

# Storm Resistant Affordable Housing in Agra, India

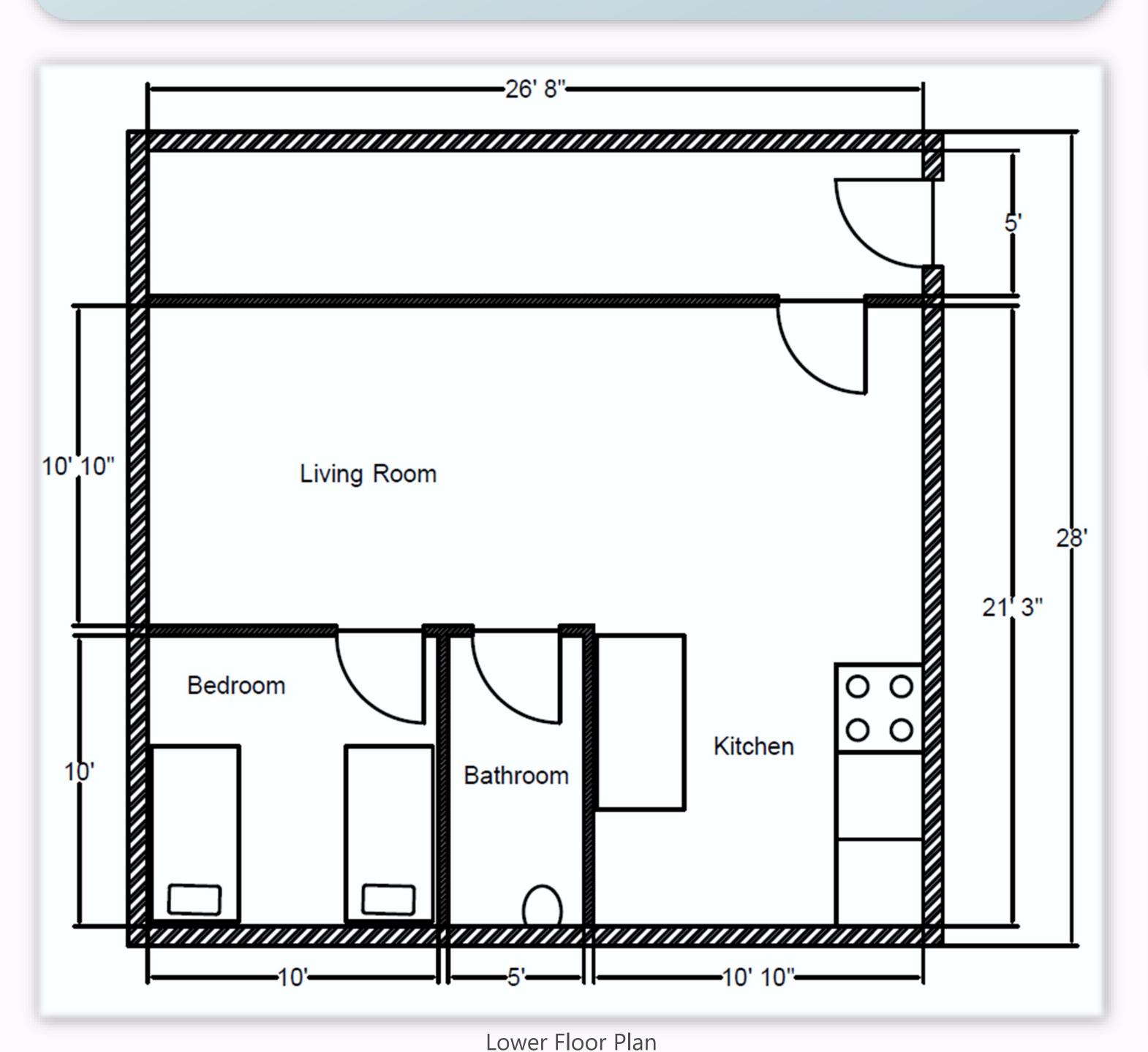
