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EmergingConstruction technology, in Anthropocene epoch, India: The EPSC Panel

Dr. Siba Prasad Mishra

Abstract

Geotextiles, Geo-membranes and Geo-grids, the products of Geo-synthetic materials are extensively used in 1980's have added Geo-EPS as a cost effective energy efficient new construction materials from 1990. The slogan of the nation, India is "Housing for all" on its 75th year of Independence, tentatively 20 million house by 2022. The herculean task cannot be met by conventional method of constructing cast in situ houses with modern amenities under Indian climate and environment is a day dream. Innovative methods must be adopted in the construction practices such as prefabricated structures or precast slabs are essential. Structural concrete insulated panels like expanded polystyrene core (EPSC) arrangement, cladded with zinc coated welded fibers sprayed with shotcrete concreting are one of the best choices of early, easy, light weight, energy efficient and cost effective building construction even up to G+3 to G+22 and even more.High rise buildings can provide long lasting and green buildings for the burgeoning population of India at low cost if constructed using EPSC panels. A comparative study of the ongoing building materials have been investigated and the results were the EPSC walling with concrete columns and beams are the most effective in green and smart building age.

Keywords:

EPS,
AAC,
Building materials,
green buildings,
energy efficient,
economic.

Author correspondence:

Dr. Siba Prasad Mishra, Dept. of civil Engineering, Centurion University of Technology and Management, Jatni, Bhubaneswar Odisha.

1. Introduction (10pt)

The primitive building construction with traditional materials like cement, sand, brick and stone are no longer in use for last 1980 years i.e. the acceleration period of Anthropocene epochMishra S. P., 2017[1]. The in situ construction has been ceased and replaced by prefab construction technology. Like RCC hollow and solid beams, prefab stair cases, RCC precast slabs and ties, AAC precast slab or blocks. All these prefab structures are in use at present. The time consuming, solid waste producing and thermal inefficient AAC structures have been replaced by EPS buildings that provides required building comfort und green building concept.

Structural concrete insulated panels (SCIP) like expanded polystyrene core (EPSC) arrangement, cladded with zinc coated welded fibers sprayed with shotcrete concreting are one of the best

choices for early, easy, light weight, energy efficient and cost effective building construction even up to G+3. High rise buildings with EPSC can provide long lasting dwelling shelters under green buildings for the burgeoning population of India at low cost. Expanded Polystyrene Core Panel's (EPSCP) Insulation products coupled with the construction industry from 1970 as a building materialof Anthropocene. It is a foam plastic materials manufactured from polystyrene expanded with butadiene, ethylene and butylene used as SCIP for insulation of buildings primarily. Further it is used as light weight building material having lifelong performance without thermal drift if properly constructed and maintained. The construction EPS materials have high compressive strength, great cushioning properties and water, acid/ alkali (at low conc.) resistant providing improved building comfort enhanced structural performance, fire retardant and cost effective. The novice innovative building materials are gaining popularity throughout the globe.

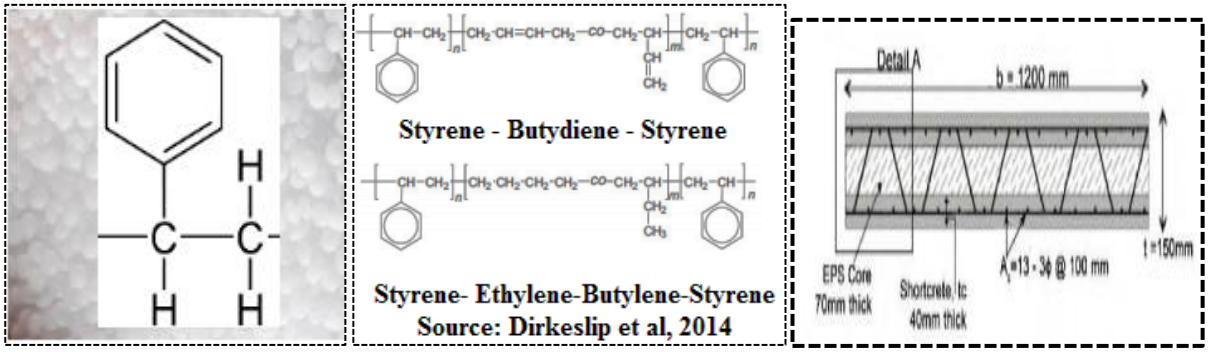

Fig 1: The chemical structure of SBS and SEBS, expanded polystyrene core as SCIP material

