Emerging Technologies in Housing Construction in India

Prof. A Meher Prasad

Department of Civil Engineering
IIT Madras, Chennai

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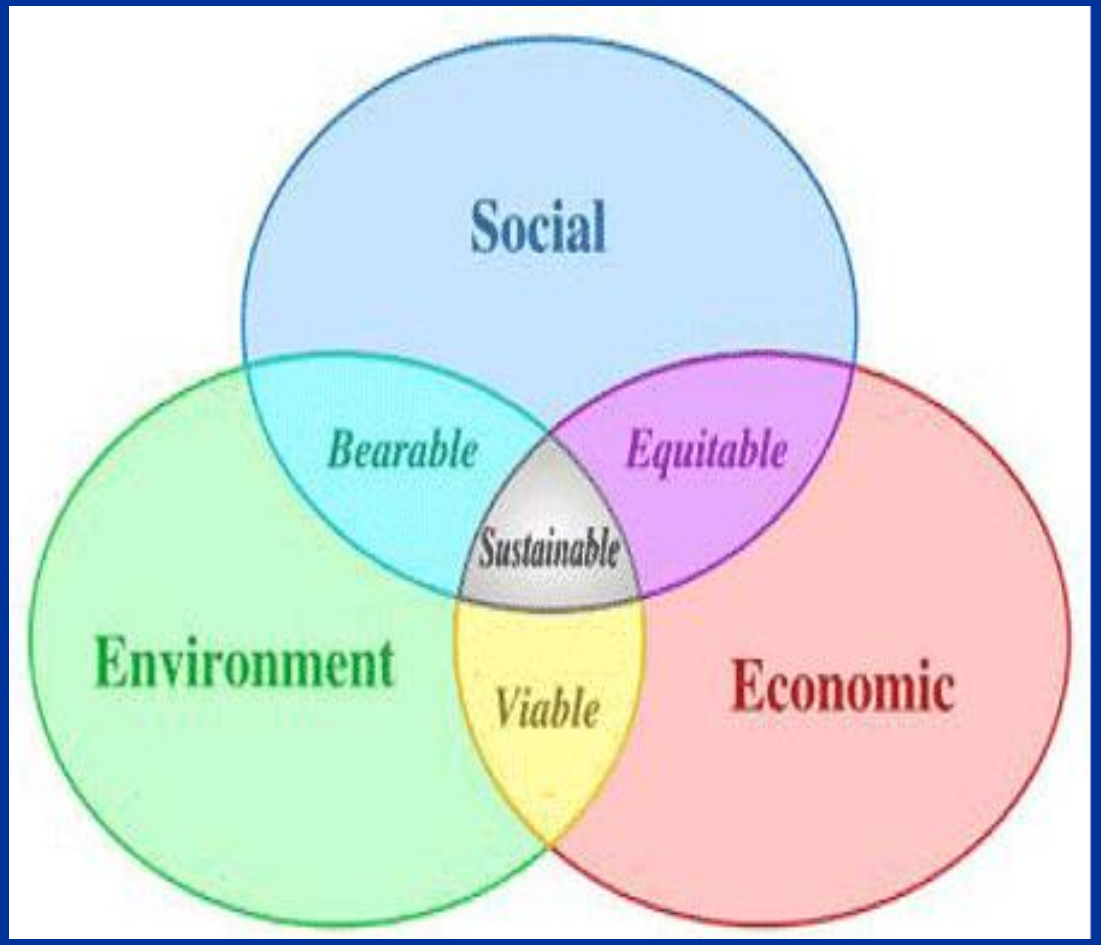
Sustainable Development & Habitat



Issues of Concern

- Affordability: cost-effective housing
- Sustainability: embodied energy, CO_2 emission, recycling
- Local availability / scarcity: of materials (river sand)
- Rapidity in construction: fast delivery
- Structural stability and strength: earthquake resistant
- Functionality: space utility, lighting, ventilation
- Aesthetics
- Constructability: quality, planning, skill
- Durability: life of structure with lesser maintenance costs
- Government policies, subsidies

