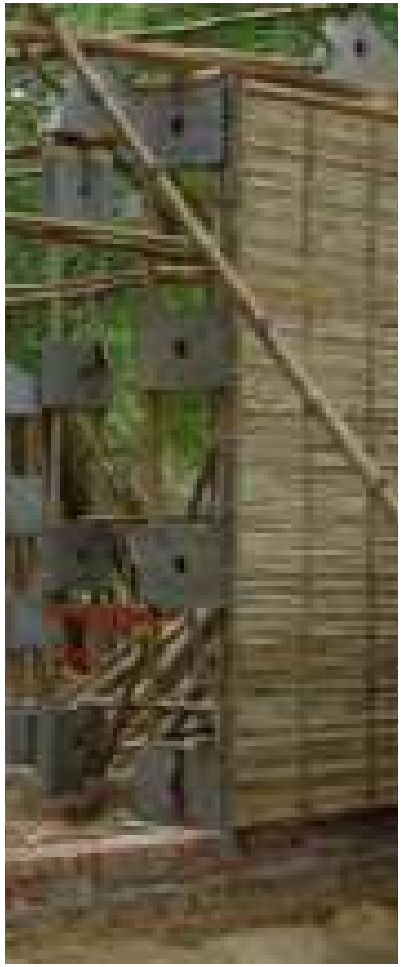
Failure Pattern





Failure of Concrete Band at 33 kN Load

Experimental House at IIT Delhi



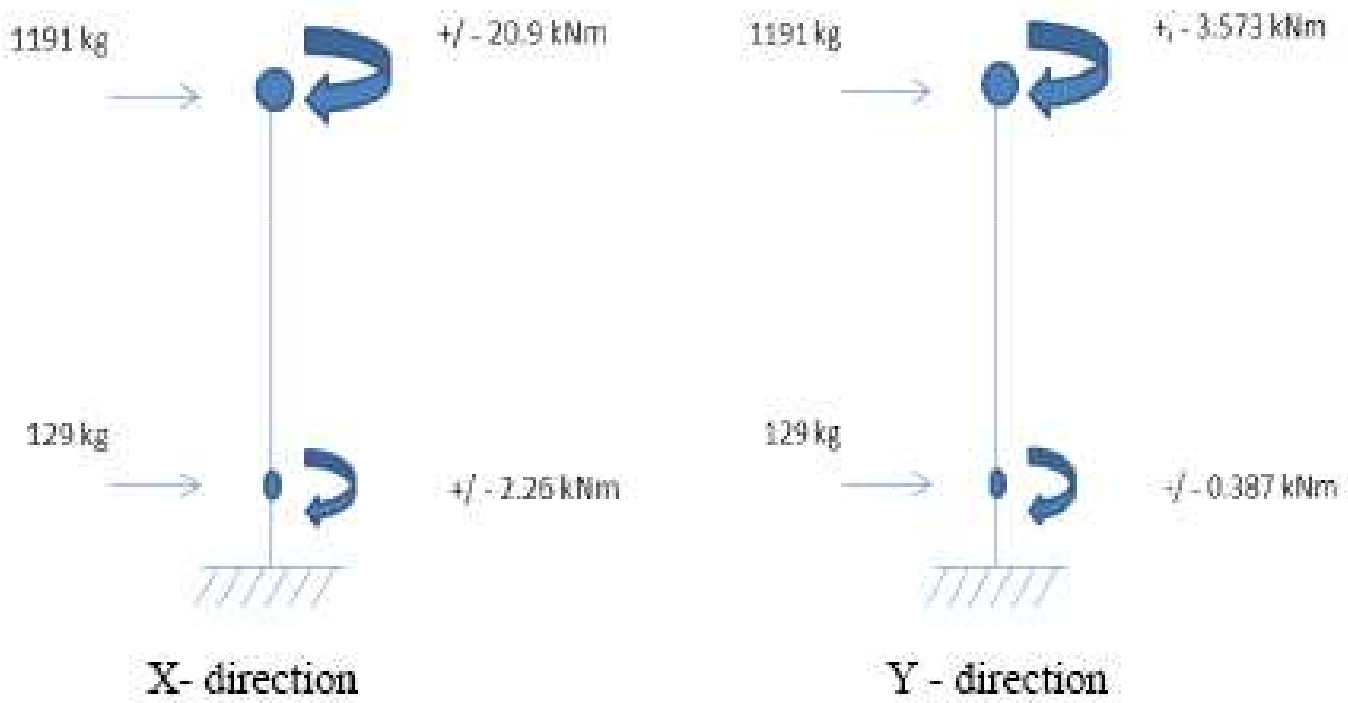
Experimental House at IIT Delhi

Experimental House at IIT Delhi

Experimental House at IIT Delhi

EARTHQUAKE ANALYSIS

A detail structural analysis is carried out to determine the forces and stiffness of the structure



