Re-looking Construction Worker Housing through the lens of COVID-19, Sustainable Energy and Energy Efficiency
Introduction

Climate change, disasters, pandemics, conflict and the unprecedented loss of livelihood opportunities has led to displacement and large scale migration of marginalised communities. Roughly a 100 million Indians have migrated in search of work. One major avenue is the booming infrastructure development projects that invite many skilled and unskilled people to urban areas for work. With the latest assessment the sector provides employment to approx. 50 million people. With the absence of affordable public housing for people at the bottom of the pyramid, catered to their patterns of migration, families and individuals are driven to squatting on empty plots of land or depend on either the government or their employers to provide them with accommodation.

These shelters built need to cater to relieving heat stress, heavy rains and flooding. There is a dire need to optimise the limited space available, create natural ventilation, thermal comfort and use durable and high quality and adaptive materials and construction technology to fit the needs in a post-covid world.

Mitigative measure to prevent spread of the pandemic are through decentralised utilities and services. These prevent cross camp circulation of inhabitants, reduced spatial occupancy/ crowdedness and better density design.

Easy to clean vertical and horizontal surfaces, better ventilation facilities in shared accommodation and service areas and other passive measures like day lighting, shading and insulation to improve overall well being to prevent contamination or infection spread within communities.

The lockdown situation has made construction workers more vulnerable in many ways without systems in place to protect: Losses in employment with the shutdown of all worksites; no income and limited savings leading to hunger and non repayment of debt resulting in the community furthering into poverty; no registration, social securities or BOCW Card resulting in lack of access to subsidies; not being able to pay rents or abandoned in high risk labour colonies leading to degradation of mental and physical health.

There needs to be a shift towards much more contextualised solutions and mapping of typologies to create benchmarks for habitat delivery. With the plethora of issues and hurdles present like land rights, finance, impermanence, there is a need to design sustainable solutions around them to create safety nets and support people with dignified habitats.
### Needs and Impacts of Built Environments on Workers’ Quality of Life

#### SHORT TERM - COVID 19 RESPONSE

Workers housing are not designed to prevent overcrowded conditions. Studies show average habitable area per person ranging between 1.5 to 3.5 sqm. In such conditions, attaining acceptable physical distancing proves impossible. Transit or gathering points need to in large open areas which are generally lacking in worker settlements. Closed or narrow spaces discourage social distancing.

Reports also stress on the need for improved air quality and passive measure for ventilation and daylighting. Shelters are further made inhabitable by the lack of windows or in openable fenestrations to the built indoor environment. Green cover in settlements also help improve overall site level air quality.

The materials used to build flooring, walls, door handles etc need to be easy to clean and durable.

Compounded with factors of low sanitation services per person. A ratio of 1:10 or minimum 1:15 needs to be maintained for sanitation services to prevent infection spread and cross contamination. Servicing and cleaning of these spaces frequently need to also be adhered to.

Isolation or quarantine spaces for the sick need to be established to protect those vulnerable and healthy.

#### LONG TERM - RISK REDUCTION AND RESILIENCE

Most countries have labour laws and ethics codes that dictate standard guidelines and regulations for sustainable and quality housing for workers. In the absence of monitoring, either by regulatory bodies at governance or organisation level, habitable conditions are rarely met.

Another layer to the right to quality of living standards, is the right to inclusivity for women and workers with vulnerabilities and providing safety nets in the form of childcare, insurance, etc.

Climate stressors like heat, torrential rains, flash flooding create additional burdens in providing safe and healthy living conditions. Most built spaces are not resilient and negativity impact wellbeing and productivity in individuals.

Providing serviceable spaces for clean cooking in the form of central or individual kitchens also helps improve worker health and wellbeing.

Ample spaces for recreation and utilities need to be provided in the form of shops for groceries, personal grooming, money transfer or ATMs, pharmacies and access to clean drinking water, adequate waste management also need to be provided.
Worker Housing Typologies

**ON-SITE/IN-SITU HOUSING**

Housing settlement on construction site land. The community occupies the land till the construction. Less than 100 individuals.

