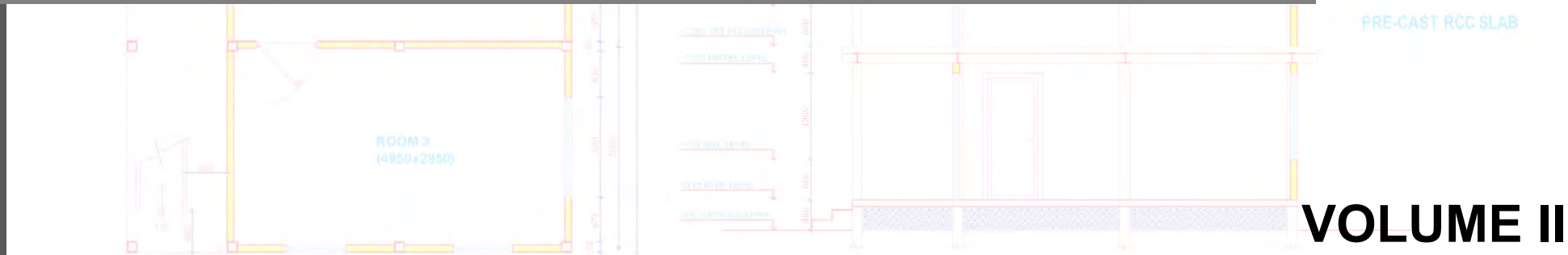


Catalogue for Alternative Construction Materials and Technologies

DESIGN CATALOGUE FOR RECONSTRUCTION OF EARTHQUAKE RESISTANT HOUSES



MARCH, 2017 (FALGUN, 2073)



GOVERNMENT OF NEPAL
MINISTRY OF URBAN DEVELOPMENT
DEPARTMENT OF URBAN DEVELOPMENT AND BUILDING CONSTRUCTION
BABARMAHAL, KATHMANDU

DESIGN CATALOGUE FOR RECONSTRUCTION OF EARTHQUAKE RESISTANT HOUSES

**Approved by Nepal Government (Minister Level/ Minister of Urban Development)
2073/12/16**

VOLUME-II



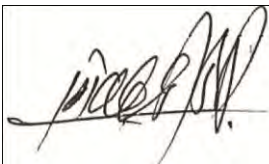
**GOVERNMENT OF NEPAL
MINISTRY OF URBAN DEVELOPMENT
DEPARTMENT OF URBAN DEVELOPMENT AND BUILDING CONSTRUCTION
BABARMAHAL, KATHMANDU**

FOREWORD

It is my immense pleasure that Design Catalogue Volume II comprising of alternative construction materials and technologies is published. The devastating Earthquake of 25th April 2015 and its aftershocks not only resulted in massive loss of life and properties but also raised awareness among development practitioners the need to improve our physical infrastructures to make our communities resilient against these kind of disasters. I see this post-earthquake reconstruction as an opportunity to improve our housing construction technology and practice at grass root level.

The objective of this document is to pave way for use of alternate materials and technologies in the reconstruction process. As per the principles set by Post Disaster Needs Assessment (PDNA) for housing and human settlements recovery and reconstruction, the proposed cost efficient, environment friendly and green technologies are expected to be helpful for sustainable reconstruction of both urban and rural houses.

I would like to sincerely thank Mr. Deependra Nath Sharma, respected Secretary of Ministry of Urban Development for his valuable support and suggestion during the process. I am also thankful to Mr. Ravi Shah, former Deputy Director General, Mr. Ram Chandra Dangal, Deputy Director General (Housing Division) and Mr. Raju Neupane, Senior Divisional Engineer and all the staffs of Housing Division for their continuous involvement during the preparation of this document. I also express my thanks to the team of Central Level Project Implementation Unit (CLPIU) for their support in bringing out this publication. My thanks also goes to all the personnel and agencies for their hard work and concerned efforts on preparation of this important document.



Er. Shiva Hari Sharma

Director General,

Department of Urban Development and Building Construction (DUDBC)



PREFACE

I would like to congratulate all the personnel and agencies involved in the development of Design Catalogue Volume II for reconstruction of Earthquake Resistant Houses. This publication has been developed by the Department of Urban Development and Building Construction to support urban and rural households in the reconstruction of their houses.

The second volume of Design Catalogue consists of seventeen model designs based on twelve alternative materials and technologies not covered by Nepal National Building Code. A wide variety in terms of materials, technology, cost, size and layout are provided to cater the diverse need of both urban and rural households. The proposed designs are ready to use designs and technical details are provided accordingly.

I again express my sincere thanks to members of Technical Working Group, Task Force, Structural experts, UNDP and all personnel of DUDBC and Central Level Project Implementation Unit (CLPIU) involved directly or indirectly in preparation of this publication.



A handwritten signature in black ink, appearing to read 'R. Dangal', written over a horizontal line.

Er. Ram Chandra Dangal

Deputy Director General,

Department of Urban Development and Building Construction (DUDBC)

BACKGROUND

The devastating earthquake of April 25th, 2015 and its aftershocks caused widespread damage to both life and properties. Housing and Human settlement sector was one of the most affected sector. The Government of Nepal figures indicate that around 602,257 houses were fully damaged, 285,099 houses were partially damaged and loss of life was about 9000.