The Expanded Polystyrene:

As per Australian technical data of urethane and styrene, it is a polymerized lightweight close cell prepared from polystyrene (a polymer product of Benzene and Ethylene in form of beads) having five stages of manufacture i.e. Pre-expansion, property enhancement, ageing,moulding and finishing http://www.thermalps.com.au/ imagesDB/wysiwyg/TDS_Expanded_Polystyrene.pdfFig 1. The beads pre-expansion stage steamed under increased vapour pressure to have softening and volumetric expansion. To enhance the properties of the polystyrene, impact modifiers are added like SBS (Styrene butadiene styrene) or SEBS (Styrene Ethylene butylene styrene). For ageing the beads were stored in large silos on drying beds for fluidization. For drying, the beads are passed through ovens under a controlled temperature. Finishing is done by cutting the EPS to required shape and size for use.For property improvement the Polystyrene the EPS panels have the advantages like energy efficient, light weight, maintain buildings thermal comfort, low maintenance, reduces solid waste as recyclable and reusable, anti-vermin, rot protective, fast construction and reduced radiation, air leakage and infiltration rates.

Review of literature

Thermal comfort due to use of proper building materials was started from 19th century Rowley et all 1932[2], and 1937[3]. The geo expanded Polystyrene Core panels like geo-synthetics, geo-membranes and geo-g rids can be used under low or deteriorated soil conditions (Greenlay et al., 1997) [4]. During recovery of EPS beads during manufacture faces the problem of blowing agent so SBS or SEBS as impact modifier added to improve manufacturing problems. PS/SEBS exhibited higher tensile strength than PS/SEBS products (Direksilpa C., 2014) [5]. The EPS materials can be a low cost replacement for the wood doors and shutters (Asthana et al, 1996) [6]. Sailus et al 2006[7], have reported that stability and durability of polymeric foam used in building construction is associated generally with compressive strain. The Food and Drug Administration(FDA), Food Safety Modernization Act (FSMA), and the law by President Obama were provoked on January 4, 2011 in USA which protects public health by firming the food safety system https://www.fda.gov/Food/GuidanceRegulation /FSMA/ucm 253380.html.

Building materials & technology promotion council, Ministry of Housing and urban poverty alleviation, GOI has recommended the use of EPS materials for the fast and economic building construction. Bengaluru Police housing Board has adopted the EPS panel boards in their housing schemes. Karnataka State Police Housing Corporation (KSPHC) for Fire and Emergency Services has constructed anEPC panel structure within just 17days.CSIR – Central Building Research Institute Roorkee, June 2017 has prepared for Manual for Expanded Polystyrene (EPS) Core Panel System and its field Application sponsored by MoH&UpA, GOI [7] andAgrawal et. al 2014[9].Gitau N. S., 2014[10], reported the EPC system of building saves 50% time and 30% cost through transport, labour and cost of construction machineries.DenizCarroll, 2017[11] has reported EPS panel boards with Aluminum foil, array of facers., polyethylene and Kraft paper increases performance and protect fromabrasion, UV degradation and increase resistance to radiant heat absorption.Morgan D R R et al., 2008[12]and Qiao P et al. [13], have given guidelines for construction of shotcrete wall structures.Rohit Raj et al., 2014[14] mentioned that EPSC panels have thermal conductivity (0.032 - 0.038W/m•K) is less energy efficient hat of traditional concrete has much less values 0.4-0.7 W/(m•K).Mishra S. P., 2017[15] reported that the buildings should be constructed whose materials should be energy efficient, long lasting, better indoor air quality and low running and maintenance cost, low VOC and maximum thermal comfort as per norms of Indian green building council (IGBC) and LEED (Leadership in energy and environmental design) and GRIHA (Green rating for integrated habitat assessment.