- **Occupancy**: ~100 members
- **Average Unit Size**: 2.5 m x 3 m
- **Persons per Unit**: 2-7
- **Area per Person**: 1.5 - 2.7 m²
- **Setbacks between Buildings**: Row type or 3 m maximum
- **Type of Materials**: GI Metal or Asbestos sheets, Tarpaulin, Bamboo or Casuarina Poles, Unfinished or cemented floor
- **Typical Land Use**: 20% built area [80% housing and 20% services] and 80% open area

**Examples of Layouts**

**OFF SITE DORMITORIES**

Housing settlement on rented or leased land in walking distance to the construction sites. Grid connection or DG Sets and temporary infrastructure is set up to service the inhabitants for the duration of construction.

**Type 1**

- **Occupancy**: 100 - 1000
- **Average Unit Size**: 3 m x 6 m
- **Persons per Unit**: 8 - 16
- **Area per Person**: 1.8 - 2.2 m²
- **Setbacks between Buildings**: Row type or 3 m maximum
- **Type of Materials**: GI Metal sheets with Hollow Cement Blocks, Scaffolding framework, PCC floor plinth
- **Typical Land Use**: 50% built area [70% housing and 30% services] and 50% open area

**Examples of Layouts**
Worker Housing Typologies

**TYPE 2**

<table>
<thead>
<tr>
<th>OCCUPANCY</th>
<th>AVG UNIT SIZE</th>
<th>AREA PER PERSON</th>
<th>PERSONS PER UNIT</th>
<th>TYPE OF MATERIALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>500 - 2500</td>
<td>3 m x 6 m</td>
<td>2.8 - 3.7 m²</td>
<td>8 - 16</td>
<td>Prefabricated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 m - 6 m</td>
<td></td>
<td>Panels Units</td>
</tr>
</tbody>
</table>

**TYPICAL LAND USE**

60% built area [70% housing and 30% services] and 40% open area

**OFF SITE HOSTELS**

Housing settlement built by contracting companies who rent out infrastructure to real estate developers or centrally set up worker housing by developers to cater to multiple construction sites. Grid connection, transformers and permanent infrastructure is set up to service the inhabitants.

<table>
<thead>
<tr>
<th>OCCUPANCY</th>
<th>AVG UNIT SIZE</th>
<th>AREA PER PERSON</th>
<th>PERSONS PER UNIT</th>
<th>TYPE OF MATERIALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;2500</td>
<td>5 m x 7 m</td>
<td>3.1 - 4.7 m²</td>
<td>8 - 16</td>
<td>Prefabricated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;4.5 m</td>
<td></td>
<td>or Precast</td>
</tr>
</tbody>
</table>

**TYPICAL LAND USE**

60% built area [70% housing and 30% services] and 40% open area
### On Ground Practices vs Best Practices/Guidelines