The Post Disaster Needs Assessment (PDNA) report of Government of Nepal, sets out principles for housing and human settlements recovery and reconstruction as follows:

- Encourage the participation of communities by empowering them to take control of reconstruction of their houses and ensuring facilitation of Owner Driven reconstruction
- A comprehensive view of housing reconstruction should indicate holistic habitat development, with basic services and community infrastructure. The principles of Build Back Better (BBB) should translate into a concept of safer settlements.
- Reconstruction should be seen as a vehicle to build long-term community resilience by reducing vulnerabilities and strengthening community capacities to mitigate future disasters through improved construction practices for the majority of building stock in the country.
- Strengthen the local economy through reconstruction and processes that work to the benefit of the poor and marginalised sections who are mostly in the informal sector. Reconstruction should provide an opportunity for the poor to upgrade their living conditions.
- Ensure sustainable and environment-friendly reconstruction processes, taking note of climate change, natural resource management and scientific risk assessments.
- Ensure that rehabilitation is equitable and inclusive.

INTRODUCTION

DUDBC has prepared second volume of Design Catalogue and named it as “**Catalogue for Reconstruction of Earthquake Resistant Houses Volume II**”. The Catalogue includes architectural design, structural detailing and material estimate. The main objective is to support urban and rural households in reconstruction of their houses.

The model designs of seventeen houses provided in the catalogue are placed under the following twelve technologies:

- Interlocking Brick Masonry
- Confined Hollow Concrete Block Masonry
- Hollow Concrete Block Masonry
- Compressed Stabilized Earth Block Masonry
- Random Rubble Masonry with GI Wire Containment
- Bamboo and Stone Masonry Hybrid Structure
- Rat Trap Bond Masonry
- Earth Bag Masonry
- Light Gauge Steel Structure
- Steel Structure
- Timber Structure
- Debris block Masonry

The designs provided in this catalogue are based on calculations, model test and analytical tests as these technologies are not covered by Nepal National Building Code, 2060. These designs are approved by Ministry of Urban Development. For each design included in the catalogue, the following information is provided:

- 3D view of the design
- Floor plans
- Elevations
- Section
- Structural Details
- Quantity estimate of major materials

Designs included in this catalogue can be selected and used as they are, for reconstruction of urban and rural housing . For designs, other than those included in this catalogue, detailed engineering design and approval from concerned authorities shall be done.

LIST OF MODELS

S.N.	TECHNOLOGY	MODEL NO.	PAGE NO.
1	INTERLOCKING BRICK MASONRY		
1.1	ONE STOREY	I.B.-1.1	1
1.2	TWO STOREY	I.B.-1.2	8
1.3	ONE STOREY	I.B.-1.3	21
2	CONFINED HOLLOW CONCRETE BLOCK MASONRY		
2.1	TWO STOREY	C.H.C.-2.1	27
3	HOLLOW CONCRETE BLOCK MASONRY		
3.1	TWO STOREY	H.C.B.-3.1	40
4	COMPRESSED STABILIZED EARTH BLOCK MASONRY		
4.1	ONE STOREY	C.S.E.B.-4.1	53
4.2	TWO STOREY	C.S.E.B.-4.2	63
5	RANDOM RUBBLE MASONRY IN MUD MORTAR WITH GI WIRE CONTAINMENT		
5.1	ONE STOREY	R.R.M.-5.1	72
5.2	TWO STOREY	R.R.M.-5.2	79
6	BAMBOO AND STONE MASONRY HYBRID STRUCTURE		
6.1	TWO STOREY	B.S.M.H.-6.1	90
7	RAT TRAP BOND MASONRY		
7.1	ONE STOREY	R.T.-7.1	106
8	EARTH BAG MASONRY		
8.1	ONE STOREY	E.B.-8.1	118
9	LIGHT GAUGE STEEL STRUCTURE		
9.1	ONE STOREY	L.G.S.-9.1	131
9.2	TWO STOREY	L.G.S.-9.2	142
10	STEEL STRUCTURE		
10.1	TWO STOREY	S.S.-10.1	149
11	TIMBER STRUCTURE		
11.1	TWO STOREY	T.S.-11.1	162
12	DEBRIS BLOCK MASONRY		
12.1	ONE STOREY	D.B.-12.1	171

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HOLLOW CONCRETE BLOCK MASONRY	40-52
COMPRESSED STABILIZED EARTH BLOCK MASONRY	53-71
RANDOM RUBBLE MASONRY IN MUD MORTAR WITH GI WIRE CONTAINMENT	72-89
BAMBOO AND STONE MASONRY HYBRID STRUCTURE	90-105
RAT TRAP BOND MASONRY	106-117
EARTH BAG MASONRY	118-130
LIGHT GAUGE STEEL STRUCTURE	131-148
STEEL STRUCTURE	149-161
TIMBER STRUCTURE	162-170
DEBRIS BLOCK MASONRY	171-180

EARTHBAG MASONRY

E.B.-8.1

Earthbag technology is a simple, inexpensive and sustainable method for building structures using ordinary soil found at construction site. The technology consists of Polypropylene bags filled with locally available soil, laid similarly to masonry with barbed wire serving as a mortar and provides tensile as well as shear strength. The featured design of Earthbag technology EB 8.1 consists of single storied structure with two rooms. The wall system uses Polypropylene bags filled with soil whereas CGI sheet is used for covering the roof along with wooden rafters and purlins.