Reasons for study:

India is the 2nd largest populous country (1,344,569,353 on 11.11.2017) occupies 17.74% of the total globe with a density 450/sqkm with 32.8% living in urban http://www.worldometers.info /world -population/india-population/. Provision for roof to live in for each family is a titanic task for building Economically Weaker Section (EWS)/ Lower Income Group (LIG) houses. There are housing shortfall of 18.78 million (14.99 congested households inclusive) planned by the GOI by 2022 (Agrawal et al 2014) [9]. The urgent need for enormous housing projects to be started in both urban and rural segments with traditional limited building materials and funding, it is vital that green and proven construction skill to be adopted by taking care of structural, performance and fiscal allotment. Under-developed and evolving countries are fighting against housing deficit and forced to adopt RPC system of building construction to meet the requirement faster with local men, materials and less money. India is yet to standardize and prepare an IS code on the modern method of construction though the methods and the product is quite popular in many cities all over India and the world. Present work is to highlight the economic green concept of housing by EPC panels to the common people to meet their future need.

Clay/flyash bricks, AAC blocks/panels and EPC panels as materials building construction

The major man made conventional and modern brick blocks used as popular building materials are clay bricks, Flyash bricks, AAC and EPSC blocks or panels. The physical, mechanical and Usable properties of the four types of materials are given in Table 1, Table 2, and Table 3

Table 1: Comparison of Physical properties Clay/fly ash bricks, AAC panels and EPC panels

Parameters	**Clay bricks**	**Flyash bricks**	**AAC bricks**	**EPC panels**
Composition	Soil, Sand, Lime/ concrete materials and labour more	Mortar fly ash Less labour than clay bricks production	Mix of Sand, Cement, Coarse aggt gypsum. Lesslabour than EPC Constn..	Polystyrene, steel, shotcrete. Least labour in construction
Av size in mm (L x H x B)	230 x 75 x 115(±05to 15)	230x75x110mm (±5%)	600 x 200 x (100 to 300) mm(± 1.5)	Finished thick ness:155to235mm
Colour	Non-uniform (Red)	Uniform Cement grey	Uniform (grey)	Uniform/ Cement colour
Shape	Uneven	Even	Even	Even
Finish	May distort	Smooth finish	Smooth finish	Finished
Weight (av)	3.5Kg/brick	3.5kg/brick	lighter	lightest
Dry density	1600-1750	1850-1900	550 – 650	15 – 25 in kg/m3

Loading capacity	Yes	More than CB	> EPC blocks	Least
Earthquake (EQ) resistance	Less resistant	Less resistant	More than CB/fly ash brick	Resistant, used E.Q. retrofitting
Porosity	Porous(10%to 30%	Less porous	Porous	Least Porous
Cost/sqm	Higher than Flyash bricks	Less than clay bricks	Less than EPS panels	Higher than AAC blocks
Plastering	Needs and more mortar	lesser mortar than Clay bricks	Less mortar than fly ash bricks	Least mortar
Bonding	Strong	Less than CBB	Less	Less
Breakage on transportation	200 in 3000 bricks	30 no's in 3000 bricks	<25 in 3000 bricks	No breakage as shotcrete in situ
Construction	Local workers	Local workers	Local workers	Skilled worker

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https://www.materialtree.com/blog/cat/compare/post/redbricks-aacblocks/
http://santoshranjanblog.blogspot.in/
http://www.ecogreenproducts.in/technical_specification.php
http://www.leedsbeckett.ac.uk/teaching/vsite/low_carbon_housing/resources/thermal-conduc tivity-of-building-materials.pdf
http://www.iolitecube.com/AACBlockComparisonWithBricks.html

Physical properties

Clay brick: The properties of red clay brick havesubstantialinfluenceon structural performance of the brick masonry are **compressive strength.** Thematerialsof the puddle, % of water absorption and surface texture control the effect on masonry. The physical quality also depends upon the firing temperature (over or under) and duration of firing. Further compressive strengths of Clamp Burnt (CB) and Kiln burnt bricks differ.