<table>
<thead>
<tr>
<th><strong>HABITABLE AREA PER PERSON</strong></th>
<th>1: 0.25 m²</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BEST PRACTICE/GUIDELINE</strong></td>
<td></td>
</tr>
<tr>
<td>ON-SITE HOUSING</td>
<td>3.4 - 4.8 m²</td>
</tr>
<tr>
<td>OFF SITE DORMITORIES &amp; HOSTELS</td>
<td>1.8 - 2.2 m²</td>
</tr>
<tr>
<td>OFF SITE HOSTELS</td>
<td>2.8 - 3.7 m²</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>NATURAL LIGHTING &amp; VENTILATION</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BEST PRACTICE/GUIDELINE</strong></td>
<td></td>
</tr>
<tr>
<td>ON-SITE HOUSING</td>
<td></td>
</tr>
<tr>
<td>OFF SITE DORMITORIES &amp; HOSTELS</td>
<td></td>
</tr>
<tr>
<td>ON-SITE HOUSING</td>
<td>None created</td>
</tr>
<tr>
<td>OFF SITE DORMITORIES &amp; HOSTELS</td>
<td>None or 1 window - 1/10th or 1/20th the floor area</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>KITCHEN SPACES</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BEST PRACTICE/GUIDELINE</strong></td>
<td></td>
</tr>
<tr>
<td>ON-SITE HOUSING</td>
<td></td>
</tr>
<tr>
<td>OFF SITE DORMITORIES</td>
<td></td>
</tr>
<tr>
<td>ON-SITE HOUSING</td>
<td></td>
</tr>
<tr>
<td>OFF SITE HOSTELS</td>
<td></td>
</tr>
<tr>
<td>ON-SITE HOUSING</td>
<td>For communal kitchen (2.7 m² per family or 8-10 persons or one stove or two families)</td>
</tr>
<tr>
<td>OFF SITE HOSTELS</td>
<td>None provided</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>HEALTHCARE/CLINICS &amp; COMMUNITY SPACES</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BEST PRACTICE/GUIDELINE</strong></td>
<td></td>
</tr>
<tr>
<td>ON-SITE HOUSING &amp; OFF SITE DORMITORIES</td>
<td></td>
</tr>
<tr>
<td>OFF SITE HOSTELS</td>
<td></td>
</tr>
<tr>
<td>ON-SITE HOUSING &amp; OFF SITE DORMITORIES</td>
<td>No Community Space or Clinic Provision</td>
</tr>
<tr>
<td>OFF SITE HOSTELS</td>
<td></td>
</tr>
<tr>
<td>ON-SITE HOUSING &amp; OFF SITE DORMITORIES</td>
<td>1 to 1.5 m² of dining space per person allocated</td>
</tr>
<tr>
<td>OFF SITE HOSTELS</td>
<td></td>
</tr>
<tr>
<td>ON-SITE HOUSING &amp; OFF SITE DORMITORIES</td>
<td>1 clinic/sick room for the camp - approximately 1000 people</td>
</tr>
</tbody>
</table>

### Natural Lighting & Ventilation

- **Best Practice/Guideline**
  - 2 windows or 1 window + ventilator system. One-fifth of the floor area
  - Windows to be shaded with chajjas and louvers. Screened with 16-mesh material

### Kitchen Spaces

- **Best Practice/Guideline**
  - For communal kitchen (2.7 m² per family or 8-10 persons or one stove or two families)

### HealthCare/Clinics & Community Spaces

- **Best Practice/Guideline**
  - Should accommodate 1/3 of the occupants at a time. 1.2 m² per person to be allocated
  - 1 clinic with pharmacy; 1 ward bed for every 300 persons
On Ground Practices vs Best Practices/Guidelines

### ENERGY & TECHNOLOGY

#### Best Practice/Guideline

- **Address the energy needs of individuals and families:**
- **1 ceiling fan for 4 Beds/ Bunk Beds or 1 ceiling or pedestal fans per 2 persons based on climate zone.**
- **Battery based lanterns - 1-2 lights (usually dim) and mobile charging.**
- **Light levels in toilet and storage rooms shall be at least 80 to 120 Lux. Kitchens and living quarters, shall be at least 150 to 200 Lux.**
- **1 ceiling, 1 mobile charging and 1 ceiling or pedestal fan per room.**
- **Light levels in toilet and storage rooms shall be at least 80 to 120 Lux. Kitchens and living quarters, shall be at least 150 to 200 Lux.**
- **1 ceiling fan for 4 Beds/ Bunk Beds or 1 ceiling or pedestal fans per 2 persons based on climate zone.**

#### On-Site Housing

- **Battery based lanterns - 1-2 lights (usually dim) and mobile charging.**
- **Limited time use DG Sets.**
- **Light levels in toilet and storage rooms shall be at least 80 to 120 Lux. Kitchens and living quarters, shall be at least 150 to 200 Lux.**

#### Off-Site Dormitories

- **Limited time use DG Sets.**
- **Light levels in toilet and storage rooms shall be at least 80 to 120 Lux. Kitchens and living quarters, shall be at least 150 to 200 Lux.**