MATERIAL PROPERTIES

Soil for Earthing: 25% - 30% clay & 70% - 75% Sandy soil

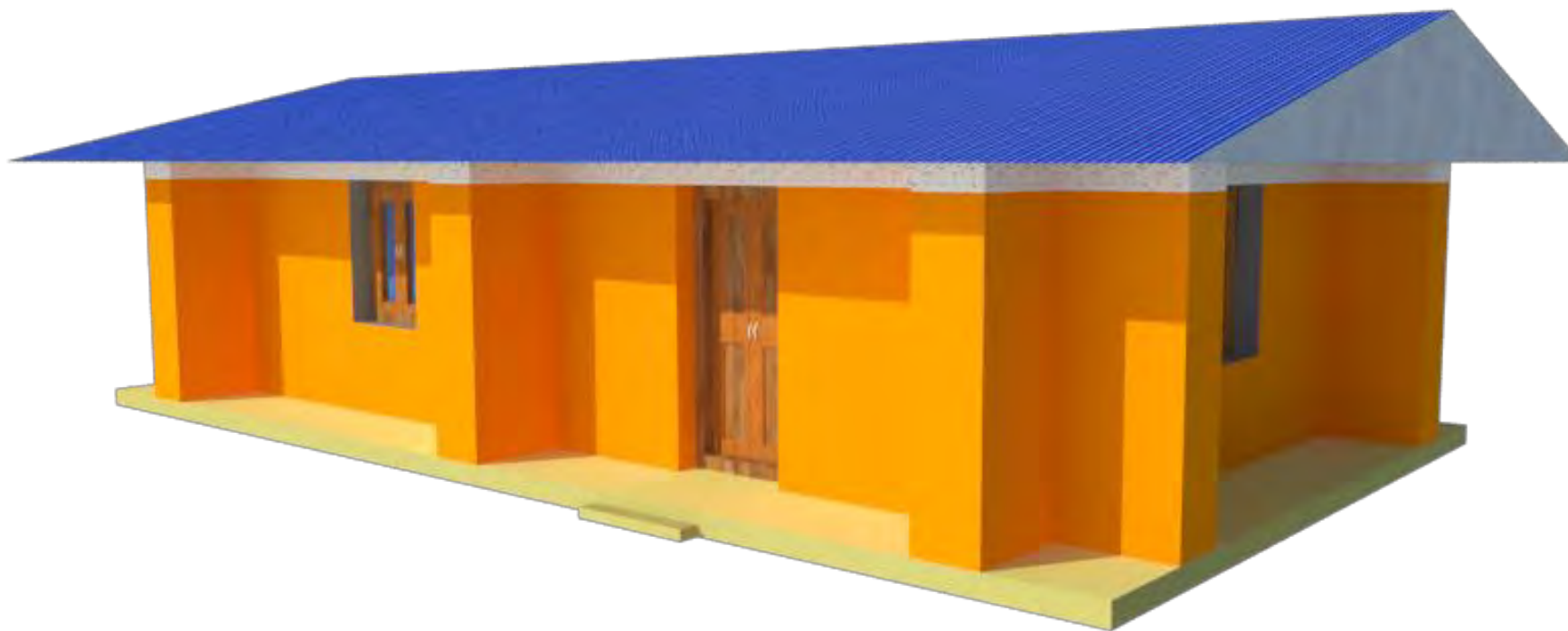
Bags: Polypropylene bags

Barbed wire: 14 gauge, 4 pointed

Rebar: Mild steel bar of Grade Fe 250

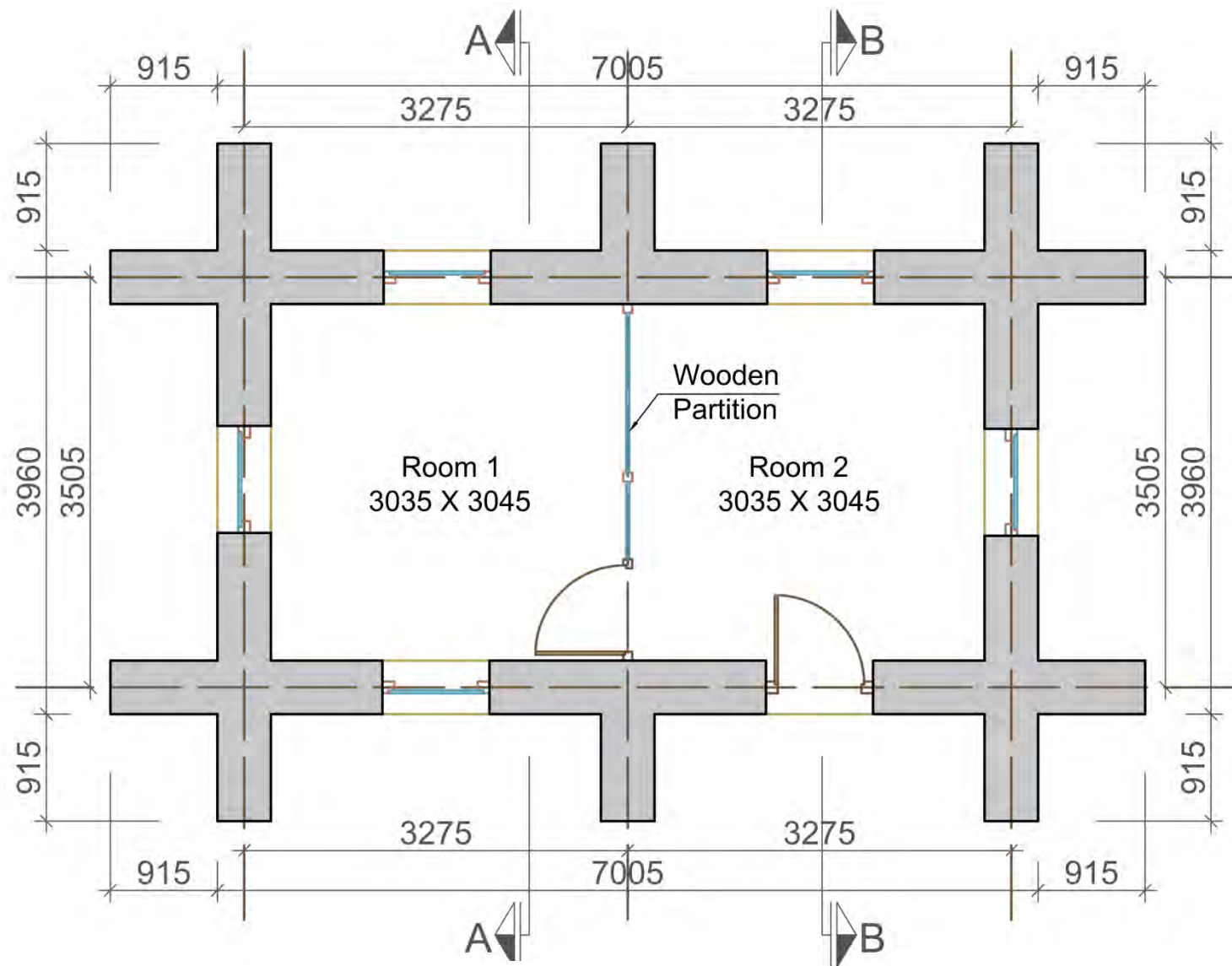
Nominal Mix Ratio : 1:1.5:3 (C:S:A)

E.B.-8.1



LEVEL	MATERIALS								
	Stone	Cement	Sand	Aggregate	Reinforcing Bar	CGI Sheet	GI Sheet	Wood	Earth
	Cu.m.	Bags	Cu.m.	Cu.m.	Kg.	Bundle	Sq.m.	Cu.m.	Cu.m.
Up to Plinth Level	12.3	-	-	-	-			-	-
Super Structure	-	18.4	1.0	2.0	237.3			0.5	25.5
Roofing	-	-	-	-	-	4.2	8.0	2.4	
TOTAL	12.3	18.4	1.0	2.0	237.3	4.2	8.0	2.9	25.5



**GROUND FLOOR PLAN**

FLOOR AREA: 31.95 SQ.M.



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HOUSING TYPE: MODEL E.B.-8.1

DRAWING TITLE: FLOOR PLAN

SCALE: NONE

DATE:

E.B.-8.1

2/11



FRONT ELEVATION



SIDE ELEVATION

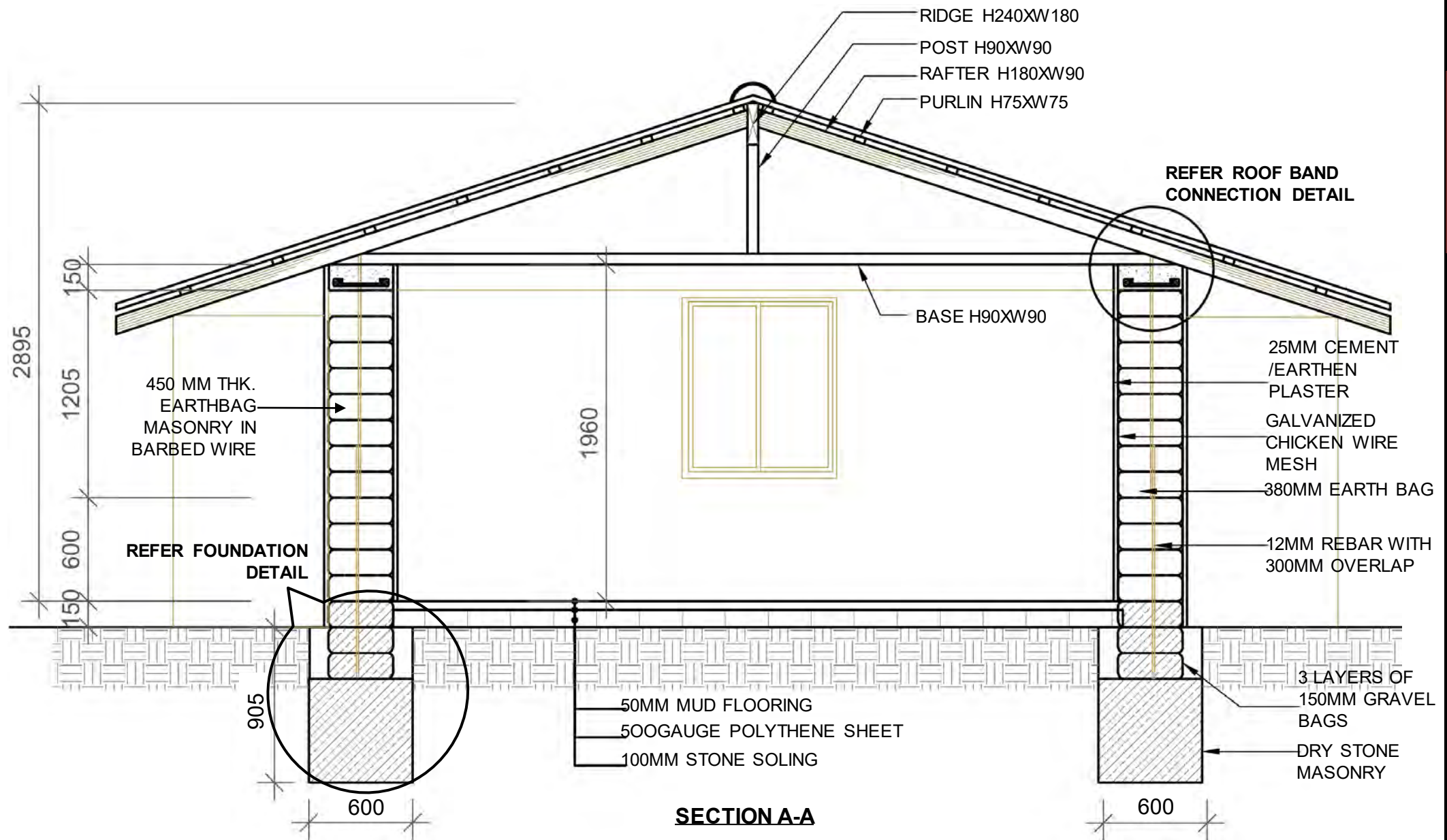


BACK ELEVATION



SIDE ELEVATION





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HOUSING TYPE: MODEL E.B.-8.1