Fly ash bricks: The local govt. is imposing royalty and cess on earth for brick manufacture and the cost of bricks have risen from 1990's. Considering the higher compressive strength of cement mortar bricks became popular but the harmful effect of fly ash, the pollution control board, India has imposed regulations. The rise in cost, low bonding, and least reusability is losing the popularity of fly ash cemented bricks gradually like plastic.

Table 2: Comparison of mechanical properties Clay/fly ash bricks, AAC panels and EPC panels

Parameters	**Red clay bricks**	**Flyash bricks**	**AAC panels**	**EPC panels**	**Source**
Weather/pest resistance	Not weather and pest resistant	Not weather and pest resistant	Resist adverse weather and pests	Resist adverse weather and pests	http://www.shimberg.ufl.edu/publications/hebelDoc.pdf http://epsa.org.au/about-eps/eps-in-building/panel http://www.ecogreenproducts.in/technical_specification, http://www.gobrick.com/port
Plaster	Not possible	Possible	Possible	Possible	
Comp. strength (N/mm^2)	2.5 - 3 N/mm2 30-35 kg/cm^2	7-10 N/mm^2 90-100 kg/cm^2	3 – 4.5 (IS 2185 part 3)	3-4 N/mm2,	
Thermalcond.(K)	0. (W/m-K)	1.21(W/m-K)	0.16(W/m-K)	(W/m-K)	
Water absorption	20-25%	06-12%	water and vapour barrier	High water barrier	
R-Value insulation	R 0.05 -0.07	R-0.5	R-30 insulation	R – 0.88	
Sound reduction Index (Db.)	50 for 230 mm Thick Wall		45 for 200 mm Thick Wall	poor insulation to sound	

Fire resistance (hrs.) 6" thickness	2hours (EN ISO 11925-2:2002)	4hours ((EN ISO 11925-2:2002)	2 to 6 (Depend on Thickness)	high and medium thermal resistant	als/25/docs/technical%20notes/tn16.pdf
Effect on environment	Clay, Affect high CO_2 emission	Uses wastes of TPP, save envt.	Eco friendly than EPCS	No solid waste, envt friendly	

Autoclaved aerated concrete blocks:

AAC blocks are about 80years old and gained popularity due to its low weight, fast construction, fire resistance, ecofriendly etc. But government restrictions, high cost, limited manufacturers, less strength making its use in construction is not alluring.

EPSC panels:

Expanded Polystyrene foam insulation with shotcrete surface board is not stable, asit has an expiry period. Though shrinkage cracks are developed, its versatility, cheapness, thermal high insulation, reusability and fast construction have made it popular in 21st century for the homes of burgeoning population

Table 3: Comparison of usable properties Clay/fly ash bricks, AAC panels and EPC panels

Parameters	Red clay bricks	Flyash bricks	AAC panels	EPC panels	Source
Advantages	Aesthetic, local, economical Hard& durable, Comp. strength acceptable low upkeep, easy Demolishing ,reusable le & recyclable, fire resistant, less eco-pollution,	Flexible/easy to construct, ideal for foundation, high strength, Ideal in cold &hot weather, durable, less up keep, less crack, crumbling, Eco friendly, acouostic, Less GHG	Light Wt., Fire resistant, moderate comp strength, workable, economy, acoustic, easy/quick to install, durable, stable, ecofriendly, acoustic, energy saver,vent-elating, nontoxic, smooth, quick const, long lasting.	Light wt., easy to install, fast constn. fire/E.Q./storm-resistant, Thermal insulation, lower cost. Airtight, flexible design, Long life, high strength, low upkeep, hygienic, economic, ,no GHG Eco friendly, reusable	https://gharpedia.com/solid-concrete-blocks-vs-aac-blocks/ http://www.bmtpc.org/DataFiles/CMS/file/PDF_Files/ http://www.house-energy.com/Walls/AAC-Advantages.html
Disadvantages	Uneven shape, delay construction, not in high seismic zones, fluorescence cause, Less tensile strength Moss growth, Color of low quality brick changes in sun. porous	Low Bonding as smooth finish, corrected by using mortar of 1:4 & curing. poor quality brick harm the structure, high quality ash or affect health (EPA)	Cost high, limited manufacturers, less strength, may need Govt. permission, high water absorption and when dry may crack, less thermal insulation. Cost, wastage and availability,	Cost, wastage and availability, need to hang nets, complex construction, long constn time, toxic,, flammable, poor strength, cracking &spelling, use within maturity period,	http://www.styrofoamdensifier.org/the-advanta ges-and-dis advantages-of-poly styrene-foam-insulation-board/
Cost benefit/ quality end product	Easily available in locally, hence economic for low rise structures. Least ecofriendly	High strength used in load bearing walls, need skill labour, need plaster	Skyscrapers re-duction in dead wt. leads to saving concrete &steel/ Exactor is good		