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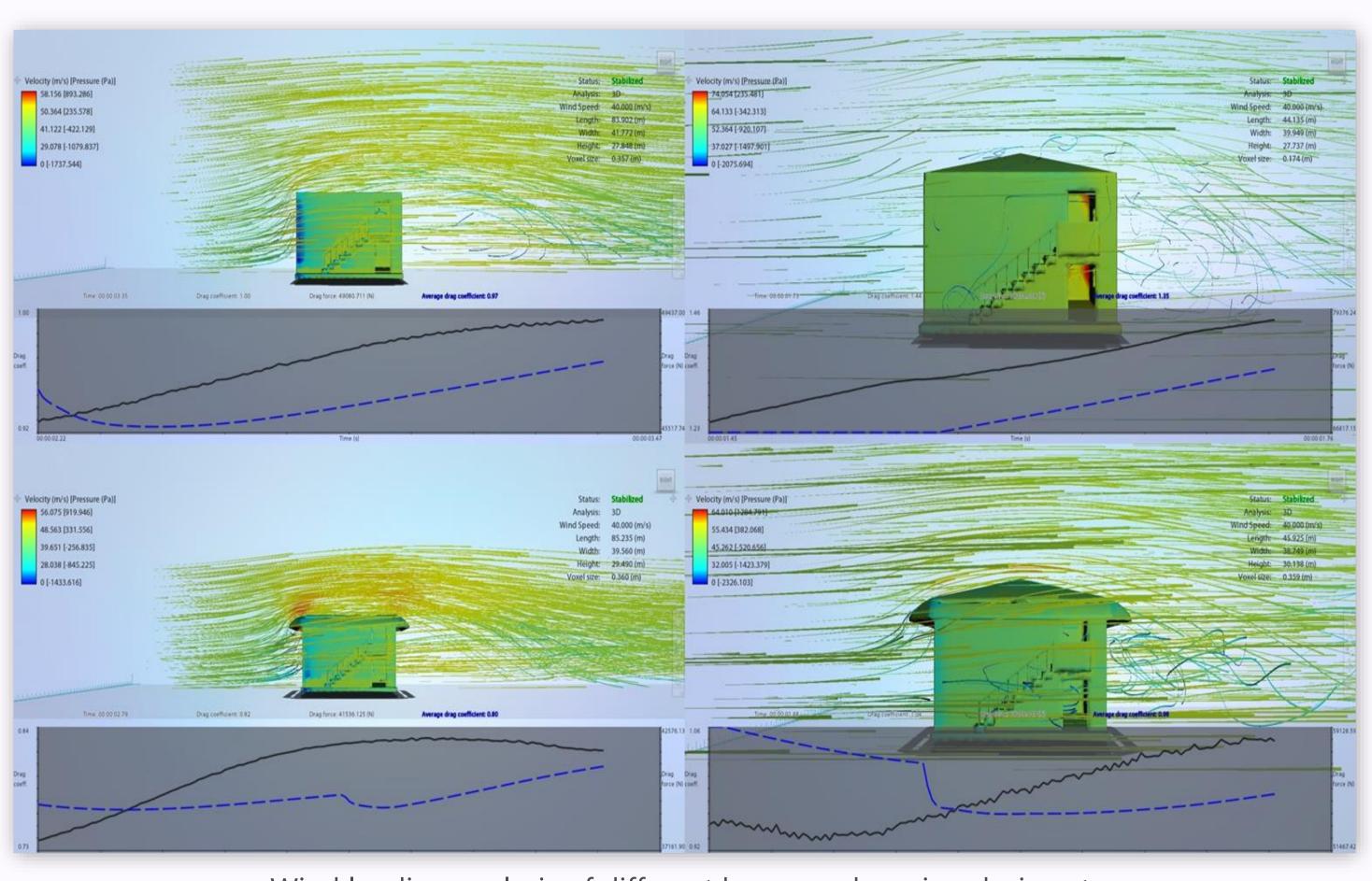
## **Abstract**