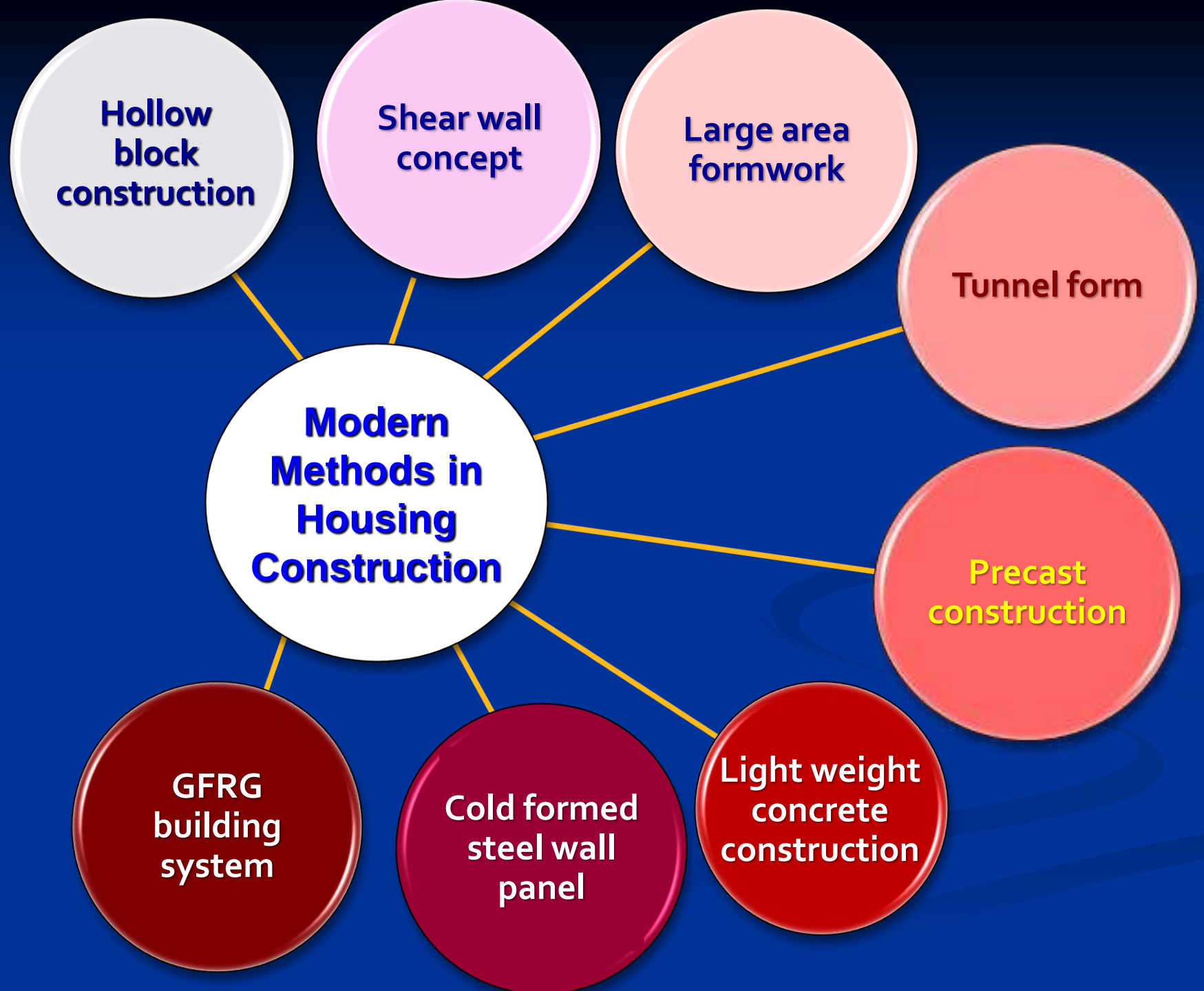
Basic Requirements of Building

- Strength and stability
- Utility
- Comfort and convenience
- Durability
- Economy
- Aesthetics
- Security
- Resistance to moisture ingress
- Fire protection
- Thermal insulation
- Day lighting and ventilation
- Sound insulation
- Termite protection

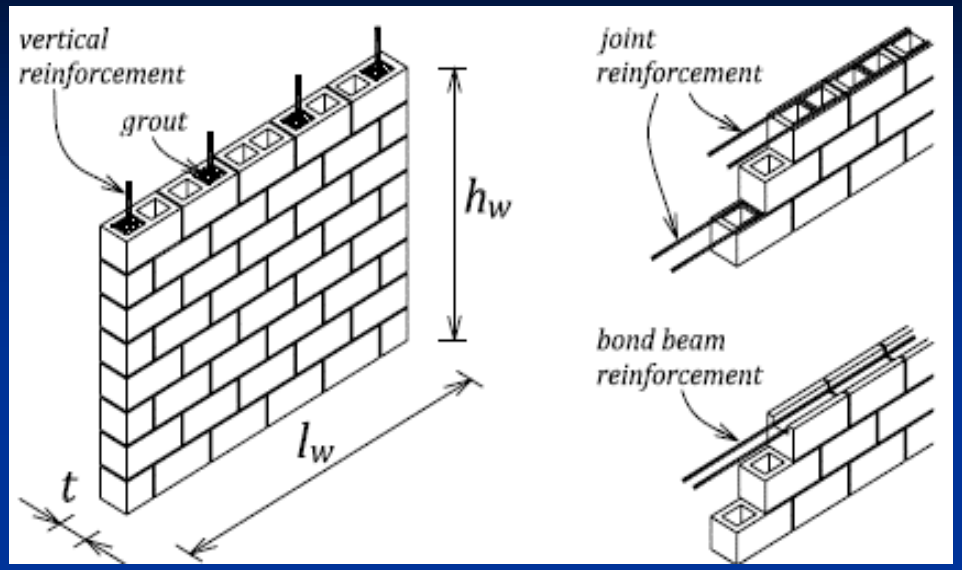
Sustainability

"Development that meets the needs of the present without compromising the ability of future generations to meet their own needs"

- Brundland Commission


Modern Methods in Housing Construction
Hollow block construction
Shear wall concept
Large area formwork
Tunnel form
Precast construction
Light weight concrete construction
Cold formed steel wall panel
GFRG building system