Whether IS code available	Available (IS 1077-1992)	Available IS:12894-2002)	No IS code	IS 4671:1984 (EPC),IS 9012: 1978 (shotcrete)	

Advantages of the EPS panels as building material: The multi advantageous EPCS panels are used for Load bearing wall panel, Non-load bearingwall panel, Shear Wall, Floor / roof slab. The advantages in embedding the housing walls , doors and windows with EPS panels are

1. **Eco-friendly and green concept**: The panels are reusable and recyclable. They generate little solid wastes in comparison to the conventional construction materials. EPS materials are stable, energy efficient, biologically non-degradable and nontoxic so produces less CO_2 and CH_4. Risk of pollution to air, surface and UG water is least and maintain green concept.
2. **Cost saving:** Traditional standard construction cost of building in India varies from (Fly Ash Bricks, water supply/electricityfittings, etc.), then here's an approximate cost for construction on basis of Built-up Area: (https://www.quora.com/What-is-the-building-cost-per-sq-ft-in-India), For G+1 , G+7 , G+12 , G+22 buildings are tentatively INR 13000/sqm, INR 17000/sqm. INR 19000/sqm, INR 21000/sqm respectively. Whereas the traditional structural construction with insulated EPS buildings comes around INR 750 -1000/sqm. The Odisha State Housing Board has constructed by DSP MR ENERGY INFRA JV, Hyderabad, 42 low cost buildings with overall cost of Rs 14000/- INR/sqm. The traditional std. building cost is Rs 25000/sqm.