#### Off-Site Hostels

<table>
<thead>
<tr>
<th>2 persons</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 ceiling light, 1 mobile charging and 1 ceiling or pedestal fan per room</td>
</tr>
<tr>
<td>Common utilities and services with ceiling-type light fixture.</td>
</tr>
<tr>
<td>Common rooms have other services for TVs, play rooms, shops etc</td>
</tr>
</tbody>
</table>

### SANITATION

- **1 Urinal**
- **1 Lavatory**
- **1 Wash Basin**
- **1 Shower**

#### On-Site Housing

- **None**

#### Off-Site Dormitories

- **None**

#### Off-Site Hostels

- **None**
Parameters for Upgradation

**SHORT TERM - COVID 19 RESPONSE STRATEGIES**

### SETTLEMENT LEVEL

The mobility of people to and fro the housing settlement needs to incorporate thermal screening and hand wash stations. Separate clinic and isolation ward should be set up.

All entry and exit points with security guard chambers needs to be outfitted with IR thermometers to screen everyone entering the settlement. Queueing area need to be shaded and provided with markings for physical distancing. Upon entry, handwashing stations need to be provided. If an inhabitant is screening with fever, clinic/ isolation ward need to be located near to entrance to immediately quarantine them.

### UNIT/BLOCK LEVEL

The unit or block level housing has to be provided with decentralised services of hand wash stations, toilets, bathing areas, water supply, energy, recreational and dining spaces.

### CLINICS & ISOLATION WARDS

1 Clinic station mandatory per camp

Setting up 1 bed per 300 population for isolation and quarantine

2 Beds for a 600 occupancy camp

8 Beds for a 2400 occupancy camp
Parameters for Upgradation

LONG TERM - RISK REDUCTION AND RESILIENCE BUILDING STRATEGIES

DESIGNED DENSITY

Occupancy of a unit/room (living/sleeping area), open area at site level, Ratio of services/utilities per person

Strategies to maintain density without overcrowding

‘High density’ is commonly confused with ‘high rise’. In the cases of labour colonies, high density is usually the result of over crowdedness at a unit level and having low rise residences. The critical contribution higher densities can make to reducing energy consumption is in lowering the cost of servicing urban areas. As development density increases the per capita cost of providing services such as water, gas, electricity and waste disposal reduces. In labour colonies, designed density can optimise cost spent per person/inhabitant.

DECENTRALISED UTILITIES AND SERVICES

Upgradation of settlement layout by providing Decentralised Utilities and Services

Access to Energy
Access to energy for unit and settlement lighting, cooling. Energy for common utilities and services as well as for WASH, Water, Kitchen usage.

WASH Services
Latrines, not more than 50m from shelter and not closer than 6m. Waste water to be directed towards soak pits. Sufficient hand wash and showering units as per population.

Water Supply and Filtration
At every 30 m with sufficient clean supply (90L/person/day), hands free usage and maintained efficiently

Kitchen, Cooking and Dining
Dedicated entries and exits, Storage facilities, mechanical ventilation, easy to clean surfaces and hand washing stations.

Creches and Childcare Spaces
Provisions of hand washing stations, allowing for staggered timings, insisting on sanitation

Stores and Shops
Regulating numbers, controlling queue and using plexiglass and contactless payments.

Community and Recreation Spaces
Provision of hand washing stations, focus on sanitation and allowing space for social distancing

Waste Management
Dedicated spaces with adequate coverings and forward treatment, collection linkages

PASSIVE DAYLIGHTING AND VENTILATION STRATEGIES

Mapping the sun path diagram and micro climate wind direction to arrive at climate responsive designs to reduce heat gain, improve natural ventilation and optimise on daylighting.