EARTHQUAKE ANALYSIS

Sr. No.	Load Combination	2nd Storey deformation (mm)
1.	Dead Load	5.256
2.	Live Load	0.044
3.	EX Torsion Positive	0
4.	EX Torsion Negative	0
5.	EZ Torsion Positive	0
6.	EZ Torsion Negative	0
7.	1.5 (D.L. + L.L.)	7.95
8.	1.2 (D.L. + L.L. + EXTP)	6.36
9.	1.2 (D.L. + L.L. + EXTN)	6.36
10.	1.2 (D.L. + L.L. - EXTP)	6.36
11.	1.2 (D.L. + L.L. - EXTN)	6.36
12.	1.2 (D.L. + L.L. + EZTP)	6.36
13.	1.2 (D.L. + L.L. + EZTN)	6.36
14.	1.2 (D.L. + L.L. - EZTP)	6.36
15.	1.2 (D.L. + L.L. - EZTN)	6.36
16.	1.5 (D.L. + EXTP)	7.884
17.	1.5 (D.L. + EXTN)	7.884
18.	1.5 (D.L. - EXTP)	7.884
19.	1.5 (D.L. - EXTN)	7.884
20.	1.5 (D.L. + EZTP)	7.884
21.	1.5 (D.L. + EZTN)	7.884
22.	1.5 (D.L. - EZTP)	7.884
23.	1.5 (D.L. - EZTN)	7.884
24.	0.9 D.L. + 1.5 EXTP	4.73
25.	0.9 D.L. + 1.5 EXTN	4.73
26.	0.9 D.L. - 1.5 EXTP	4.73
27.	0.9 D.L. - 1.5 EXTN	4.73
28.	0.9 D.L. + 1.5 EZTP	4.73
29.	0.9 D.L. + 1.5 EZTN	4.73
30.	0.9 D.L. - 1.5 EZTP	4.73
31.	0.9 D.L. - 1.5 EZTN	4.73