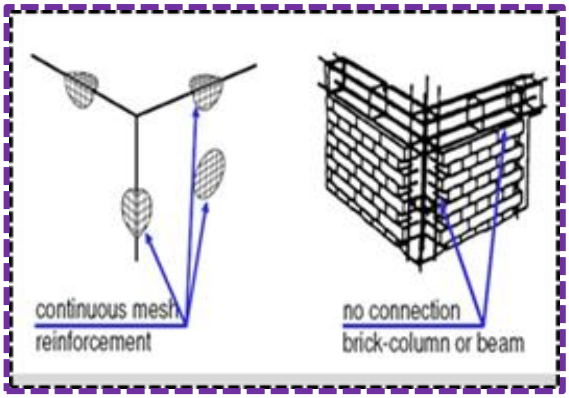


Fig2: Safe connection of nonstructural elements

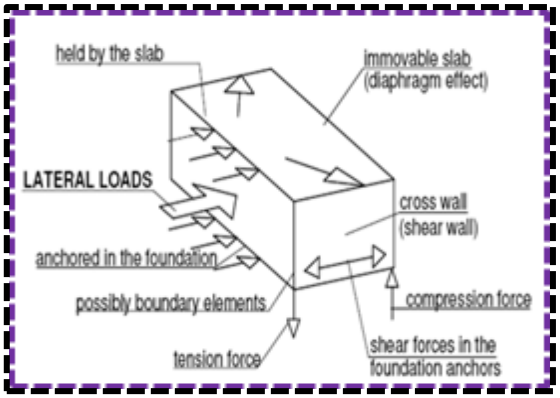


Fig 3 : Less damage during seismicity

3. **Light in weight**: The EPS panels are light in weight so easy to transport, handle and install which saves the cost of construction to a lot. The tentative weight of the panels varies from 3.5Kg to 5.0kg/sqm.
4. **Seismicand storm resistance:** The materials are best suited for earth quake retrofitting of walls and partitions as the panel is cladded with wiremesh which protect the building from tremors and gusty winds under erratic climatic changes in India Mishra S. P. 2017[13]**(Fig 3).** The panels have strong protection against strong gusty winds and even during hurricanes.
5. **Fast and safe installation:** The panels are pre-fab structures. The installation need local minimal less-expert workers and handling no heavy materials which make the process of construction and fabrication easy smooth and quick. Once the foundation beams and columns are erected, all other items are much faster than traditional building construction**(Fig 2).**
6. **High load bearing capacity:** The EPS structures have high structural resistance. As light in weight, the less live load is fragmented and easily borne by the load bearing walls and part of the tension is taken by cladded wire mesh.

7. **Thermal and acoustic insulation:** OSHB buildings have standard 4cm thick EPS panel with density 15 kg/m3 against 1800 – 2100 kg/m^3 and with a 3cm thick shotcrete on both faces by (thickness 10cm) is 0.78 W/sqm ºK which saves energy of about 40%. The concrete of 3.5cm thickness on both faces have average sound insulation of 43.50 db. The panels are fire resistant, self-extinguishing.
8. **Thermal and energy efficient:** the expanded Polystyrene core system with concrete and steel reinforcement (EPCSCSR) sheets are water-resistant, need long-term repair in areas of meteorological extreme (even wind up to 300Kmph and tolerate earthquakes of 0.4 g Ground Acceleration or more than7.5 on the R- scale **(Zarnani et al., 2009)**[14]

Men, machine and materials used:

The inner core of the panel is polystyrene with impact modifier (SBS or SBES) and conventional building materials used for shotcrete The EPC core is prefabricated as the Industry output (IS 4671:1984 and EN 13163:2013 EPS 80, splice mesh, Reinforcement bars (IS 1786:2008 and shortcrete ingradients (IS 456:2000,IS 2185 (Pt.3):1984 and IS 6073 : 2006) . The machineries and gadgets required are stapuling gun, shotcreting machine, and shuttering and scaffolding materials. Generally minimal semiskilled and unskilled labours are needed those who have hands on practice in the job.

Raw Materials

Steel Wire –2.5/3.0 mm ϕ and Zinc coated cold drawn galvanizing shall be of 60 gm/m^2 ± 5 gm/m^2 of mechanical properties Yield stress : > 600 N/mm^2, Breaking load : > 680 N/mm^2 , Elongation : > 8% and Chemical properties -- Weldability % C : < 0.24 % P : < 0.055 % S : < 0.055 % Ceq: < 0.52 Building Materials & Technology Promotion Council Ministry of Housing & Urban Poverty Alleviation, GOI, New Delhi.

EPC: Self-extinguishing type EPS 80 is in accordance to UNI EN 13163:2013 (IS 4671: 1984) having density not less than 15 kg/m^3

Shotcrete materials: Portland cement, fly Ash, 6mm and downgraded coarse aggts,.admixers (IS : 9012 – 1978) or ASTM C33:Standard (Std.) Specification for Concrete Aggts. & ASTM C150: Std.Specification for Portland cement, Shotcrete, ASTM C1140& IS 9012-1978: Std. Practice for Preparing Testing Specimens from Shotcrete Test Panels, ASTM C1141.

Methodology of application

EPS panel after shotcrete has the following five components like, the outer layer of shotcrete, Welded reinforcing mesh of high wire, the core of expanded polystyrene sheet, Diagonal wire (stainless or galvanized wire), and the inner layer of shotcrete.http://www. Mortar sprayer .com/diy-shotcrete/

Methodology of application

EPS panel after shotcrete has the following five components like, the outer layer of shotcrete, Welded reinforcing mesh of high wire, the core of expanded polystyrene sheet, Diagonal wire (stainless or galvanized wire), and the inner layer of shotcrete.

