INFORMAL HOUSING:
REDUCING DISASTER VULNERABILITY
THROUGH SAFER CONSTRUCTION

Manual for Improving
Construction
in Informal settlements

WORLD BANK
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This manual provides guidelines for improving construction of houses in informal settlements. It is aimed at reducing the vulnerability of the houses and increase their safety and livability. It is designed to be used as a quick reference for house owners and contractors in informal settlements. For the house owners and occupants, it serves as a guide for construction and maintenance of the house; for contractors, it presents ways to explore new possibilities with existing as well as alternative materials.
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1.1 USING TIMBER

PRECAUTIONS
A. While choosing wood house owners should ensure that wood is free of rots, cracks, bends, excessive holes and infestation.
B. The house occupants should be watchful for signs of wood damage. Wood with infestation, rot, bends should be removed, and any cracks stitched.

A Typical defects in second hand timber

B Embedding timber members using waterproofing compounds

C Typical assembly for timber beams
**PRECAUTIONS:**
A. Ensure that the steel is not corroded/ rusted.
B. Be watchful for rust and immediately remedy such occurrences by scrubbing off the rust and applying a coat of paint over the steel.
C. Scrub off any minor surface corrosions before use. Coat all steel members with red-oxide. A coat of oil paint will further enhance the life of the steel.

1.2 USING STEEL

Welds are faster, easier and cheaper to install than rivets.

Steel sections should be embedded using Black Japan waterproofing or a base plate.

Steel sections should be installed vertically for structural purposes.

A Structural steel members.

B

C

D
1.3 USING BRICK

A. Concrete pads with nominal reinforcement at 1m intervals to strengthen the brick wall.

B. Plastic sheet can be used as a cladding materials where plastering is not possible.

C. Corbelled openings with protective iron mesh are cost effective. Rectangular openings must be maximum 2’ with kudappa lintel.

PRECAUTIONS
A. Bricks must be hard, uniform in color and free from holes or cracks.
B. Soak the bricks in water two hours before use.
C. Mortar : 1 part cement and 4 to 6 parts sand
D. Tests for quality of sand –
   i. Check by rubbing the sand against the fingers: if it sticks to the hand it contains clay/organic matter.
   ii. Keep a small portion of sand in a transparent jar with water for some time. The clay layer will be distinctly formed if present.
   iii. The water can be tasted to identify the presence of salt.
E. Do not ignore critical signs like vertical deep cracks, sinking, tilting, etc. Take immediate measures to remedy it. Fungus/ mold may be observed on the internal surfaces during monsoons. Scrubbing and application of boric powder dissolved in water is effective against such fungus mold.
1.4 USING GALVANIZED & CORRUGATED SHEET

PRECAUTIONS:
A. Ensure that the GI sheet is not rusted, and that the coating of galvanization is intact. Thicker gauge sheets are preferred.
B. House occupants should be watchful for signs of rusting. Where rusting is observed immediately remedy that by scrubbing off the rust and applying a coat of paint over the sheet. If the damage is severe, the sheet should be replaced.

A) Corrugations should be vertical when GI sheets are used for wall cladding.

B) GI sheets should be bolted at the crests and never at the troughs. While fixing the bolts, rubber washers should be used.

C) Accessories can be used to resolve corners and joints.

D) Detail showing overlap of GI sheets and location of J-bolts.
1.5 USING PLYWOOD

Typical deterioration that can occur in re-cycled plywood sheets.

PRECAUTIONS:
A. Second-hand plywood may also come in varying sizes. Smaller pieces are cheaper, but create more joints and are difficult from a construction perspective. Avoid using plywood as external cladding as it is susceptible to rotting from dampness or water.
B. Be watchful for signs of termite infestation, bends and cracks in plywood. Immediately remove and replace pieces with infestation, rot, or bends, and stitch any visible cracks.
1.6 USING PLASTIC, VINYL & TARPULIN

PRECAUTIONS:
A. Ensure that the sheet has no holes and that is does not crack when bent. The material should be thick enough to withstand the weather.
B. Remove sheets after every monsoon; if left longer, they will collect dirt causing pest infestation.
C. Ensure that the sheets are stored away from fire hazards. Also take care to avoid rips or scratches from rodents or animals. In case of a tear, the sheet should be mended with rubber solution.