MAXIMUM ALLOWABLE DEFORMATION = 0.004 h = 10.8 mm; hence safe

COST PROJECTON – R & D MODE

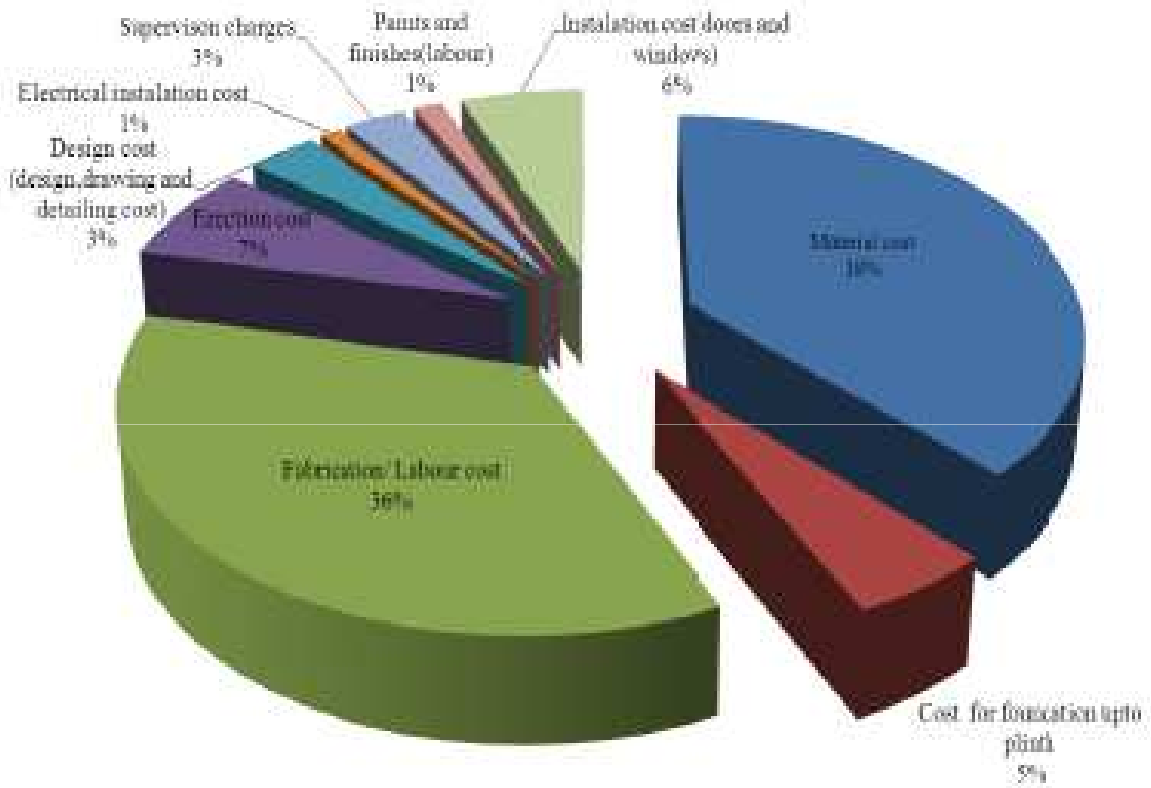


Fig.8.11Cost estimates for 45 sqm experimental demonstration structure under R & D mode;

Total Cost of Structure = Rs. 11.6 lakhs; Total Area of Construction = 45 m^2; Cost per Sq m. = 26000; Cost per Sqft = 2300