The steps for construction are

1. Start erection from corners and initially connect to starter bars.
2. Fix splice mesh by using pliers and pneumatic tools like hog ring gun
3. Shoring is done by using adjustable props with tripods and bracing. Allow beams to support panelsPrepare the slab panels is done by providing corner bars as additional reinforcement and straight bars for flexural reinforcement and for support the stirrups are used.
4. Place slab panels in position with maximum space between beams 1500mm.
5. Top concrete for roof is done by providing 6cm concrete on top of the slab.
6. In walls, shotcrete is done in one or two layers of 40 to 50mm thick on both sides.

7. For smooth finishing of walls and roof top, manual plastering is done in 2 to 3 layers by 40 to 50 mm thick cement mortar (Morgan et al.,2008).
8. Curing is done for minimum 21days to gain strength of shotcrete

Precautions during erection

1. The EPSC is sandwiched between two layers of 11-gauge 5cmx5cm welded-wire steel mesh connected by steel or plastic connectors through the polystyrene. Use plastic connectors to decrease thermal bridging **Fig 4.**
2. At corners only the strips of splicing mesh include a 90-degree bend are to be used.
3. Openings for doors and windows are to be cut on site. So necessity for bolt cutters or reciprocating saws are needed to cut the mesh and a handsaw to cut the foam. Pressure-treated lumber frames are to be fixed in the window openings before spraying shotcrete.
4. The water supply line, electrical conduits and boxes are inserted and fixed inside the mesh using propane torch prior to shotcrete.
5. The water supply line, electrical conduits and boxes are inserted and fixed inside the mesh using propane torch prior to shotcrete.
6. Shotcrete is pumped wet, gunite (water mixed at thenozzle) is pumped with a 2,500 psi concretegun. Where shotcrete is not possible hand plastering with cement concrete using bazri (6mm or less size chips) or done with stucco / mortar spraying tools
7. Casting roof panels are laid over surfaces supported by props, purlins and shoring till shotcrete is set.
8. During shotcrete by a jet wall blaster the procedures to be followed are:
   - Arrange complete process into steps and organize each one smoothly.
   - Frequently examine the material flow and quantity.
   - Mixing and pumping place should be close by shortening the hose length for easy pumping.
   - Stack sand, bajri, cement water and other ingredients close to the mixer and donot hoard more shotcrete concrete.
   - Regularly clean the gun and hose before pumping.

Characteristics of EPSCCSR panels:

The behaviors of the sandwiched panels are connected as fully composite, partially composite and non-composite materials. The fully composite panels are the Wythe's (concrete layers) are coupled so that both faces of the panels resist applied flexural loads as if monolithic and there is 100% transfer of longitudinal shear. In semi composite EPCS panels, the connectors transfers <100% longitudinal shear. The non-composite EPCS panels are those there is no transfer of longitudinal shear and both concrete faces have separate identity. The stress diagram for composite and non-composite panels are shown in **Fig-5**

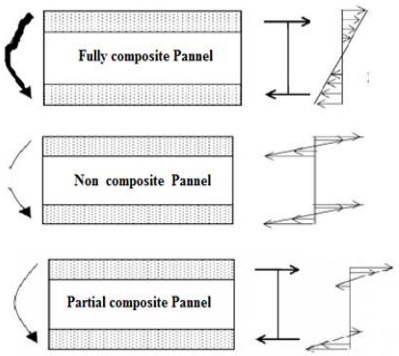


Fig 5: The stress diagram of EPCSCSR

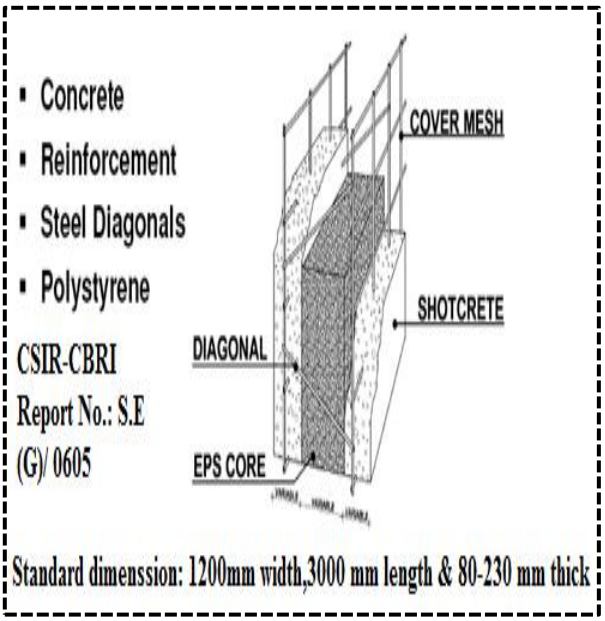
Modular Ratio= E_{SC}/E_{EP} Where E_{Sc} = The Young's modulus of Shotcrete