Modern Methods in Housing Construction



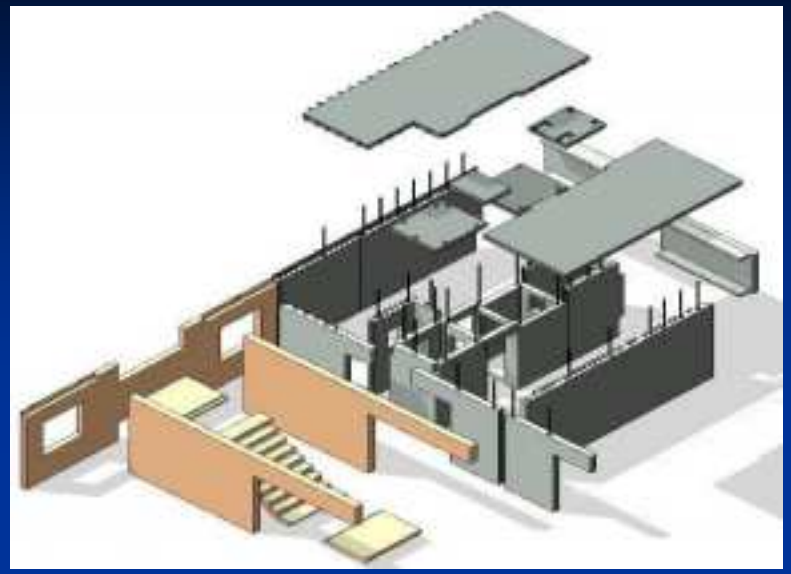
Hollow Block Construction

Shear Wall Building Construction

Large area formwork

Tunnel form

Modern Methods in Housing Construction



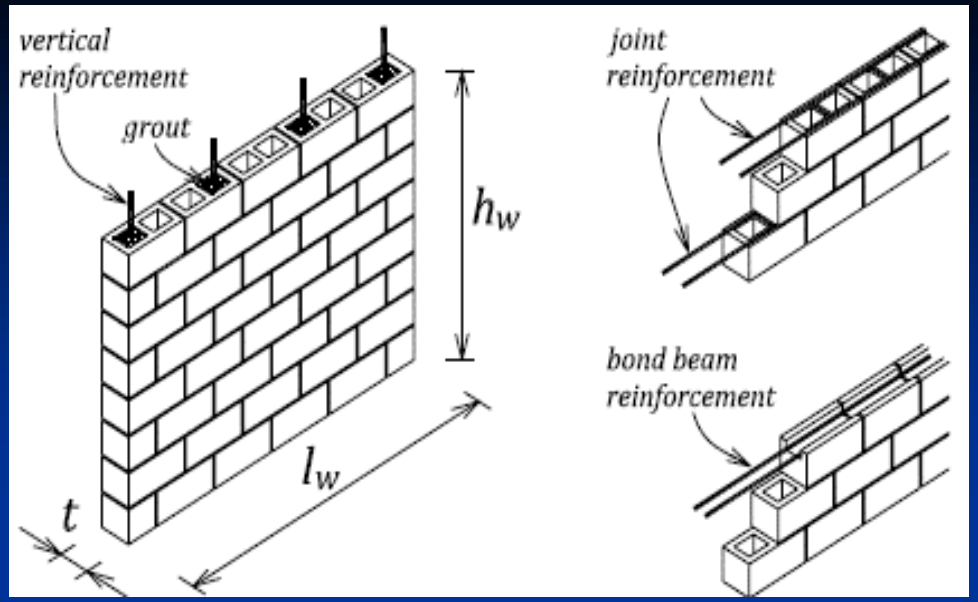
Precast Conrete Construction

Light-weight Conrete Building

Cold-formed Steel Construction

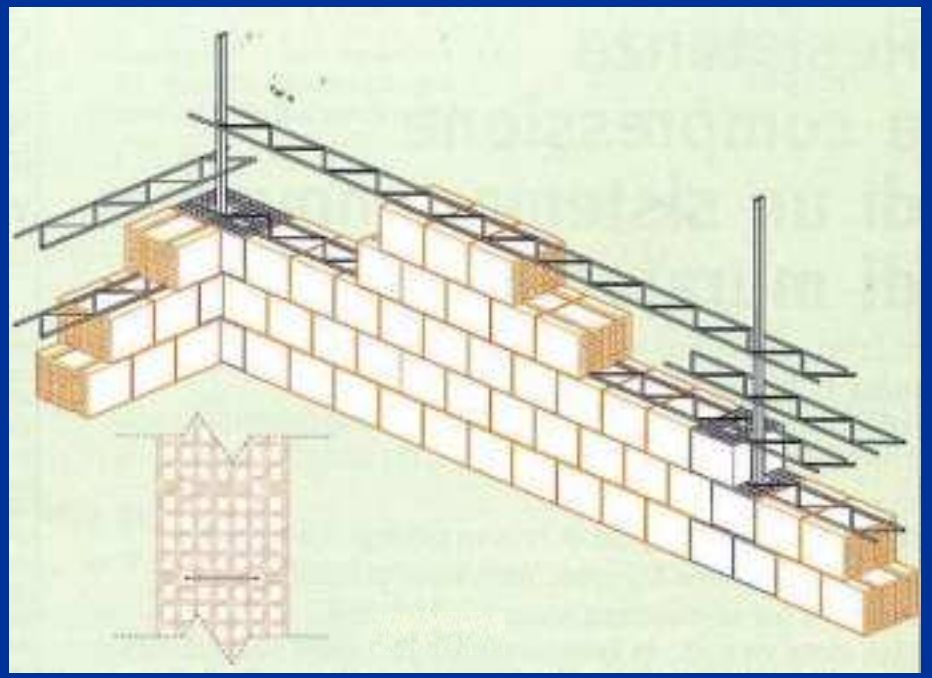
GFRG Building Construction

Hollow Block Construction



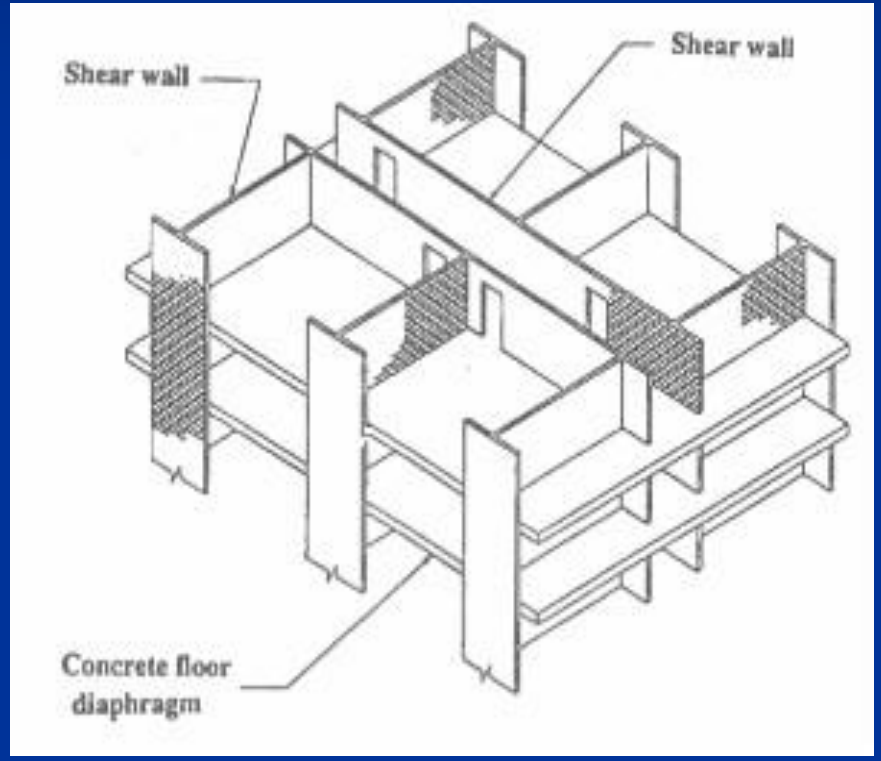
Horizontal bed joint, bond beam and vertical reinforcement in a hollow block masonry wall

URM structure - concrete blocks (16” × 8” × 6”) with cement mortar



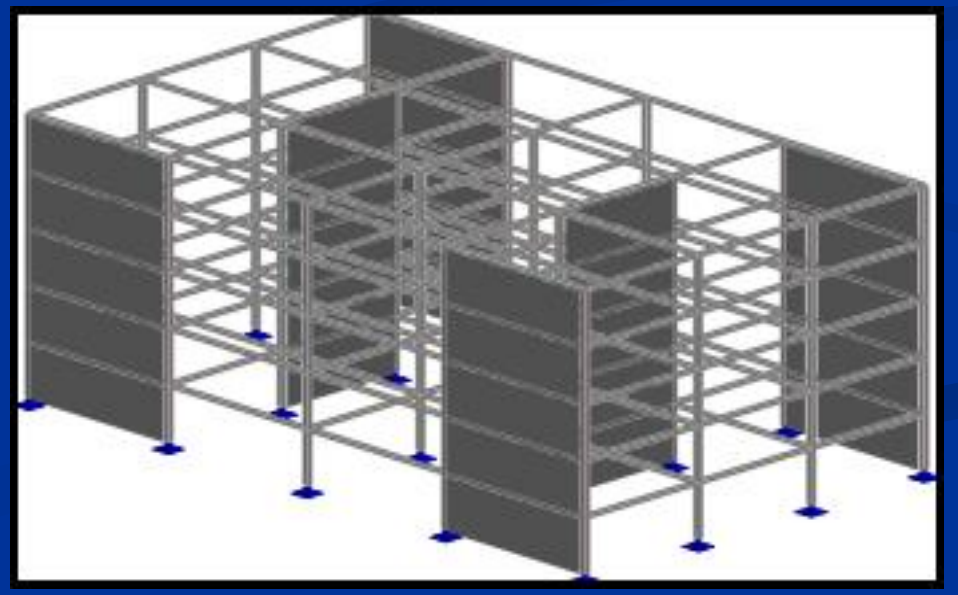
Horizontal bed joint, truss-type reinforcement and vertical reinforcement in a hollow block masonry wall