Currently, the slums are populated with inadequate shelters for the increasingly dangerous conditions present in Agra, India. In the most recent dry season, one dust storm leveled many slum residences resulting in nearly 125 deaths. The families and individuals left with no shelter then had to brave the severe rain and flooding during the monsoon season. In this project, we design a shelter, which has a slotted awning to help reduce the wind loading on the structure, and GFRG panels to improve strength and ease of construction. We modeled the building, performed a cost analysis, and created a plan for the construction process of an initial run of 5 houses, that meet all of the constraints put on houses in Agra slums.

### Constraints

- Vasta Shastra, the doctrine of Hindu architecture, is reflected through orientation, site planning, and proportionality by placing kitchen on east side and living space on north end
- Average family size of 6.7 people per house
- > Typical house size ranges from 729 ft<sup>2</sup> to 900 ft<sup>2</sup>
- Average monthly income of 40.67-67.78 USD per household
- Area of undersized and structurally deficient urban slums
- Dust storms and monsoons impact the structurally integrity of the houses and the safety of the residents with their high winds and flooding

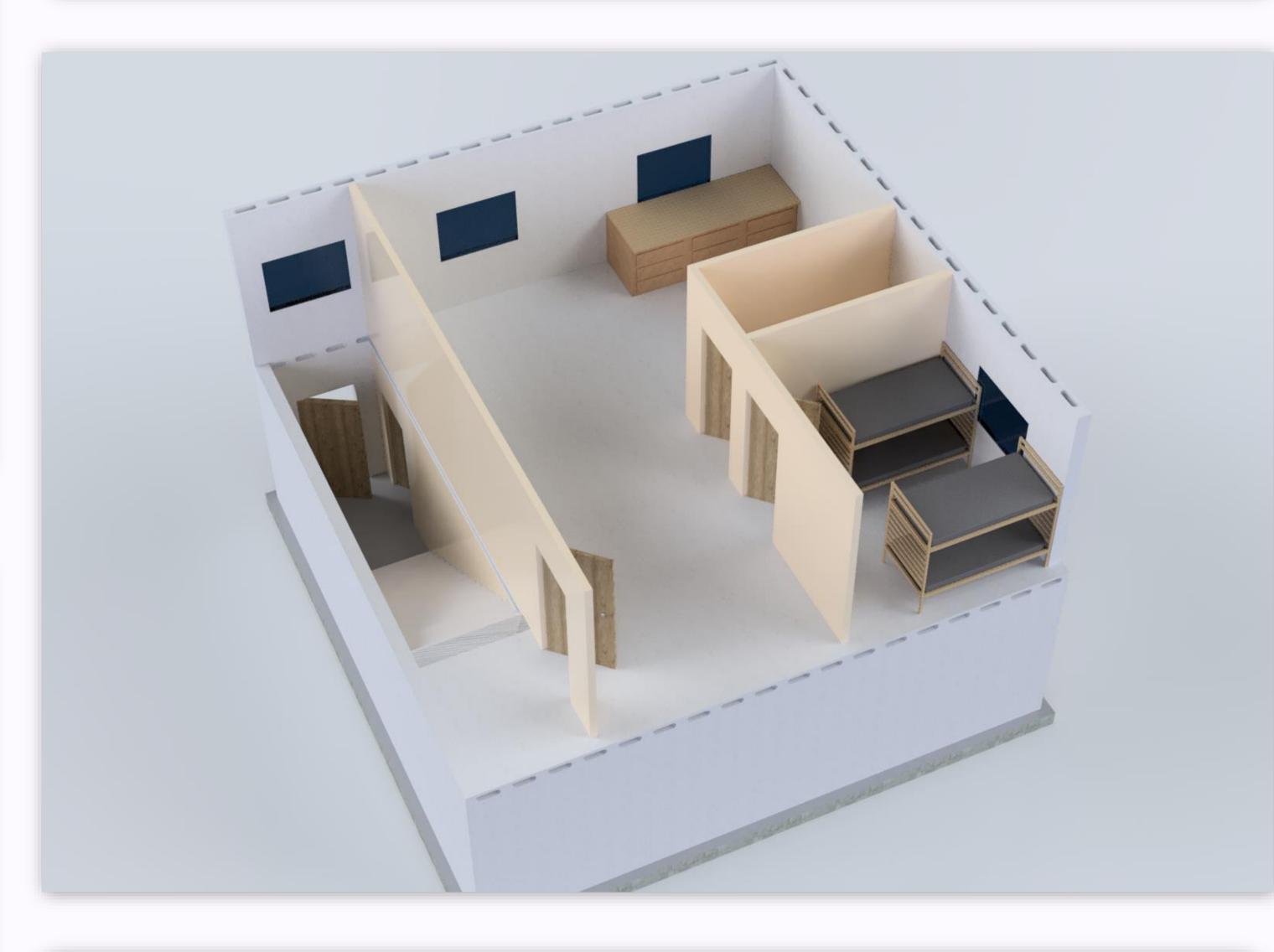




Wind loading analysis of different house and awning designs to determine the most effective design solution

### Design

- Glass Fiber Reinforced Gypsum (GFRG) panels for walls
- Flat roof with slotted awnings
- > Liquid barrier on bottom of walls
- Shield for door
- > 10-week implementation process



#### **Cost & Construction**

- Compared the cost of brick and GFRG
- A brick building would be slightly cheaper, but GFRG panels reduce maintenance cost and greatly reduce construction time
- Estimated construction cost: 8500 USD
- Estimated furnishing cost: 1000 USD
- Total estimated cost: 9500 USD

| Affordable Housing in Agra Gantt Chart *= Cakvlated Valve |       |                       |       |                 |   |     |   |   |   |   |   |   |   |    |
|---|-------|-----------------------|-------|-----------------|---|-----|---|---|---|---|---|---|---|----|
| Task  | Start | Duration <sup>3</sup> | * End | Months<br>Prior | 1 | 2   | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Fundraising   |       | -                     |       |                 |   | 4.5 |   |   |   |   |   |   |   |    |