DRAWING TITLE: SECTION

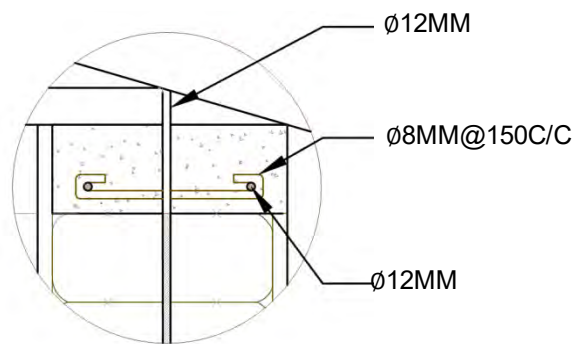
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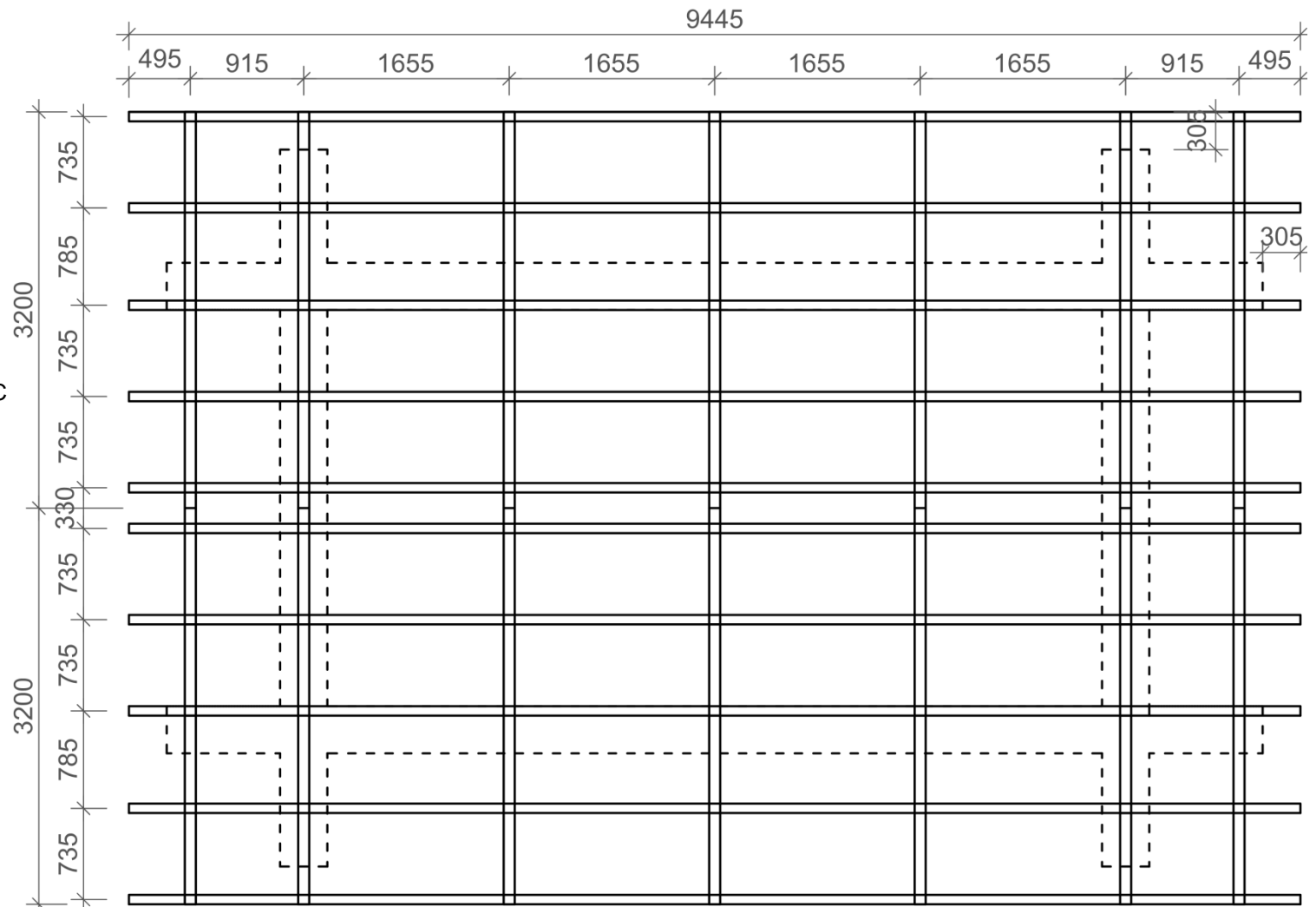
E.B.-8.1
4/11