Shear wall concept



3d model of a building with shear walls

Tall building with shear walls



Large Area Formwork

Flex Table System

Aluminium Formwork System - MIVAN

- Light weight
- Simple connection arrangement
- Easy to handle
- More than 100 repetitions
- Eliminates use of P & M
- Improves Labour productivity

MIVAN formwork used for the construction of South City residential complex, Bangalore

Systems Housing

- Use of Tunnel form and Pre-fabricated building elements
- Slabs & walls of a building are cast in continuous pour

- Structural steel mould
- Mechanized construction process
- Ideal for a repetitive structure
- For economy, speed & ease of construction

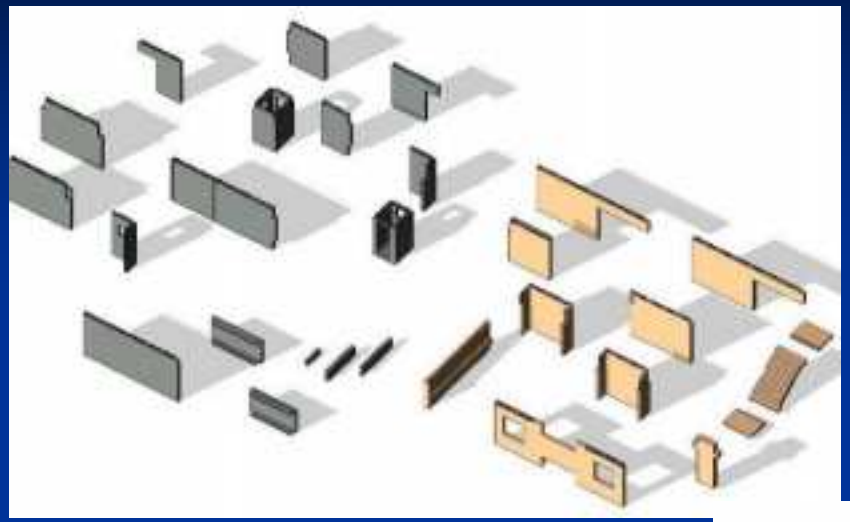
Tunnel Form Construction

- 750 Dwelling units each of built-up area 70 sq.m
- Tunnel Form system & Precast concept

Precast elements used:

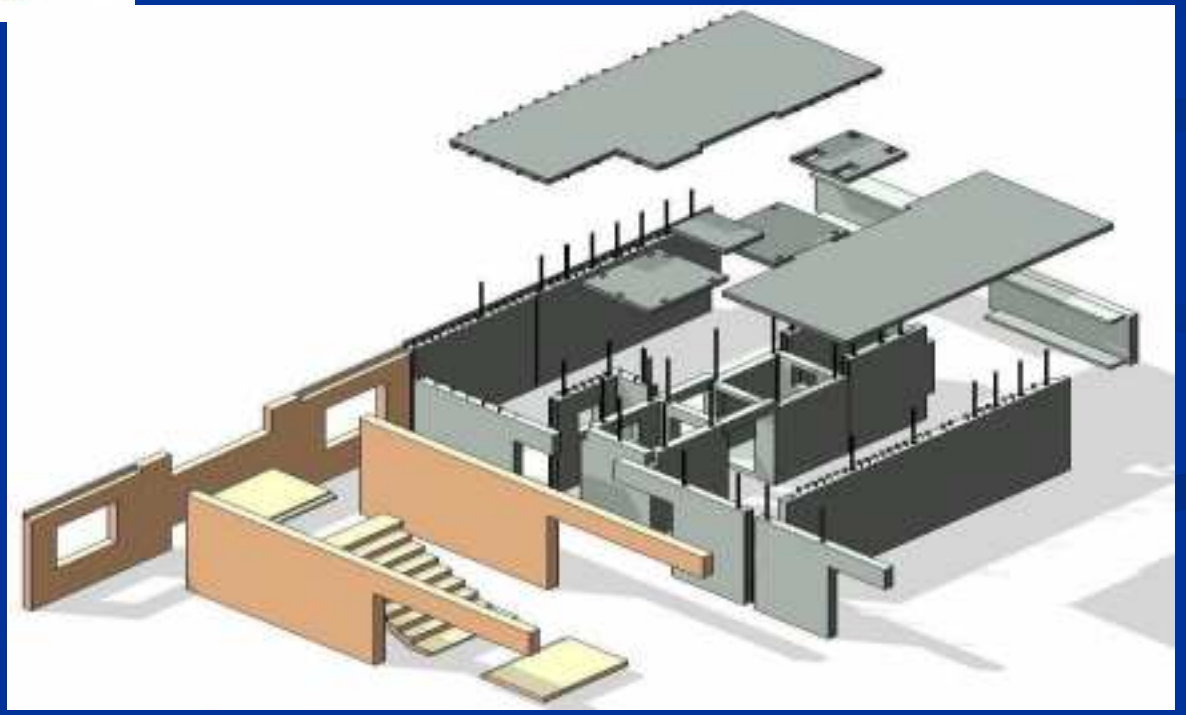
- Facade panels
- Balconies
- Sunshades
- Landings
- Stair flights
- Cup boards
- Kitchen platforms
- Water tanks

Types of Precast Elements and Construction Sequence



Types of precast elements used (for a typical floor)

Typical construction sequence



Precast Construction

Construction of Rehab Buildings at Bhoiwada, Mumbai

- **No. of Blocks : 6 nos.**
- **Floors : G+23 storeys**
- **Dwelling units : 2024 nos.**

Project Strategy:

- Pile Foundation
- Ground floor by conventional method
- 1st floor to 23rd floor constructed using precast elements
- Finishes of all floors except WC and bath done at site