A. Plastic sheet can be used as a cladding material where plastering is not possible.
B. Method for fixing plastic sheets on roofs.
C. Recommended method for joining two sheets.
D. Method for fixing plastic sheet to a timber member.
2.1 IMPROVING EXISTING METHODS: TYPES OF CONSTRUCTION

Slum construction consists of 3 main types –

A. *Dry construction with steel frame and GI sheet cladding*
B. *Hybrid construction (brick walls for the ground floor and GI sheet cladding for upper floors).*
C. *Wet construction, using brick walls and GI sheet roofing.*

![Dry Construction with Steel Frame and GI sheet Cladding](image1)

![Hybrid Construction (Brick for the ground floor and Steel frame + GI sheet cladding for upper floor).](image2)

![Wet Construction with Brick Walls and GI sheet Roofing](image3)
2.2 IMPROVING EXISTING METHODS: FOUNDATION & PLINTH

A Ensure footing below walls and an internal plinth above ground level

B Typical foundation details with pedestals

C Recommended plinth configuration: include recycled plastic sheet to guard against water seepage from the ground.
2.3 IMPROVING EXISTING METHODS: WALLS

A. Wooden structure

B. Steel structure

C. Brick structure

NOTES:

A. Use a coat of Black Japan on structural members wherever steel and wooden structural members come in contact with the ground or with wet construction.

B. Anchor the steel and wooden structural members: a 300mm anchoring into a pedestal for wood and in case of steel, a base-plate over the pedestal is required.

C. Vertical structural members should be full length for at least one storey.

D. The spacing between two such members should be 1.2 m. These members should be tied by horizontal short struts/long ties (3.75cm X 5cm wooden sections or 3.75cm X 3.75cm angles in case of steel). Use of cleats to support struts is recommended. At the top level, the vertical structural members should be tied with a long continuous member on the edge or a ring beam.
Details for wall/ring beam assembly

D Use of ring beams and base plates in wood, steel and brick construction.

E Method for fixing J-bolts for wooden and steel members

F Alternate methods for securing corners of GI sheet walls.

NOTES:
A. Secure corners of GI sheet cladding by folding sheets or use a corner/angle piece. GI sheets used for cladding should always be aligned so that corrugations are vertical, with an overlap of at least 10cm.
B. Use a brick wall at least one brick thick on the lower level and half brick thick on the upper level.
C. Horizontal reinforcing ties after every one meter height will make the walls stronger.
D. Plaster and paint both sides of the wall (should funds be scarce all the external faces of brick walls must be plastered).
E. If plaster is not possible on the external surface, a plastic sheet or tarpaulin sheet should be stretched over such surface during monsoons.
2.4 IMPROVING EXISTING METHODS: FLOOR ASSEMBLY

NOTES:

A. Coat all structural members (steel, wood) with Black Japan wherever they come in contact with ground or with wet construction. All structural members should be coated with red-oxide before use; a coat of paint is recommended after installation.

B. All spanning members should be used in vertical sections. Use of cleats / capitals is advisable to support them. As far as possible, joists should sit over vertical members. Where this is not possible, they should sit on a ring beam spanning across structural members.

C. Steel joists: Steel joists for a span of 1.2m should be 3.75cm x 3.75cm angles. The joists should then sit on beams that span the shorter dimension of the room. These should sit exactly over the vertical structural members. A steel beam spanning 3m should be at least 5cm x 7.5cm
NOTES:
A. Block-board is preferable over plywood. If plywood is used, it should be at least 25mm thick.
B. The floor boards are to be supported over joists that are not more than 0.6m apart from each other, and spanning no more than 1.2m.
C. Wood joists: The joist size for a span of 1.2m should be 3.75cm x 5cm. The joists should then sit on beams spanning the shorter dimension of the room, aligned exactly over the vertical structural members. A beam spanning 3m should be at least 7.5cm x 15cm.
D. Stone flooring can only be used when the vertical structure is in brick or steel.
E. Anchor the steel beams (with Black Japan treatment) into the brick wall or weld them to the steel vertical members. The beams should be I, C or box sections of size 7.5cm x 12.5cm, spanning a distance of 3m, and should be placed at a distance of 1.2m.
F. Attach the joists (I or inverted T sections) of dimensions 5cm x 10cm to these beams; ensure that the distance between two joists is not more than 60cm.
G. Minimum 3.75cm thick kota or 5cm thick kuddapa should be placed on these joists. These surfaces should be then covered with a coba of 5cm before finishing the surface with another thinner stone or tile. Ensure that none of the steel members are exposed to rain water.
2.5 IMPROVING EXISTING METHODS: ROOF ASSEMBLY

A Recommended overhangs and slope.

B Recommended spacing of joists for roofs.