E_{EP} = The Young's modulus of the EPC

Reinforcement and the steel diagonals areto be provided to make the materials fully composite

Advantage of building characteristic with EPSC

1. **Higher Value**: Higher the Rvalue, more resistance to heat. Vacuum insulated panels have the highest R- value of 7.92 m^2 K/W followed by that of aerogels as 1.76-5.28 m^2 K/W. TheR-value of EPCS is 0.7 m^2 K/W. so some producers offer an increased R-value by%https://www.bdcuniversity.com/sites/sgc-university/files/Fabcon%20-20Precase%20Concrete%20Panels.pdf,



Fia 4: The section of the EPSC core

2. **Indoor air quality**: The precast shotcrete concretes needs less finishing and about zero plastering. The compatibility of water based paints with the shotcrete is good, the emission of VOC (volatile organic compounds) is least which maintains a good indoor air quality
3. **Recyclabilityend-of-use**: The panels, the steel can have reuse which is more than 50%

Sustainability of EPSC in long run:

Environmental Impact: EPS of Ireland is composed of 98[illegible] whereas Expanded Polystyrene in Europe or EUMEPS, [illegible] from one liter of oil saves in its lifetime 150 liters in heating a building.

Toxicity, Non bio-degradable and no waste: The EPS is nontoxic, non-degradable during production in its lifetime use and generate 0.1% waste (in Europe) as all flawed materials are either reused or recycled.

Building benefits:

Prefabricated EPSCCSR panels are usually used as walls or roofs in India in framed RCC structures but not as foundations or columns and beams. The construction is not that much cost effective

Fig 6: Column concrete before and after concreting when casted with internal wiring and plumbing

Saving GHG emission: Building constructed or retrofitted with EPS saves 40% of GHG gas emission and zero CFC or HCFC.

EPSC in India:

In Indian scenario, pre-fabricated EPSC have multiple wide uses in walls and roofs but not in base /foundation, columns and beams. The new green building and smart city concept is facing

thechallenge of cost of construction. The methodology for construction by EPCSCSR is about 50-60 years old stillnot popular and acceptable. Till today no IS code have been prepared for EPSCCSR construction technology (Fig 6).

Since the materials are light in weight, durable and sustainable for strong gusty windsof storms and water logging for SWMonsoon/NEMonsoon, can prove to be the best choice for construction materials even in coastal structures. The durable, fast and simple construction can solve the problems of govt machinery to meet the demands of the exponentially rising population. Uses of less quantity of cement shotcrete enhance the environmental safety and accelerating saving in production of CO2 in cement industry.Non-adaptability to EPCS technology in India is due to its use as

a. EPCS are used for Filler walls but not for load bearing walls.
b. Not much cost effective than traditional building materials
c. Builder's non-acceptance of EPCS panel as the R-Value of composite is less.
d. Local construction industries are ignorant of the shotcrete and gunite equipment's which are expensive
e. Manufactured EPCS panels are to be jointed as exact size is not available in the market.
f. Errors in cutting and wastage of EPSC Panels may lead to financial loss

4. Conclusion (10pt)

Green house concept for the intensifying populations of the world the conventional building materials, labour and machines are rising abnormally. The sweet home concept middle income group of people in India is a day dream. The EPSC technology is 30 years old and still underutilized. EPSC a, sustainable ecofriendly, reusable, recyclable building material will not overexploit the natural resources stone, earth, wood, iron etc. Considering the escalating demography, fast erection, dwelling thermal comfort with rising solar radiation, EPSC panels as the building materials can be one of the unique construction methodology in the Anthropocene epoch.

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