Residential Projects

TISCO HOUSING, JAMSHEDPUR

APSEB HOUSING, MUDDANUR

Ministry of Defense Township

TOWNSHIP FOR

MINISTRY OF DEFENSE AT KARWAR

NO. OF HOUSES 946

Zernograd Township

ZERNOGRAD TOWNSHIP, RUSSIA

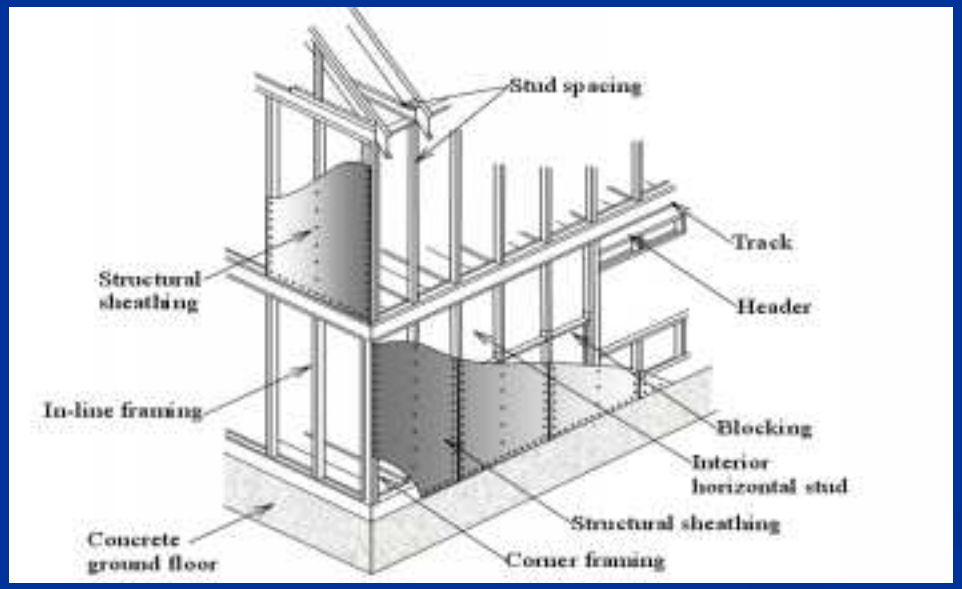
- Total Built Up Area - 110,000 Square meters
- 600 Flats + Community Buildings
- Completion Time 3 Years