C Junction of GI roofs (& overhangs) and adjoining walls.
2.6 IMPROVING EXISTING METHODS: THERMAL COMFORT

A  Transparent sheet for lighting

B  Ventilator over roof

C  Improving heat resistance in GI walls

D  Section, view of ventilator gap between wall and roof

E  Views of rain screen and window

F  Small corbelled openings with mesh for protection, small corbelled openings
2.7 IMPROVING EXISTING METHODS: SPACE UTILIZATION

NOTES:

A. By increasing the height of single storied structures to 4.2-4.5m, instead of 2.8-3.0m, a loft can be inserted to create more living space inside the house. Storage or living space can also be created under the pitch of a sloping roof. All such lofts and mezzanines should be supported on vertical structural members or walls.

B. Ladders, beds, seating places, etc. could be designed to double their usability as storage spaces.

C. Brick walls can be modulated in such a manner that they can double as storage spaces. Instead of a complete single brick wall, it can be half brick thick with piers of one and half brick thickness. This will save material and also create niches for storage, saving on furniture costs.
2.8 IMPROVING EXISTING METHODS: MAINTENANCE

A  Bends/cracks to be immediately strengthened by adding another member

B  Rotting wood to be removed and replaced either partially or completely

C  Treatment to structural members against structural weakening, corrosion and rotting

D  Maintaining clean surroundings to avoid infestation by insects and pests
Notes for selecting construction-grade bamboo:

A. Depending on the species, 3 to 5 year old bamboo is best for construction purposes.
B. Do not expose the bamboo poles to direct sun, moisture and rain.
C. Use only straight portions from the bamboo culms for construction poles. Poles should be treated to protect against insects and fungus.
D. Basic components for construction of a bamboo house include wire, bolts, chicken mesh, and cement.
Details for bamboo house assembly

- Anchor bolt inside bamboo
- Concrete
- Bamboo
- MS bars for anchoring bamboo grid
- Timber roof top plate
- Chicken wire mesh
- Vertical split bamboo
- Cement mortar
- Bamboo trussed rafter
- Bamboo purlins
- Split bamboo ridge
- J-bolts
- Bamboo mat corrugated sheet

Inserting short smaller diameter bamboo pole to strengthen bamboo pole at joint

- Timber ring beam
- Anchor bolt
- Bamboo pole
- Bamboo truss
- Timber ring beam
- Bamboo pole
3.2 ALTERNATIVE MATERIALS & METHODS – TIRE FOUNDATION & WALLS

**STEP 1:** Make a pit of width equal to the diameter of the tire. Ram well and make compact. Lay out a course of tires to establish the optimum lay with the least spacers. Half tires may be used to satisfy the required dimension. However, they are not to be used at the ends or corners.

**STEP 2:** Use sticks to prop the tire “open” and fill with dirt/earth. Remove sticks and pound the earth to compact. Plumbing lines may be placed between/along the tires, if needed, and pipe chases may be installed during tire wall construction.

**STEP 3:** Pour concrete over this layer. Set reinforcement bars into alternate tires with 5” of to be fitted on top

**STEP 4:** Install treated 2” X 12” sill plate and non-treated bond beam. This will ensure better construction joints for superstructure.
3.3 ALTERNATIVE MATERIALS AND METHODS – ALUMINIUM CANS

A **House with walls made with aluminum cans**

B **As a module**

C **As individual units**

D **Crushed cans**

E **In combination with glass bottles**
3.4 ALTERNATIVE MATERIALS AND METHODS – PLASTIC BOTTLES
3.5 ALTERNATIVE MATERIALS AND METHODS – GLASS BOTTLES

NOTES;
A. Prepare the bottles by removing the labels and washing each thoroughly with soap and warm water.
B. Leave caps on empty bottles only if they are completely clean and dry inside.
C. Use the glass bottle as a masonry unit and bind with sand, adobe, cement, stucco, clay, plaster or mortar.
D. Reinforcement bars can be set in foundation and continue vertically.
E. The wall will be more sturdy the more mortar it has.
3.6 ALTERNATIVE MATERIALS AND METHODS - FLY ASH

A. Buildings made with fly ash bricks

Advantages over bricks:
A. Better strength to weight ratio.
B. Reduction of dead load resulting in reduction in foundation size.
C. Better acoustical and thermal insulation.
D. Saving in consumption of mortar.
E. Higher Fire Rating.
3.7 ALTERNATIVE MATERIALS AND METHODS - FURNITURE

A Chair made from cardboard

B Bed of plastic bottles

C Crushed aluminum cans

D Storage unit made of pipes

E Sofa from paper mache

F Bottle cap curtain