Based on the sun path diagram, designing shading devices like chajjas, louvers, roof overhangs and courtyards to create spaces for heat relief. This also helps capture north light for glare free uniform lighting.
Building Technology Status and Potential Upgradations

**Based on climate zones (ref: Trewartha classification), climate stressors like heat, rains, floods, cyclones etc, terrain - informed decisions can be made on planning, shape, hierarchy of spaces, fenestration designs and material or insulation selection.**

**ON-SITE/IN-SITU HOUSING**

**GI SHEET**

<table>
<thead>
<tr>
<th>LIFETIME</th>
<th>RECOMMENDED OCCUPANCY</th>
<th>ROOM SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;5 Years</td>
<td>2 to 7 persons</td>
<td>3 x 3 m</td>
</tr>
</tbody>
</table>

**ATTRIBUTES**

- LABOUR INTENSIVE
- CONSTRUCTED IN-SITU

**COMMON MATERIALS USED**

- Gi Metal, Asbestos sheets, Hollow Cement Blocks, Tarpaulin, Bamboo/ Casuarina Poles, Scaffolding framework, earth, cemented, PCC floor plinth

**INSULATION UPGRADES**

- **White Puf Panel Colour Coated**
  - Size: 3.5ft x 10ft
  - Thickness: 80 mm
  - U-Value: 0.297 w/m²k

- **Bamboo Mat Sheet**
  - With reflective surface treatment
  - Size: 3.5ft x 10ft
  - Thickness: 3 mm
  - U-Value: 5.2 w/m²k

**LIGHT AND VENTILATION UPGRADES**

**Fenestrations**

**Before Intervention**

**After Intervention**

**Turbine Air Ventilator**

- **Material**: Aluminium, steel or stainless steel turbines
- **Location**: Mounted on roof
- **Size**: 21"/24" Diameter
OFF SITE HOUSING

PREFABRICATED COMPONENTS

LIFETIME
15+ Years

RECOMMENDED OCCUPANCY
2 to 7 persons

ROOM SIZE
3 x 3 m

ATTRIBUTES

 jot

 COMMON MATERIALS USED

 Colour coated metal/ EPS/ PUF panel walls and roofing, MS or light gauge steel frame with PVC sliding window and door

INSULATION UPGRADES

Ekopanely or Ecoboard
Size: 13ft x 6ft
Thickness: 90-120 mm
U-Value: 0.099 w/m2k

Fibre Glass Insulation
Add on
Thickness: 80-125 mm
U-Value: 0.09 w/m2k

Mineral Wool Slabs
Add on
Thickness: 100 mm
U-Value: 0.25 w/m2k

LIGHT AND VENTILATION UPGRADES

Fenestrations
Heat

Wall Ventilators

Material: With louvers, shutter made from glass, polycarbonate, UPVC or wood etc

Air and Light Vent

Mineral Wool Slabs
Add on
Thickness: 100 mm
U-Value: 0.25 w/m2k

Fibre Glass Insulation
Add on
Thickness: 80-125 mm
U-Value: 0.09 w/m2k

Ekopanely or Ecoboard
Size: 13ft x 6ft
Thickness: 90-120 mm
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Before Intervention

MS framed Polycarbonate or Acrylic Skylight

Customised to site

After Intervention

Ekopanely or Ecoboard
Size: 13ft x 6ft
Thickness: 90-120 mm
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Add on
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Mineral Wool Slabs
Add on
Thickness: 100 mm
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Before Intervention

MS framed Polycarbonate or Acrylic Skylight

Customised to site

After Intervention
Case Study - Sustainable Built Environment Breakeven Calculation

The finding stated here were analysed post the assessment of housing settlements across Bangalore and detailed assessment of a labour colony, in collaboration with a developer in Bangalore for Off site Dormitory type settlement on rental land and grid electricity.

The study analysed both spatial planning and efficient use of resources in the running of a large settlement. It also attempts to cater to the complex cultural and social issues which people face with the hope of proposing a feasible architectural solution which would be appropriate, portable and sustainable. The same has been done by understanding the lifestyle of the residents occupying these settlements and best practices from other organisations referred to in this report.

Additionally, a study was done on the feasibility of implementing the proposed solutions, understanding the transitory nature of such camps that are rebuilt in new locations every 4 to 5 years and curtailing the reuse of the materials to a maximum of 12 years. The comparison was made between existing conditions and solutions with ideal Built Environments and Efficient Equipment.