Lightweight Concrete Construction

Malad, Mumbai

Powai, Mumbai

Cold-formed Steel (CFS) Housing System

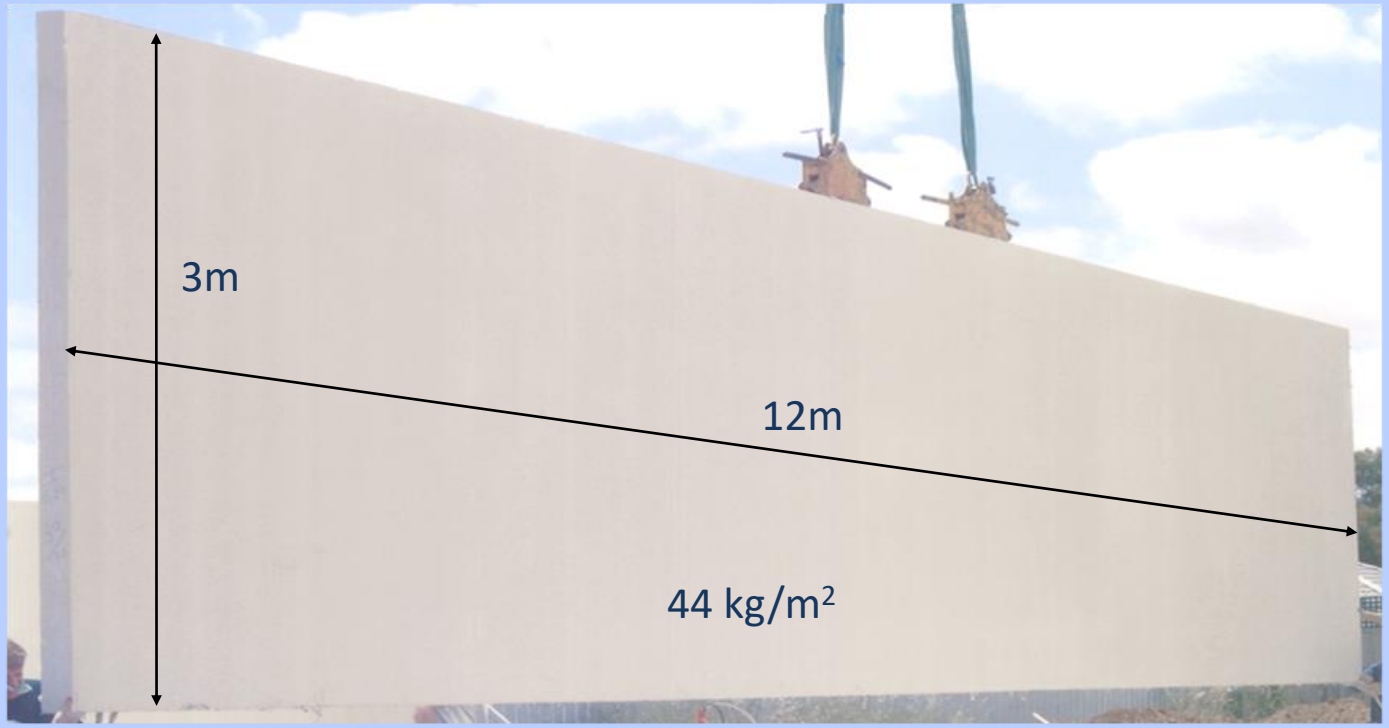


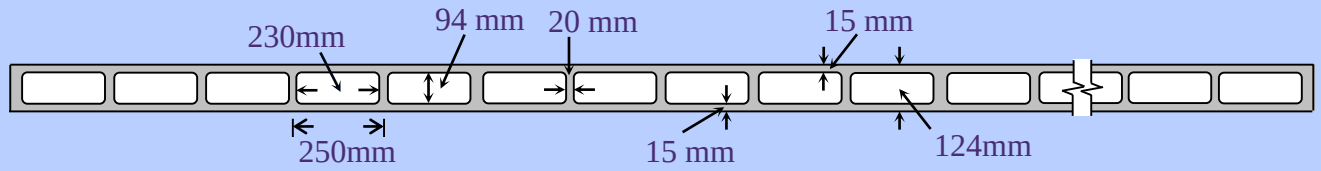
CFS building and its elements

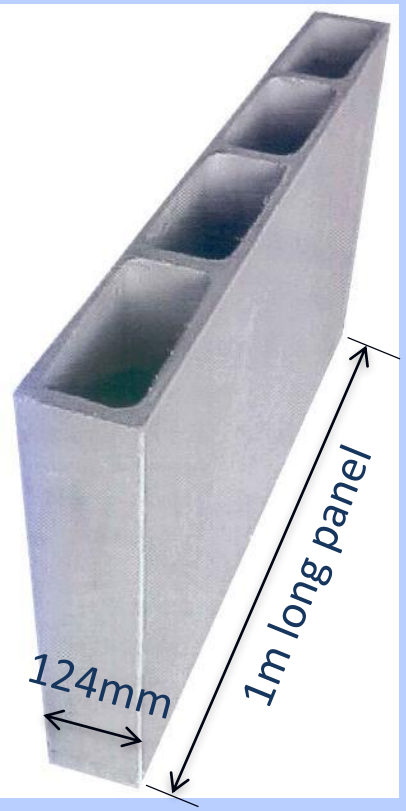
- CFS system is an alternative to existing masonry and wood frame construction
- Can be used for single and multi-storey houses
- Cold-Formed Steel Shear Wall panel (CFSSWP) is the main lateral load resisting element in CFS system Use of recycled waste products
- Failure is due to the failure of screw connections between the sheathing and CFS framing Mechanized Construction Process

GFRG wall panel (Rapidwall®)

– Glass Fibre Reinforced Gypsum - an alternative building material, introduced in Australia (1990)