ONE STOREY





**ROOF BAND CONNECTION
WITH TRUSS**



ROOF PLAN



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HOUSING TYPE: MODEL E.B.-8.1

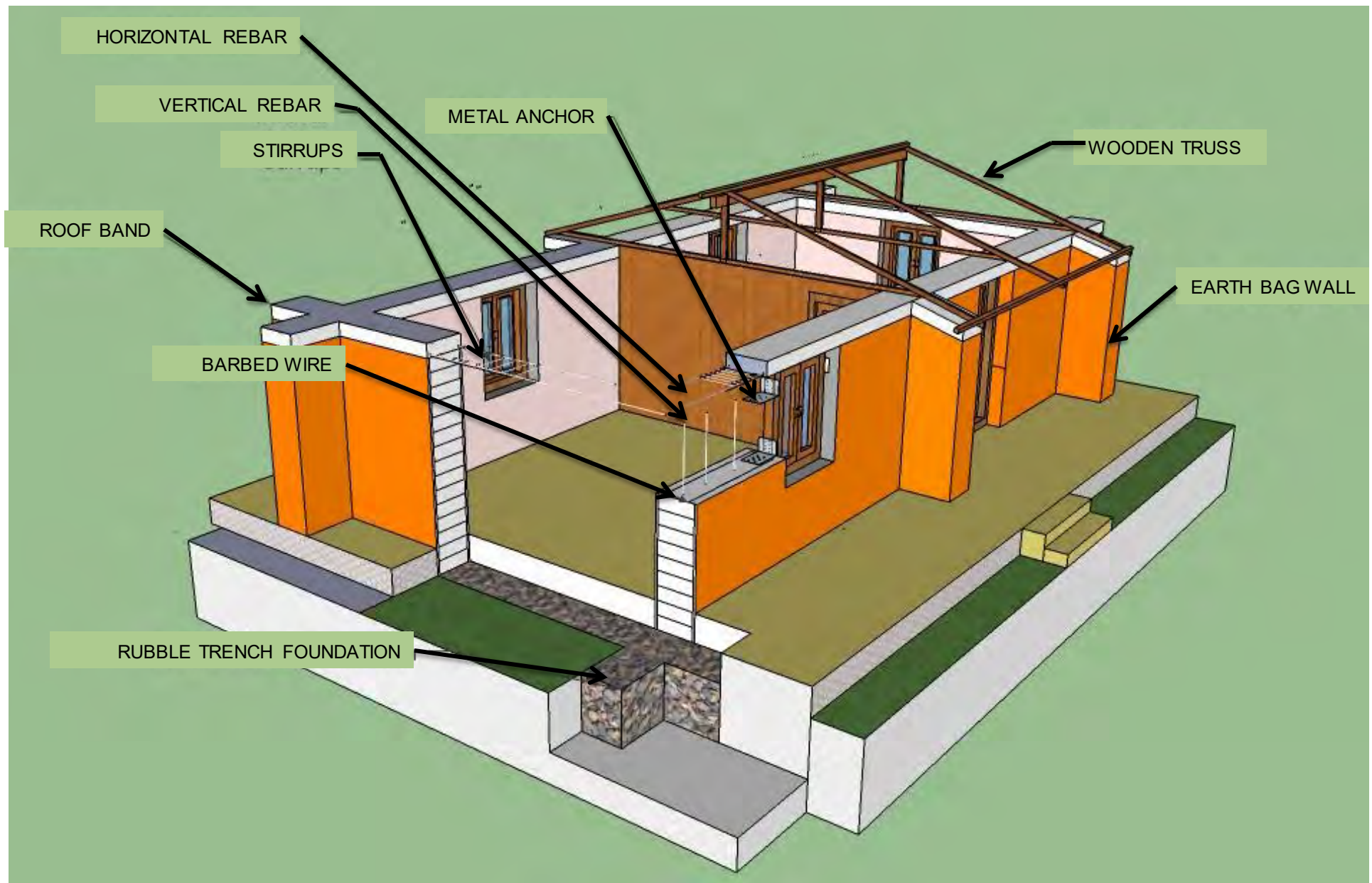
DRAWING TITLE: ROOF DETAILS

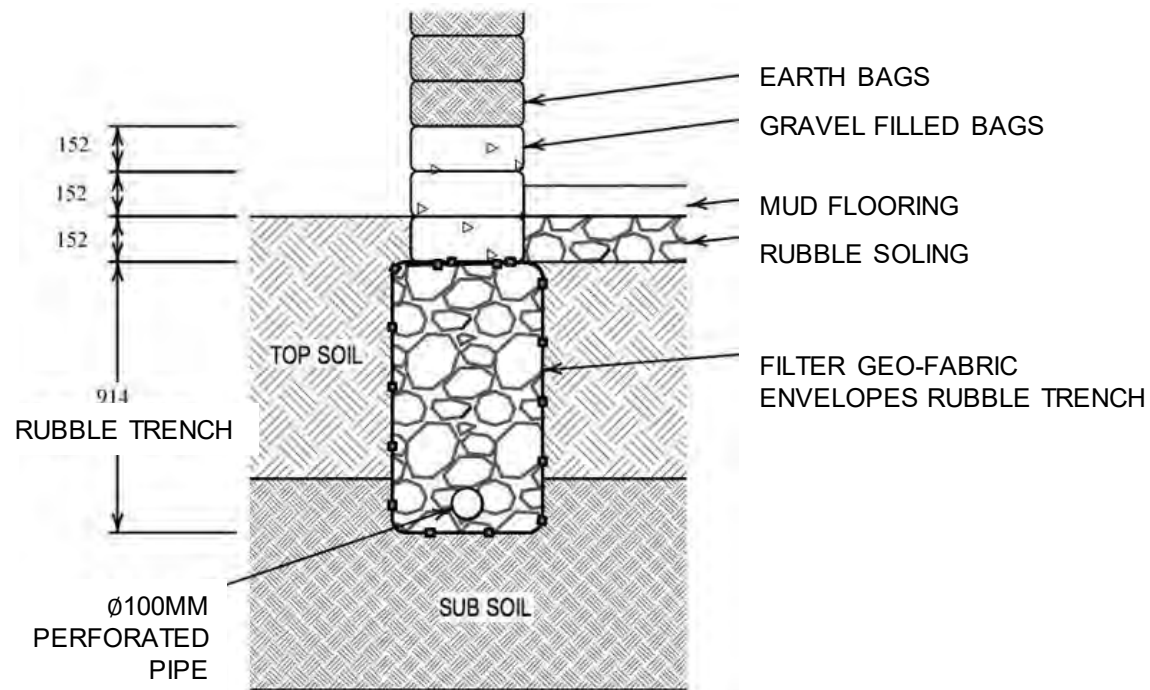
SCALE: NONE

DATE:

E.B.-8.1

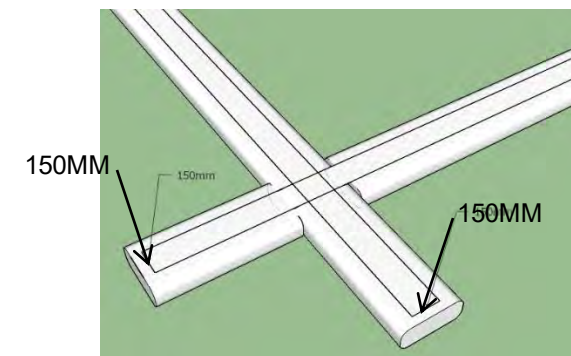
6/11





BASE WIDTH OF FOOTING = 200 + 1 BAG WIDTH

FOUNDATION SECTION



BARBED WIRE SHOULD BE LAID CENTRALLY WITH A MINIMUM GAP OF 150MM AS SHOWN IN THE FIGURE ABOVE