COST PROJECTON – 27 sq. m

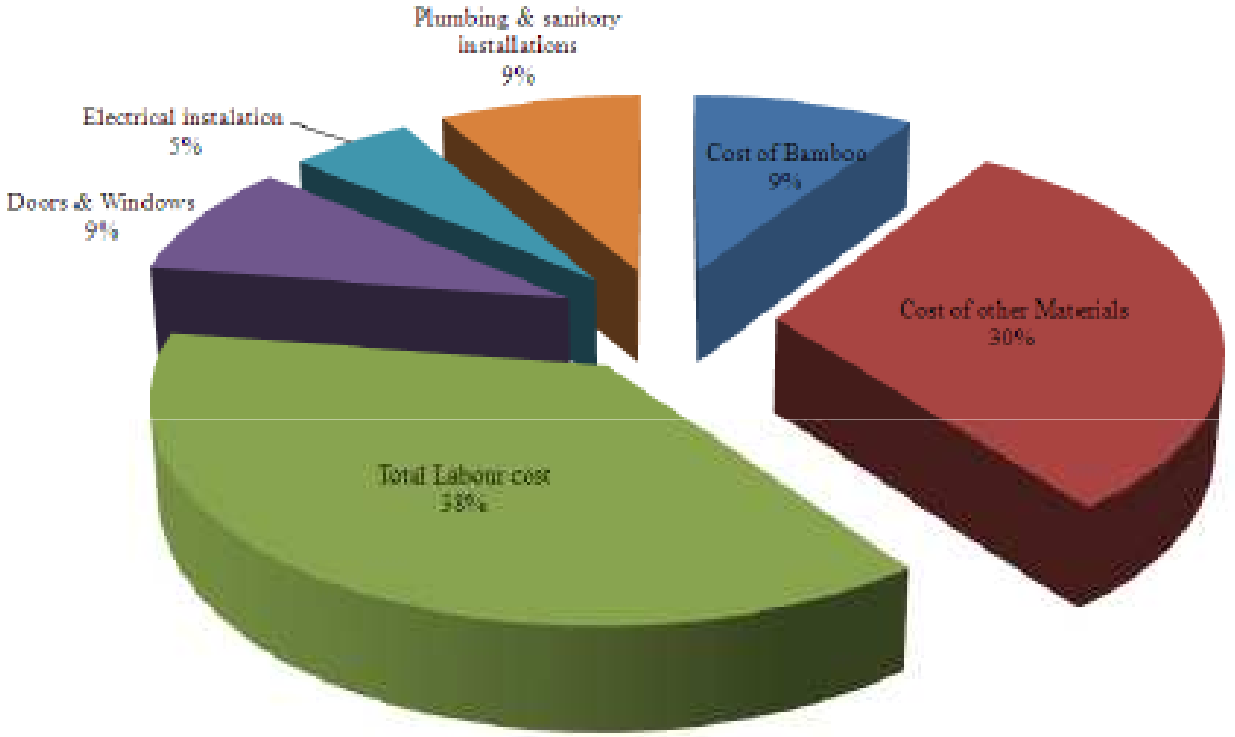
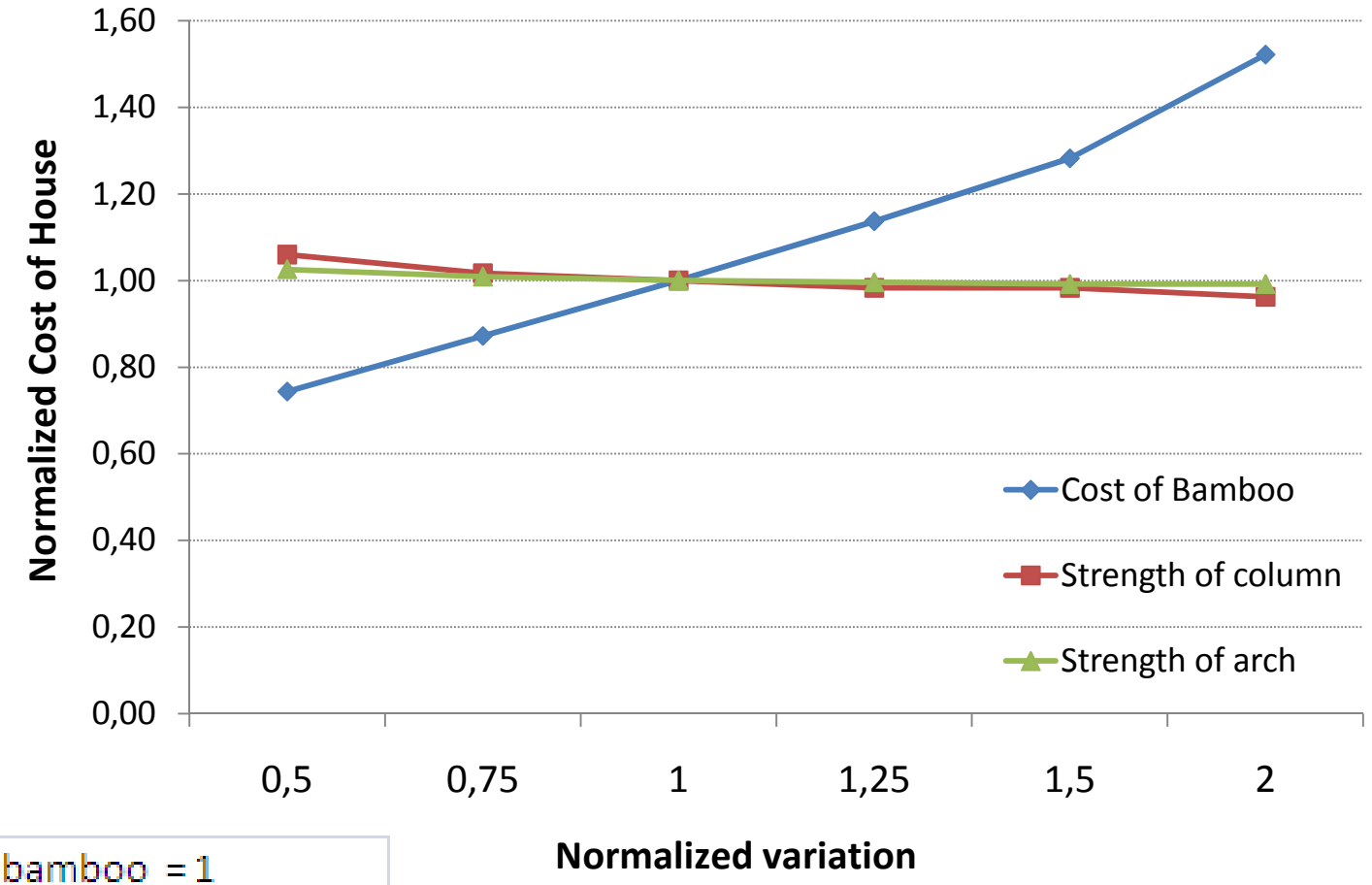


Fig. 8.12 Cost estimates for 27 sqm structure under replication mode; Total Cost of Structure = Rs. 1.17 lakhs; Total Area of Construction = 27 m^2; Cost per Sq m. = 4276; Cost per Sqft = Rs. 385 per sq. ft. & Estimated time = 10 days with a team of 18 artisans