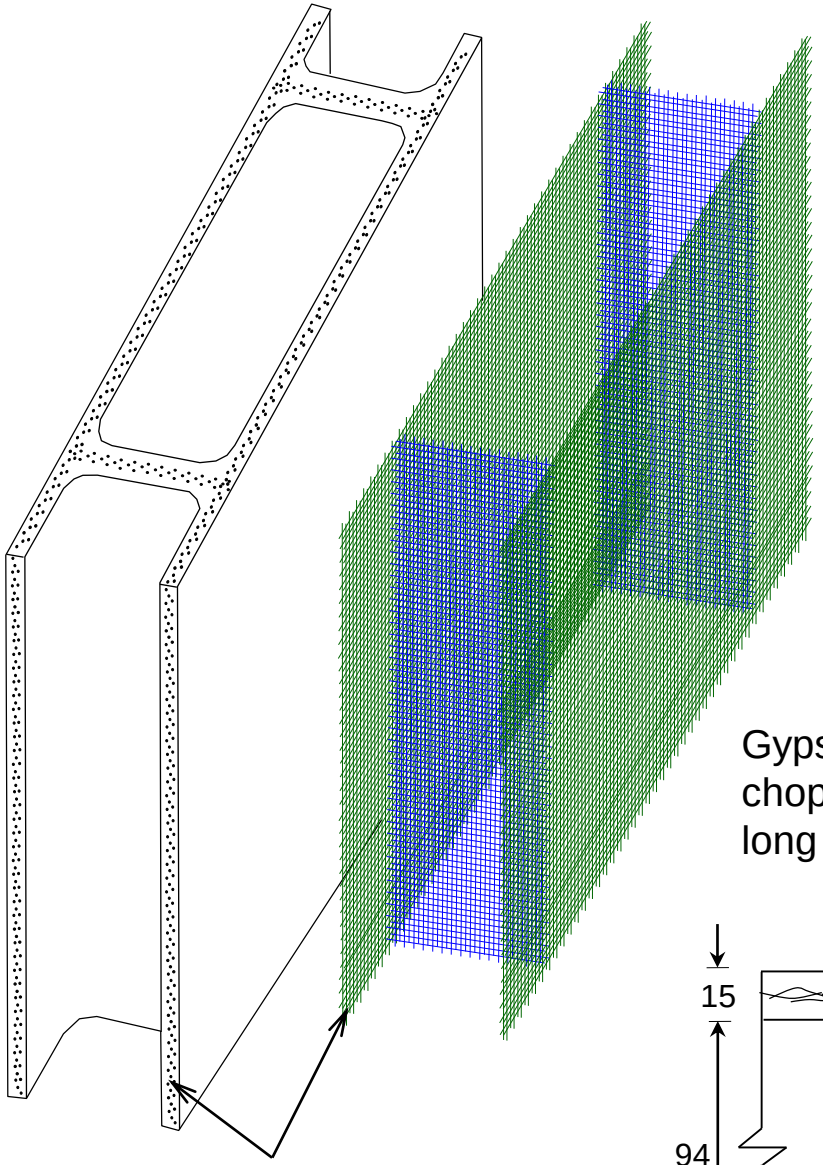




Cross-section

GFRG panels can be used as walls and floor / roof slabs in combination with RC

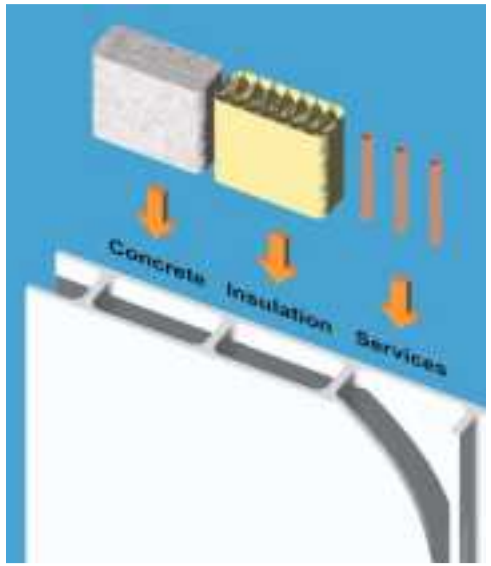
Segment of GFRG panel and cross-section



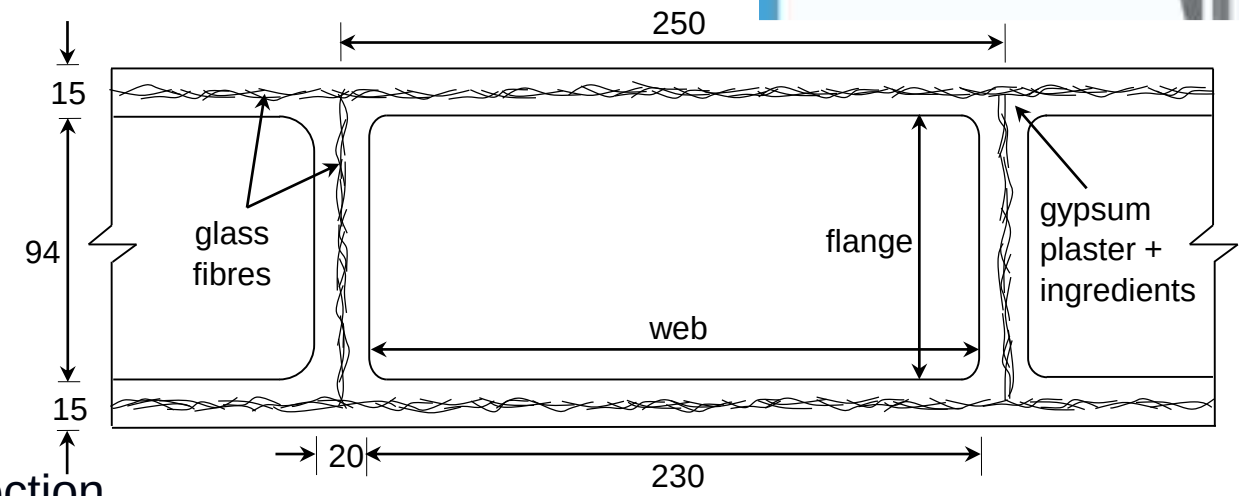
reinforced by glass rovings

Tensile strength of glass fibre (single filament) is 3100 – 3800 MPa

- The hollow cores inside the wall panels can be filled with:
  - in-situ concrete
  - reinforced concrete
  - thermal insulates



Gypsum plaster, reinforced with chopped glass fibres, 300 – 350 mm long (spread at 0.8 kg/m^2)

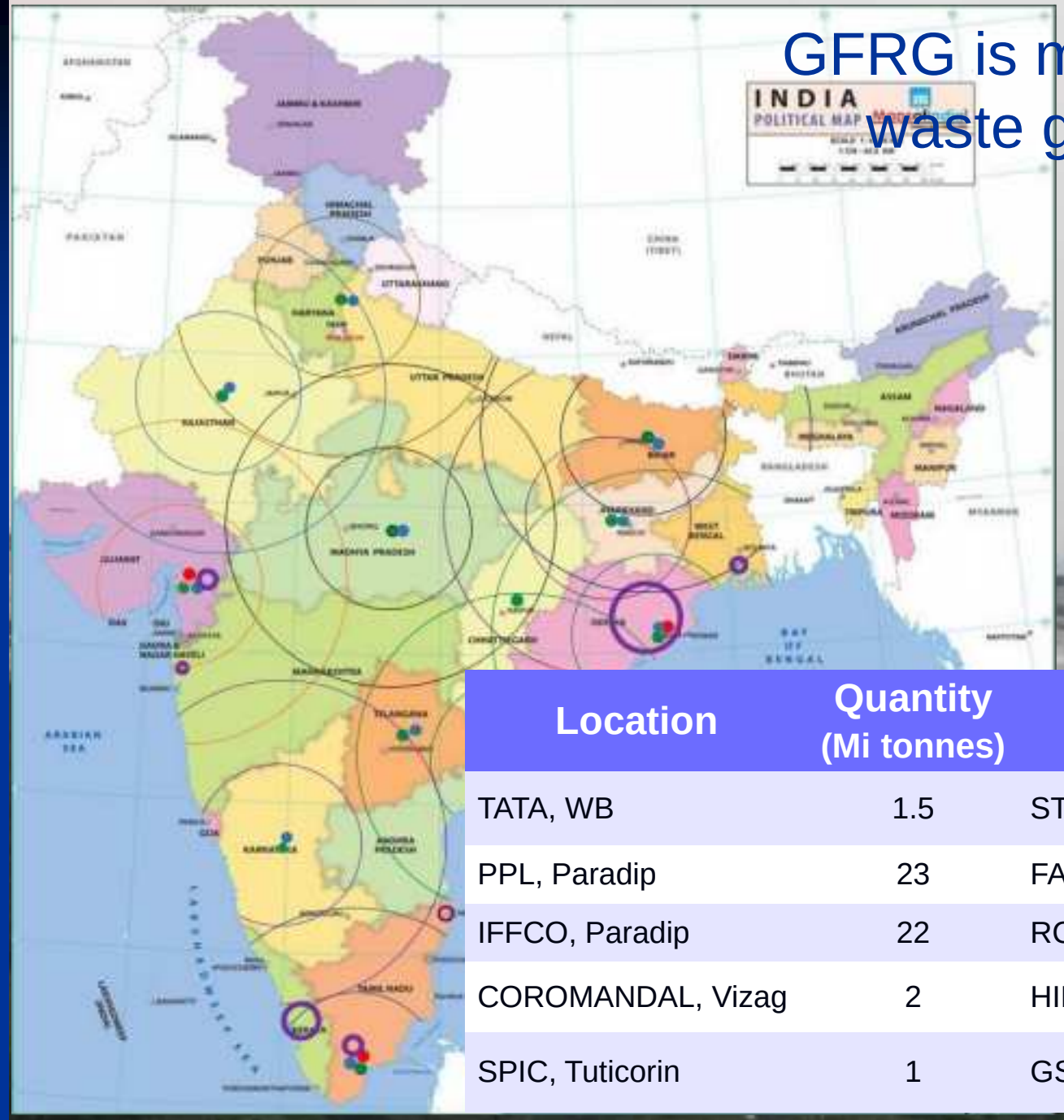


Cross-section

Outline

1. Introduction
2. Manufacture of GFRG panels in India
3. GFRG Panel as a Structural Material
4. R&D outcome and ongoing research works
5. Deliverables from R&D works
6. Finished GFRG Buildings

GFRG is manufactured from waste gypsum (phospho-gypsum) in India



India has 64 million tonnes of stockpiled gypsum

Location	Quantity (Mi tonnes)	Location	Quantity (Mi tonnes)
TATA, WB	1.5	STERLITE, Tuticorin	3
PPL, Paradip	23	FACT, Kochi	7.5
IFFCO, Paradip	22	RCF, Mumbai	0.5
COROMANDAL, Vizag	2	HINDALCO, Gujarat	2.5
SPIC, Tuticorin	1	GSFC, Gujarat	1