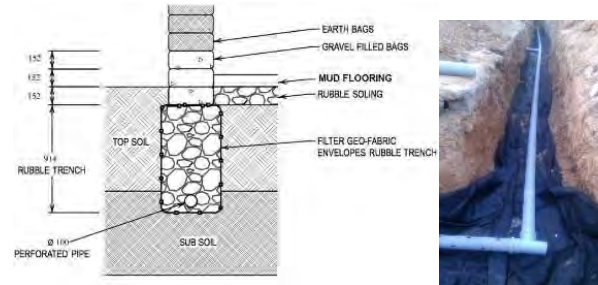


CONSTRUCTION SEQUENCE

- 1 SURVEY THE SITE AND SAMPLE THE SOIL. GET ADVICE FROM AN ENGINEER



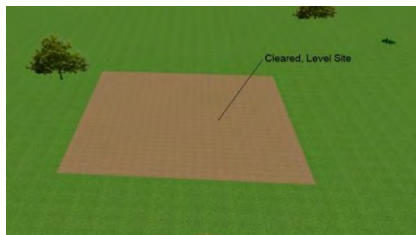
- 4 BUILD RUBBLE TRENCH FOUNDATION. INSTALL FRENCH DRAIN & PLUMBING



- 7 LAY SECOND OR THIRD GRAVEL BAG LAYER ABOVE FLOOR LEVEL



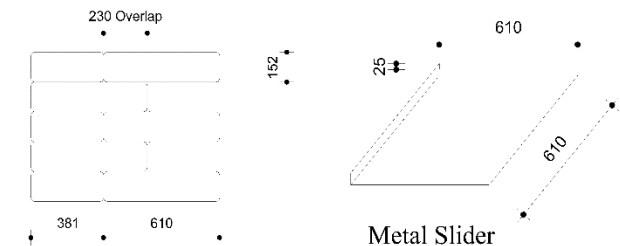
- 2 LEVEL THE BUILDING SITE AND COVER WITH TARP TO PROTECT BAGS FROM RAIN & SUN



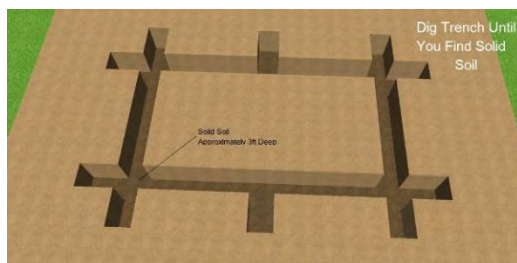
- 5 FILL AND PLACE FIRST COURSE OF GRAVEL BAGS