| Community Meetings  | 1     | 8                     | 8     |                 |   |     |   |   |   |   |   |   |   |    |
| Design Input  | 3     | 8                     | 10    |                 |   |     |   |   |   |   |   |   |   |    |
| Worker Recruitment & Training                             | 9     | 10                    | 18    |                 |   |     |   |   |   |   |   |   |   |    |
| Site Preparation  |       |                       |       |                 |   |     |   |   |   |   |   |   |   |    |
| Site Clearing   | 16    | 4                     | 19    |                 |   |     |   |   |   |   |   |   |   |    |
| Site Grading  | 19    | 5                     | 23    |                 |   |     |   |   |   |   |   |   |   |    |
| Materials Transport                                       | 21    | 5                     | 25    |                 |   |     |   |   |   |   |   |   |   |    |
| Construction  |       |                       |       |                 |   |     |   |   |   |   |   |   |   |    |
| Foundation Laying   | 23    | 3                     | 25    |                 |   |     |   |   |   |   |   |   |   |    |
| 1st Floor Wall Construction                               | 25    | 6                     | 30    |                 |   |     |   |   |   |   |   |   |   |    |
|   | 31    | 2                     | 32    |                 |   |     |   |   |   |   |   |   |   |    |
| 2nd Floor Wall Construction                               | 33    | 6                     | 38    |                 |   |     |   |   |   |   |   |   |   |    |
| Roof Construction   | 38    | 3                     | 40    |                 |   |     |   |   |   |   |   |   |   |    |
| Interior Furnishing & Finishing                           | 36    | 7                     | 42    |                 |   |     |   |   |   |   |   |   |   |    |
| Wrap Up   |       |                       |       |                 |   |     |   |   |   |   |   |   |   |    |
| Site Cleanup  | 40    | 5                     | 44    |                 |   |     |   |   |   |   |   |   |   |    |
| Move In   | 44    | 2                     | 45    |                 |   |     |   |   |   |   |   |   |   |    |
| Community Debrief   | 46    | 5                     | 50    |                 |   |     |   |   |   |   |   |   |   |    |