COST – BENEFIT ANALYSIS: 27 sq. m house

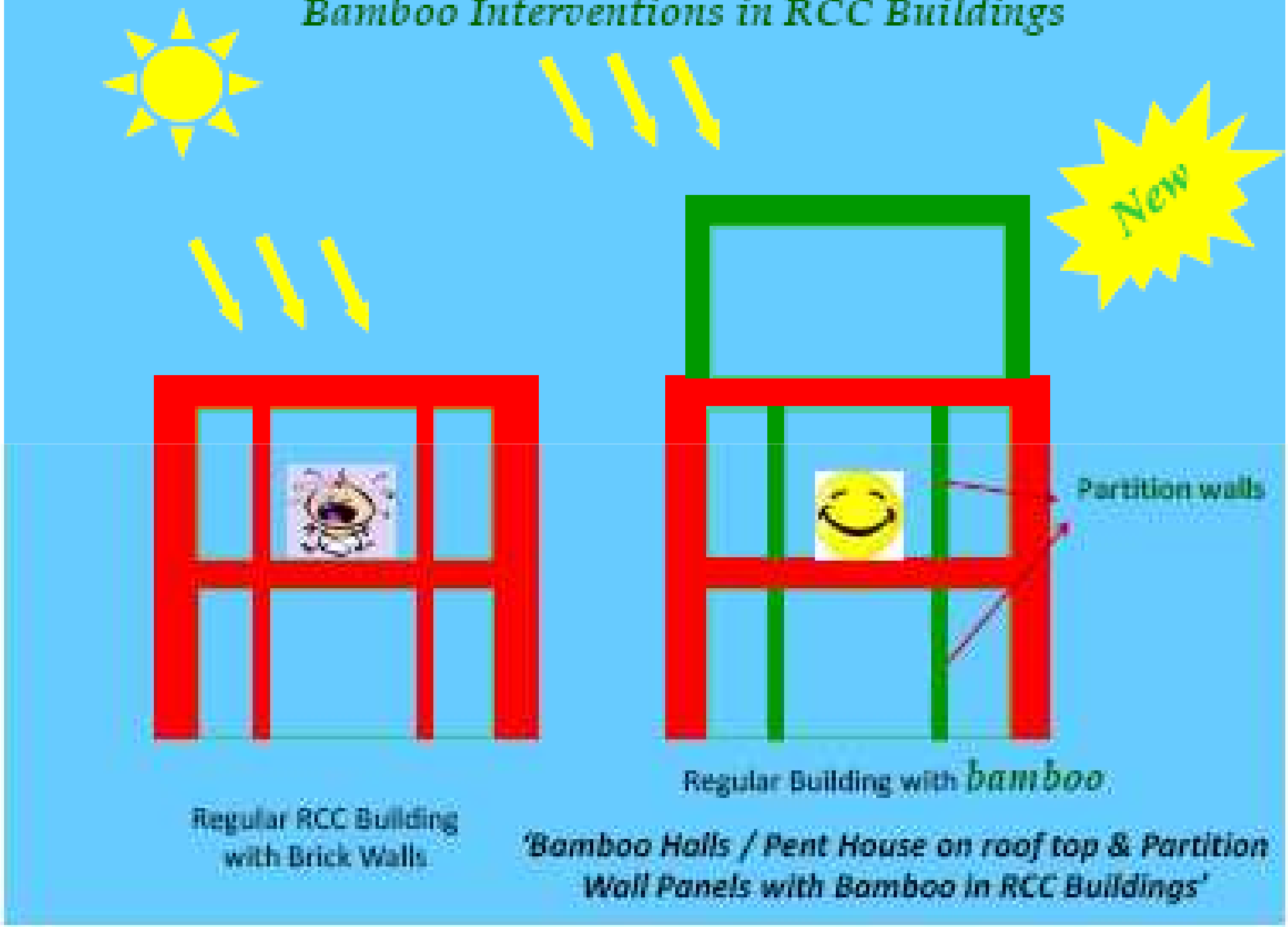
1.17 lacks (U.S. $ 2400)



Type of bamboo = 1	
Type A1; column	50
Type A2; arch	35
Type B; wall	30

Strength of column	1000 kg
Strength of arch	1000 kg

Bamboo Interventions in RCC Buildings



Experiments/ constructions at Haritha

Bamboo Pent House Studies

R& D in Bamboo: Buildings/ Infrastructure

CHOICE IS OURS

Sustainable Technology

Technology to *Just* sustain

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THANK YOU