Locations of phosphogypsum availability in India

Panel being shifted to dryer chamber for 1-1.5 hrs drying

Manufacturing Process- GFRG Panels

Mfd. wet panel taken from casting table

GFRG Manufacturing Plant – FRBL Kochi

Air drying

Automised cutting of panels

Loading of stillages (packed with cut panels) into truck at factory

Outline

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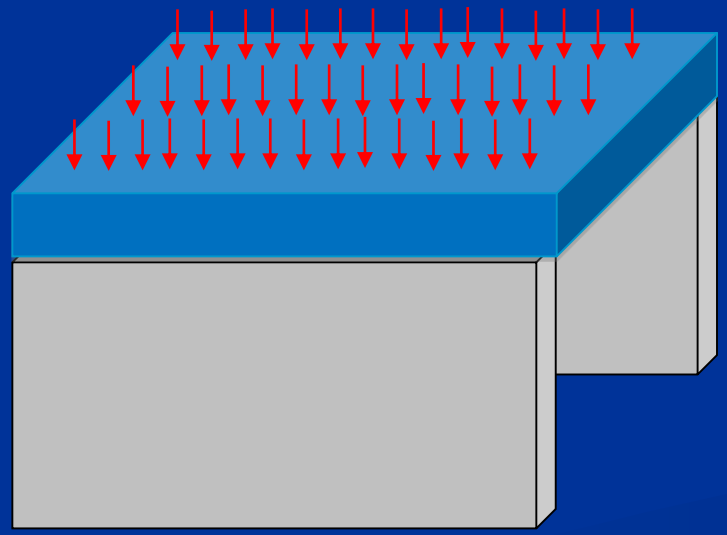
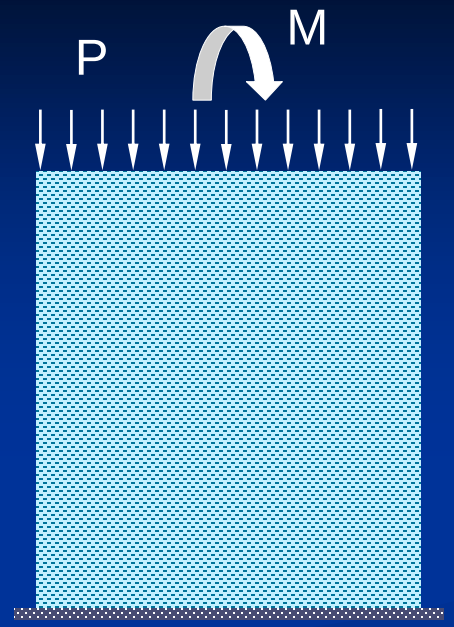
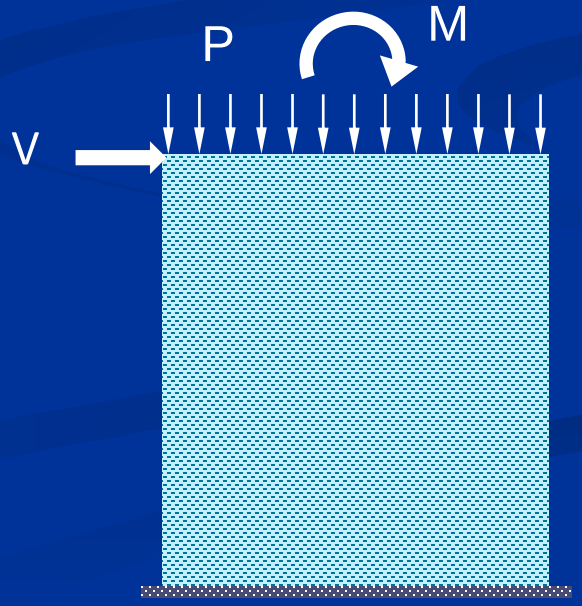
Structural Action of GFRG Panels

- ✓ Axial Loads
- ✓ + Out of plane Bending
- ✓ + In plane bending
- ✓ + Lateral Shear



- ✓ Slabs under gravity loading





Typical Mechanical Properties (unfilled panels)

Unfilled panel

Mechanical Property	Characteristic Value
Unit Weight	44 kg/m^2
Uni-axial Compressive Strength	160 kN/m (4.77 MPa)
Ultimate Shear Strength	21.6 kN/m
Uni-axial Tensile Strength	35 kN/m (1.04 MPa)
Ductility	4.0
Elastic Modulus	4000 – 7500 MPa
Coefficient of Thermal Expansion	12 x 10-6 mm/mm/^{0}C
Water Absorption	1% in 1 hr, 2.85% in 24 hr
Fire Resistance	4 hr rating, withstood 700-1000 ^{0}C

Typical Mechanical Properties (fully filled panels):

Infilled panels – (all cavities infilled with M20 concrete)

Mechanical Property	Characteristic Value
Uni-axial Compressive Strength	1360 kN/m
Ultimate Shear Strength	61 kN/m

Advantages of GFRG building systems

- reduction in structural weight of building
- saving of cement, steel, sand, water
- more carpet area
- saving of construction time
- effective use of industrial waste product
- suited for affordable mass housing

Applications

- As lightweight **load bearing walls**
- As **shear walls***
- As **floor slabs / roof slabs**: with reinforced concrete micro beams*

* Design and construction methodology developed at IIT Madras

Residential buildings

Manipal, Udupi (2013)

Mangalore (2013)

- Architect – Sudhir Acharya
- Builder – Hastha Pvt. Ltd., Bangalore

Nursing home, Trichur

(2015)

built-area – 5,000 sq.ft.

- Architect – N.M. Salim & Asc.
- Builder – N.M.S. Rapidwall, Calicut

Malayalam University, Tirur

Library cum classroom building

(built-area – 10,000 sq.ft.)

Canteen building

(built-area – 1,600 sq.ft.)

Office Buildings of Kerala State Electricity Board

KSEB building, Haripad

(built-area – 10,000 sq.ft.)

KSEB building, Manimala

(built-area – 1,600 sq.ft.)

Luxury villa,

Bangalore (2015)

- Architect – Sudhir Acharya
- Builder – Hastha Pvt. Ltd., Bangalore

School buildings

Perinjanam, Trichur (2016)
(16,000 sq.ft. built area)

Chennai (2017)
(6,000 sq.ft. built area)

- Builder – Enness Constructions, Calicut

JCO quarters (2016) at Military Cantonment, St. Thomas Mount - by MES (Military Engg. Service)

Commercial building,

Coimbatore (2016)

(built-area – 22,000 sq.ft.)

- Client – Bace India Pvt. Ltd., Coimbatore
- Builder – Enness Constructions, Calicut

Take-a-Break Building,

Trivandrum (2017)

Client – KTDC, Govt. Of Kerala

(built-area – 500 sq.ft.)

20 such buildings have been constructed along the NHs and SHs in Kerala

Nursery School Building,

Piravom (2017)

(built-area – 650 sq.ft.)

Typically, many such school buildings have been built in kerala

G+3 Hostel Building at IIT Tirupati (Elevation)

under construction

G+3 Hostel Building at IIT Tirupati

under construction

Thank you