Left: Interior view depicting passive methodology of cross ventilation, daylight and roof insulation and shading that create conditions of thermal comfort and energy efficiency.

Right: Ideal courtyard cluster planning for housing settlements - Circulation from the public to the private is curated. Foyer like conditions at the entrance of each cluster. Shaded semi public spaces for interacting safely while maintaining physical distance. Allows for maximum exterior walls and design of fenestration for cross ventilation.
## Case Study - Sustainable Built Environment Breakeven Calculation

<table>
<thead>
<tr>
<th>Settlement size - 1 Acre / 800 persons</th>
<th>Life of infrastructure</th>
<th>Breakeven Period</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Built Environment</strong></td>
<td>Current Scenario</td>
<td>Proposed solution</td>
</tr>
<tr>
<td></td>
<td>1 construction cycle**</td>
<td>4 construction cycles (actual 10 cycles) - within 3 construction cycles</td>
</tr>
<tr>
<td></td>
<td>including material and labour cost; Excluding maintenance and transportation costs</td>
<td>Including material, labour, maintenance and transportation costs</td>
</tr>
<tr>
<td><strong>Basic Energy for households and street lighting only</strong></td>
<td>1 construction cycle - recurring electricity costs; new electricity connection for each camp/colony</td>
<td>4 construction cycles - One time infrastructure cost; Battery, luminary and fixtures replacement every 8 years, reinstallation every cycle</td>
</tr>
<tr>
<td><strong>Basic Energy for other utility or recreational only</strong></td>
<td>1 construction cycle*</td>
<td>1 construction cycle*</td>
</tr>
</tbody>
</table>

### Inefficient Old Design vs Efficient New Design - Comparison of total accumulated cost for 13 years over various construction cycles

- **GI Sheet walling with Scaffolding framework with single door and window and concrete base plinth (excluding maintenance and transportation cost)**
- **Transitionary (nut-bolt) MS Pipe framework with Bison board walling, one door and two windows with gable clerestory for natural light (including material cost, replacement of sheets and framework, labour and transportation charges)**
Case Study - Sustainable Built Environment Breakeven Calculation

For Housing Units

For Kitchen and Dining Units

For WASH Units

For Shops and Other Auxiliary Functions

- Grid Cost with Efficient Luminaries and without Sustainable Built Environments
- DC Cost with Inefficient Luminaries and with Sustainable Built Environments
- DC Cost with Efficient Luminaries and with Sustainable Built Environments
Solar panels powering the whole colony

Rooms open to the common corridor that connects with the central space

Each room can occupy 4 people comfortably

Optimum storage provided in each room.

**ENERGY OPTIMIZATION STRATEGIES**

- Materials used include insulated aerocon panels and puffed panels for roof. Insulation helps in keeping the space within comfortable range of temperature.

- Solar is used for clean energy and efficient electrical appliances are used.

- Sufficient fenestrations are given and rooms open towards corridors that reduce the use of artificial lighting and use of fan for ventilation.

**MODULE HOUSING FOR 100 WORKER INTEGRATED WITH SUSTAINABLE ENERGY** - Case study to outline standardised templates and business models

**Without energy optimizing appliances**

52.8 KW/day

**With energy optimizing appliances**

17.5 KW/day

Saves 66.86% energy per day
W O R K E R ’ S H O U S I N G, W H I T E F I E L D
PARTNERED WITH LABOURNET

GROUND FLOOR PLAN

ROOMS
(4354.3 sq ft)

LAUNDRY
(525.4 sq ft)

RECREATION
(2012.6 sq ft)

DINING
(1118.3 sq ft)

WASHROOM
(582.4 sq ft)

KITCHENS
(444.6 sq ft)
Inefficient Old Design vs Optimum New Design - Comparison of costs for Built Environment - Breakeven will be achieved at year 16

Comparison of costs for Energy + Built Environment
Re-looking Construction Worker Housing through the lens of COVID-19, Sustainable Energy and Energy Efficiency

Thank You!
For more information please get in touch:
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