- 8 USE SLIDERS AND ALWAYS OVERLAP THE BAGS WHILE BUILDING THE WALL



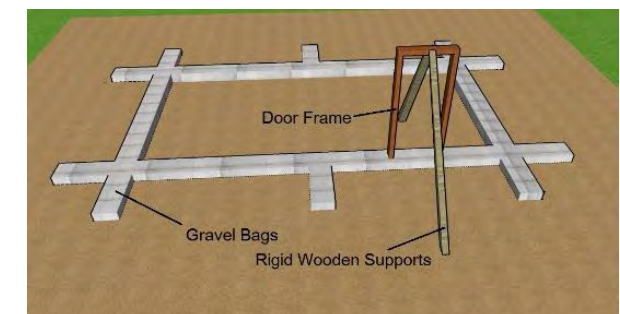
- 3 MARK THE FOOTPRINT, INCLUDING CORNER & WALL BUTTRESSES, EXCAVATE TRENCH 3FT DEEP, 2FT WIDE



- 6 LAY TWO STRANDS OF 4-POINT BARBED WIRE ON TOP OF EACH COURSE AND ADD WALL TIES



- 9 MAKE DOOR THRESHOLDS, INSTALL DOOR FRAMES AND OPTIONAL DOOR BUCKS



CONSTRUCTION SEQUENCE

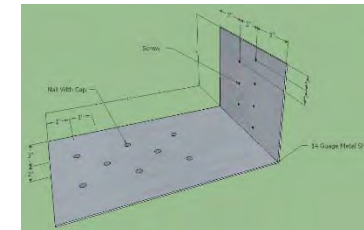
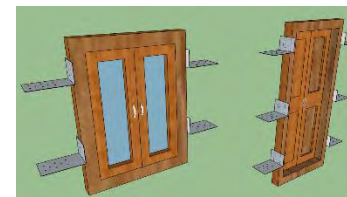
- 10 PREPARE SOIL FOR EARTHBAGS:
SIEVE AND MAINTAIN 10% MOISTURE



- 14 TAMP, LEVEL AND FLATTEN WALLS
AFTER EACH COURSE



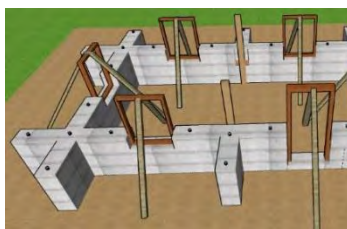
- 17 USE ANCHOR PLATES TO ATTACH DOORS AND
WINDOWS



- 11 FILL BAGS WITH EARTH, PLACE FIRST
COURSE AND TAMP



- 15 PLACE THE WINDOW FRAME SO THE
LINTEL LEVEL COINCIDES WITH THE
BOND BEAM LEVEL

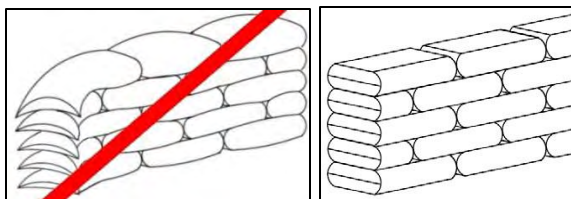


- 18 INSTALL GALVINIZED/PLASTIC MESH FOR
PLASTERING

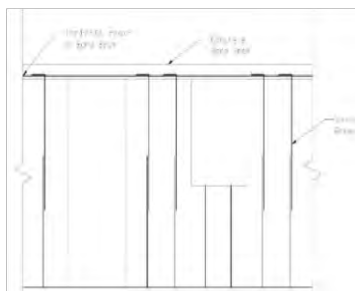


- 12 REPEAT STEP 6 AFTER EACH COURSE

- 13 PREVENT CORNER DROP



- 16 INSTALL VERTICAL REBARS AT SILL
AND LINTEL LEVEL



- 19 INSTALL BOND BEAM, LIGHTWEIGHT ROOF AND
ELECTRICAL WIRING



- 20 PLASTER AND PAINT



TECHNICAL REQUIREMENTS

Structure System	Load bearing Earthbag masonry structure.
Foundation	Strip Foundation of dry stone masonry of width 600 mm and depth 900 mm.
Plinth	Three polypropylene bags filled with gravel shall be placed up to plinth level.
Wall System	450 mm thick Earthbag masonry shall be interconnected in each layers with barbed wire. Buttress shall be provided along the unsupported length of wall as shown in drawing.
Roof Band:	RCC (1:1.5:3) roof band shall be provided throughout the wall at roof level. The minimum depth of the band shall be 150mm. Main reinforcement shall be 2 nos.12mm dia. bars with 8mm Ø stirrups at 150mm C/C.
Roof:	Lightweight roof of corrugated iron sheet over wooden truss. All joints in the truss shall be properly connected as shown in the drawing.

